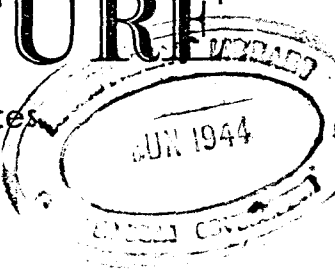


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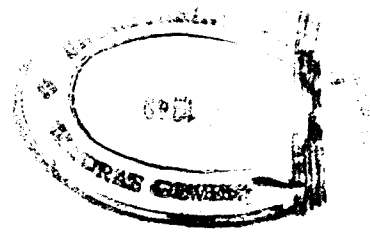
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FAMINE ?

WE make no apology for proceeding to discuss a problem whose gravity is increasing at an alarming rate. Nobody including the Government will now deny that we are in the midst of a critical food situation. The spectre of famine is stalking the land. Deaths due to starvation are of daily occurrence. Resistance to diseases is fast diminishing as a result of gross and continued malnutrition. In fact, the retinue of diseases following in the wake of starvation is already making itself felt. The effect on adults is bad enough. The effect on infants, children, adolescents, pregnant and nursing women is worse. This will mean not only a loss of population which may possibly be greater than that caused by bombing or bombardment by a foreign power, but also the devitalisation of an entire population and the emergence of a new generation crippled both in body and in mind. Scientists in India can no more be divorced from this heart-rending environment than scientists in other countries can keep aloof from their contemporary political and economic situation. When thousands of women and children in tatters sleep on the pavement, even in rains, coming to the cities in search of food, when a thin rice gruel becomes a luxury to numberless people and when starvation and despair are writ large on the faces of most people that we see, it becomes hardly possible for scientists to pursue their work in a calm atmosphere at Olympian heights. It looks as if the flesh and blood of our nation is falling to pieces without any body being able to stave the collapse. Such a dreadful condition is unprecedented within living memory, namely rice and *atta* selling in Bengal at Rs. 35/- and Rs. 27/8/- per maund respectively when the average annual income per head is estimated to be about Rs. 60/-. That is to say, a whole year's income would buy a man less than two maunds

of rice. Mr. J. H. Methold, leader of the British Group in the Calcutta Corporation, admitted in a speech on the 21st July 1943, that people were ransacking the dustbins for food and spreading diseases. In fact, there was a tragic discussion in the Calcutta Corporation on 26th July, 1943, regarding the disposal of corpses of starved people in the streets of Calcutta. It was reported that in one day alone 27 dead bodies had to be removed from the streets. We wonder whether the British Government—our "Trustees"—take any responsibility with regard to this appalling condition, to which the people of India have been reduced.

COMPARISON WITH OTHER COUNTRIES

The food situation appears to be the worst in India, China and perhaps in one or two European countries now under German occupation. Among the United Nations, India and China seem to be in the gravest condition. In the United Kingdom, the British Government reports, prices have risen by only about 25 per cent while in Calcutta the rise has been of the order of 800 per cent and that for a country which is proverbially poor. In America prices rose but by giving subsidy to the American farmers and by energetic legal and executive action President Roosevelt has been trying to arrest the rise in prices. Governmental action in these countries as also in other countries has been sufficiently thoughtful, scientific and energetic to prevent the situation from getting out of hand. This is revealed in the following Table which gives the legal food rations of some countries in the last quarter of 1942 published in the "Monthly Bulletin of Statistics" of January, 1943 issued by the League of Nations.

It will be seen from the Table that for the United Kingdom bread flour, cereals and potatoes are free so that there appears to be no restriction on the chief sources of carbohydrate. As the rise in prices England avoiding submarines from America and Australia. Apparently the British Government is taking and discharging full responsibility with regard to the feeding of *their* own population.

LEGAL FOOD RATIONS IN THE LAST QUARTER OF 1942.

GRAMMES PER WEEK PER HEAD

Country	Consumer Category	Bread Flour	Cereals	Potatoes	Sugar	Jam Honey	Meat	Fats	Milk	Cheese	Eggs No.	Coffee or Tea
Canada ..	Normal Consumer ..	Free	Free	Free	225	Free	Free	225	Free	Free	Free	90
United States ..	Normal Consumer ..	Free	Free	Free	225	Free	Free	225	Free	Free	Free	
United Kingdom	Normal Consumer	Free	Free	Free	225	105	550	225	1420	85	1	
	Children under 6 years	Free	Free	Free	225	105	225	225	3980	85	1	
	Children 6-17 years.	Free	Free	Free	225	105	550	225	1990	85	1	55
Italy ..	Normal Consumer ..	1050	500-625	1000	125	105	100-200	100	1990	100	1	nil
	Light worker ..	1750		1000	125	105	100-200	100	1990	100	1	nil
	Heavy worker ..	2800	630-755	1000	125	105	100-200	100	1990	100	1	nil
Germany ..	Very heavy worker ..	3500		1000	125	105	100-200	100	1990	100	1	nil
	Normal Consumer ..	2250	150	4500	225	175	350	200	nil	60	0.5	60
	Children under 3 years	1100	275	4500	225	205	200	125	5250	60	0.5	nil
	Children 3-6 years ..	1200	210	4500	225	205	200	190	3500	60	0.5	60
	Children 6-10 years ..	1700	150	4500	225	255	400	265	1750	60	0.5	60
	Children 10-14 years ..	2600	150	4500	225	255	400	265	1750	60	0.5	60
	Young persons 14-20 years.	2600	150	4500	225	175	400	265	nil	60	0.5	60
	Night worker ..	2850	150	4500	225	175	550	220	nil	60	0.5	60
	Heavy worker ..	3650	150	4500	225	175	700	300	nil	60	0.5	60
	Very heavy worker ..	4650	150	6000	225	175	950	570	nil	60	0.5	60

of these commodities has not been very high, they are within the purchasing power of all. This means that there is no shortage of calories for the British population. (The calorie requirement for a normal consumer may be taken to be of the order of 2,500 calories per day). In addition, the rations of sugar, jam, meat, fats, milk and cheese are sufficient though not considerable. This additional ration alone provides 900 calories a day for the normal consumer. There is fairly severe restriction of eggs but that is because egg transport is difficult. The United Kingdom normally produces only about a third of the footstuffs that she requires and imports the rest. Even so her food situation is heaven compared with that in India which produces the vast bulk of her foodstuffs. The British Government has built up food stocks in their country to last for a considerable period. A few months back when owing to German submarine activity the British food stocks had to be drawn upon to a small extent there were angry and anxious questions in Parliament. Lord Woolton, the Minister of Food, tried to allay the alarm by pointing out that the small depletion of the stock of footstuffs was only temporary. British Government spokesmen have said that food ships are still regularly reaching

Who is doing the same in India? Bread flour, rice and other cereals are, of course, also free in India, but the Himalayan prices have produced a condition far worse than even a severe rationing could do. The situation is so bad in Bengal that the Government is reported to be working in terms of a ration of 6 chittacks of rice per day per head for the people including the peasants. Considering that rice is almost the sole source of calories to the vast majority of our people who are unutterably poor, this ration would supply less than 1,500 calories per head per day. A man of normal active habits would require about 2,500 calories a day and a peasant would probably require at least 3,500 calories a day owing to his occupation of fairly hard work. This rationing is neither based on nor related to physiological requirements. But the Government has gone further. It is now organising gruel kitchens. One only wonders how many calories the consumer would get out of this rice gruel of which at least 95 per cent would be water. Who will arrest his pangs of hunger only two hours after the "meal"? How is it that such a horrid situation prevails in India but not in England, where gruel has not been heard of since the time of *Oliver Twist*?

As the above Table would show, the rationing is more restricted for countries like Italy and Germany. In Italy, the daily provision of calories for the normal consumer works out to be about 2,000 calories without taking the rations of jam and milk into consideration, for which accurate figures are not available. For Germany, the ration works out to give over 4,000 calories, which is far above the physiological requirement of 2,500 calories for a normal consumer. The rationing is elaborately graded in these countries according to age and occupation, as it should be, where food-supply is restricted. For heavy and very heavy workers in Germany, 5,700—7,500 calories are being provided per day according to the above Table.

There is rationing also for the German-occupied countries of Europe and for these the scale of rationing is more restricted. For most of these countries however complete figures are not available so that computation is difficult. The provision of calories for the normal consumer in these countries may, however, vary from 3,400 for Belgium to perhaps very low figures for Greece. For Greece, the figures for bread flour and sugar only are given and these work out to give 820 calories for the normal consumer per day. The figures for Japan are too incomplete to permit reasonable conclusions.

We read, however, in the latest United States Office of War Information—Scientific News Letter, Medical No. 2—that "three Swedish vessels loaded with 15,000 tons of American grain recently left New York harbour for Greece to off-set starvation conditions." To send food to an enemy-occupied country requires much negotiation with the enemy through the International Red Cross and the use of neutral vessels. To send food to India from America and Australia would require neither negotiation nor the use of neutral vessels. Are those food-ships being sent? If not, why not?

We read again in the American periodical "Science" of March 12, 1943, that "American and British food in large quantities is now being shipped to French Morocco, Algeria and Tunisia". This is confirmed in a Reuter's telegram of July 24, 1943, that "more than 3,00,000 tons of coal and food have been sent from Britain to French North Africa during the last five months."

THE SITUATION IN INDIA

Even while the Government in Bengal is opening gruel kitchens in view of the acute scarcity, Mr Amery is speaking of "a larger consumption of food per head in India as a result of the increased family income" and is ascribing the present trouble not to scarcity but to "the wide-spread tendency of

cultivators to withhold food grains from the market". Whether the above remarks of Mr Amery convey a deep feeling for the starving people of India, whom he has voluntarily taken under his benign trusteeship, we shall leave to the reader to judge. The heart-rending cries of women and children in rags soaked in rains, many of them of peasant families, begging in the towns from door to door for a bowl of gruel cannot possibly disturb Mr Amery's sleep. But what is more important for us, as scientists, is to point out that a wrong analysis can hardly lead to a correct solution. Before the food crisis can be solved, it is of paramount importance, firstly, that the Government must have the will to solve it, and, secondly, that they must correctly analyse the objective situation and take measures accordingly.

The failure to take proper steps to avert or even alleviate the crisis may be directly related to a wrong appraisal of the rice position in Bengal. The Government and their hangers-on have repeatedly asserted that all the trouble is due to hoarding and not to real scarcity. In the category of hoarders they placed even ordinary house-holders and peasants. The recent house-to-house search in Bengal has, however, ultimately revealed that almost every district is a deficit area, according to the admission of the Government itself. This deficit was foreseen at least four months ago by a searching analysis in an article, "The Crisis in Food", published in the April number of SCIENCE AND CULTURE. It was shown therein that the likely deficit in rice may be even of the order of 50 per cent so far as the civilian needs of Bengal are concerned.

It is not necessary to go again over the ground in detail. It is clear that the civilian needs of food in this country were not treated with as much care as the needs of the military and of industrial labour have been in connection with the war effort. The co-ordination between the food-supplies for different sections of the people, military and non-military, as has been effected in England does not appear to exist here. There has been no food-policy for the nation as a whole. Export of food-stuffs, denial policy, lack of transport, profiteering and undue stocking by some organisations including large employers of industrial labour have led to a predicament which verges on despair. In the midst of all this, if one has to find one's way for a solution, one has to correctly find the causes and then plan and act. But the authorities would not go to the causes but *round* them. They would not acknowledge a real shortage in rice. They would say that practically all the trouble is due to hoarding. At long last the Government of India has been constrained to issue a Press Communiqué on July 23, 1943, saying that "In view of the gravity of the rice position in India, the Central Government find it impossible to undertake, until further notice,

further exports of rice from India". Good sense is now dawning but when it is almost too late.

A word may be said about the denial policy. The Government has admitted that for fear of Japanese invasion rice had to be removed from some coastal districts of Bengal. But it is a curious kind of denial when the food is removed from an area but the people are not evacuated from that area. If a coastal district of Britain were threatened by invasion, would the British Government have removed the staple food from that district leaving the people there to face starvation? Whenever the Soviet Government had to follow a scorched earth policy, they invariably made heroic efforts to evacuate as much of the civilian population as possible.

WANTED FOOD-SHIPS

What is to be done? It is clear, on the one hand, that the policy of export, denial, transport restriction, etc., without adequate reference to the needs of the civil people has to be revised and, on the other, an intensive drive for food production on scientific lines has to be put through in record time. But even these would hardly be of avail in the immediate future. The mischief has gone too far and food cannot be grown in a day. We would urge as the central measure to be taken the immediate requisitioning of at least half a dozen food-ships for bringing wheat to India from Australia and rice from some South American countries. The arrangement for importing a part of the huge wheat surplus of Australia can surely be put through immediately, provided Indian lives are considered worth while. As we have pointed out above, in spite of great difficulties food is being sent to Greece. And England, which is itself an importer of foodstuffs, is sending food to North Africa. Will India alone be in the wilderness?

Many ships are constantly bringing war materials to India from abroad. Food should be regarded as war material, as President Roosevelt once rightly remarked, and food-ships must therefore be given the same importance as ships bringing tanks and planes. This is a matter over which no time can be lost. If the authorities are slow in getting these ships here, they cannot escape responsibility for wide-spread starvation and death.*

*It is interesting to note that Dr W. R. Aykroyd, whom the Government of India sent to the Food Conference at Hot Springs in America, said in a statement on returning to Karachi that they were not concerned with feeding India at the present juncture. They were considering post-war feeding. So it was apparently a cold douche for India from Hot Springs. Incidentally, it may be remarked that the sending of a Britisher to America to speak about the food-habits and nutritional problems of the poor people of India is nothing short of grotesque.

WANTED TRAWLERS

The Bay of Bengal is a mine of fish, but a mine, alas, left quite untapped. This is the time that the oceans must be dragged to get food to famished people. The least the military authorities, in consultation with the civil, can do is to release some trawlers for catching fish in large quantities. Fish is a welcome nutritious food to the people in Bengal, and, if there is a will, this fishing can start tomorrow.

With reference to fish, of course, there will be the question of refrigeration during transport and distribution to different centres of consumption. Refrigerating units should be compulsorily installed in the river-going steamers (this is necessary even in peacetime for greater facility in fish transport). The manufacture of ice can be greatly increased to provide the vast additional quantities of ice that may be necessary.

FOOD PRODUCTION

There has been a "grow more food" campaign for some time in this country without any substantial results. The reason is that it was again a matter of *laissez faire*. Few people know where to grow, what to grow and when to grow. The main factors concerning food production are: (a) improved seeds, particularly for paddy, (b) irrigation, (c) manure and (d) use of cultivable waste. It is a matter for shame that the yield of rice per acre in India is not only the lowest, but by far the lowest, among all countries of the world (*vide* "The Crisis in Food" referred to above).

Regarding improved seeds it is perhaps still possible to secure quantities of improved heavy-yielding seeds. This should have been done by the Agriculture Department long ago in peace time. There are 50 lakhs of acres of cultivable waste in Bengal which could be brought under cultivation. But most of this land is malarious and to start cultivation there would require adoption of anti-malarial measures, construction of temporary huts for the agriculturists and the grant of subsidy to peasants, as the American Government has done in America. Otherwise all this talk of cultivation of waste land is idle.

The question of irrigation is very important and, so far as Bengal is concerned, has been very much neglected. It requires, of course, large funds and it has recently been reported that some funds are now going to be diverted to this purpose in near future. Although the results cannot be immediate, it is a step which would be very fruitful. Mr Zakariah advocates pumping from tube-wells in Western Bengal and coal is a cheap source of power there.

One of the factors of immediate and great importance is manure. The Government, we believe, has again wrongly distributed emphasis. It is carrying on propaganda regarding farm yard manure and compost. This is not to be neglected. But the most substantial results would be obtained if synthetic nitrogen fertilisers in considerable quantities could be applied to our impoverished soil. For proper manuring, it may be estimated, India would require at least 50 lakhs of tons of ammonium sulphate annually. Our consumption now is hardly a lakh of tons. This is an opportunity when a very large synthetic fertiliser industry should be developed in India. The age-old objections would certainly be trotted out. Where is the plant? Where is the technical skill and so on and so forth? Chemical plants needed for the war effort are still being brought to India. It is not only possible but urgent that synthetic ammonia plants should be imported into India immediately and put into operation. Mysore is already running a small plant and we are convinced that there will be no insuperable difficulties in running much larger plants in India. With some experience and some necessary materials of construction, it should be possible to construct these plants in India also. We may cut across Imperial interests in this matter but the life of man is more important than the interest of foreign Money-bags. We have no doubt that the liberal use of synthetic fertilisers would confer immediate benefits at the present juncture and would also be of permanent value. The nitrogen industry is an essential industry from all points of view.

Meanwhile, perishable foodstuffs should be processed and preserved. And if worst comes to worst, edible proteins can be extracted from green leaves on a large scale. Regarding, however, such unusual food, questions of habit and sentiment come into

play, but if it constitutes the ration of all from the highest to the lowest, it may gradually make its way and establish itself even in peace time.

ACTION

All the above discussion would be futile without action being taken. In the present crisis neither I.C.S. men having no knowledge of scientific and technical matters nor Committees nor Government Departments, constituted as they are, can take effective action. With the present organisation nobody knows where the responsibility lies. The whole work of the food production should be entrusted to one able scientific and technical man who should be at the head of what may be called the "Food Organisation". He should be charged with the entire responsibility for food production and, in order that he may accept that responsibility, no extraneous considerations of Imperialist policy should be allowed to cut across his work. He should choose his own assistants and must receive the allegiance of the Departments of Agriculture, Industries, Irrigation, Transport and Communications, and Finance. He should certainly take the advice from the existing advisory bodies and relevant departments but he must assume exclusive responsibility for the success of the work taken in hand. On his part, therefore, he should get no administrative interference. He should have both executive power and financial resources to implement the programme of work which is ushered in. No step short of this can effectively meet the situation. Similar and more drastic steps, we are sure, would be taken in England to-day if the people of England were faced with a crisis of similar magnitude, which might indeed have felled even a Government like Mr Churchill's.

THE CULTURAL BASIS OF RULES OF INHERITANCE

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THE term inheritance is used by anthropologists to denote the transmission of property of a deceased person to his heirs. The term succession is restricted by them to transmission of rank and office. In works on law, however, this differentiation is not observed. In this essay, the two terms will be used in the sense in which they are employed by anthropologists, except where the context clearly indicates contrary usage.

The rules of inheritance of people with different cultures, in general differ. The Hindus and the Moslems are both patrilineal; so are the English people. Their cultures are different, and the rules of transmission of property are also dissimilar. Among the Hindus, the people of Bengal have a culture which differs in some important respects from that of Bihar and the United Provinces. The rules of inheritance in these areas illustrate one aspect of these divergences. The Khasis, the Garos, and the Santals, who live in or near the border lands of Bengal, are examples of tribal people with widely differing cultures, including the rules of handing down property on death.

Administrators, when they want to modify or codify law, sometimes overlook the intimate connection between the culture of a people, and their customs with regard to the holding and transfer of property. As an example may be noted the case of the Garos of Assam, who live also in a sub-division of the district of Mymensingh in Eastern Bengal. In the plains of this district, the Garos have pushed forward their settlements into zamindari tracts owned and mostly peopled by patrilineal Hindus and Moslems. The Garos are however a mother-right folk, and only women among them can own land. The zamindars have some difficulty in understanding their rules and do not like to have women tenants owing to their usual experience of difficulties in such cases. The missionaries who work in these areas, do not also like the rule of the women. Presumably they find the women more conservative, and less accessible than men, for the purpose of spreading their religious doctrines. On the advice of the zamindars and missionaries, the administrators at one time seriously considered altering the Garo rule of ownership of land by women, by passing a law. Fortunately for the Garos, better counsels have prevailed. The Garo women firmly opposed such a violent change, and the officials, in consultation with anthropologists acquainted with Garo culture, have eventually decided to introduce only such modifications as are needed

to make the rules fit in with the changed economic conditions.

As noted earlier, the Garos are a mother-right people. Their clans are matrilineal and their women own land and most other kinds of property. In each family of means, one of the daughters is usually nominated by the parents, as the heiress. She inherits the house and the family possessions. On marriage a man goes to live in his wife's mother's house. If his wife is the heiress (*nokna*) this house passes on to his wife on the death of the mother. Where the girl is not a *noknā*, her husband is helped by his wife's people to build a separate house in her village. It becomes his wife's property. The principal heiress, it is to be noted here, has to perform certain elaborate funeral and post funeral ceremonies for the mother or other woman, from whom she inherits the property. If there is no principal heiress, all the daughters share equally, and bear the funeral expenses also in like manner.

Villages are organised, normally, on the basis of a single clan occupying one site. All the land of the village is common to the clan members. Each family cultivates according to capacity and requirements. The husbands of the women who own these plots of land are the managers. The produce belongs to the family. Whatever the man earns, by cultivation or by trade, while thus residing in his wife's house, is held to be the wife's earning. Any property acquired is taken by the widow and her heirs. The sons cannot inherit anything—unless the mother, the sisters and other female kin voluntarily agree to make a gift. A small amount, representing the contribution of the mother's group for the man's upbringing, and marriage, and also for part of the funeral expenses, is made over by the widow to the mother (or her heirs) of the deceased husband.¹ The earnings of a man before his marriage, even when kept by him after marriage, are however to be made over to his mother's family, and their heirs in the extended family and the clan (in the absence of the mother or sisters). The reason for these rules is simple. The capital *i.e.*, land or money with which a man has to work is furnished by his mother before marriage, and by his wife when he goes to live with her. But in modern times it has become possible for a man to earn and save money and acquire property, without depending on capital furnished by the mother or the wife. Thus a Garo may receive training in an automobile shop paying for it by work, and earn fair wages as a mechanic or omnibus driver. He may

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save money and purchase property while staying away from the house of his mother or wife. In such case, should the property go entirely to his mother's group if he was a bachelor at the time of earning, or to his wife's clan, if he is a married man? Or should he have complete option in the matter, to leave it to his sons and daughters or dispose of it otherwise? It should be remembered, before deciding the question, that a portion of the expenses of the funeral rite of a Garo has to be borne by his mother's family, and certain subsequent rites are also to be performed by them. The soul of a Garo has to go back to the mother's ancestral group in the afterworld. Part of the expenses of the ritual to facilitate this journey (as the Garos believe), fall on the mother's family. Hence it is only fair, that a small portion of the man's earnings should go to this social unit. The balance should go to wife and children. This is the view taken by anthropologists, and accords with Garo practice.

The Khasis, another people of Assam, also observe mother right. In their case the villages are not organised on the basis of clans. But like the Garos, land which has not been cleared is held in common; each family cultivates as much as it can or needs, and during occupation, has usufructuary rights in such land. Among the Khasis, as among the Garos, the men settle in the house of the wife's mother, and subsequently build a separate house. The youngest daughter inherits the ancestral house. New houses are built for other daughters and become their property. Fresh land cleared by the husband also becomes the wife's property. On the death of the wife, the house passes to the youngest daughter who gets also a larger share, of the cleared land and other property, than her remaining sisters. The sons are entitled to stay in the house and to maintenance (in return for work) so long as they do not marry. One section of the Khasis are known as Syntengs. Among them, the men remain even after marriage in the mother's house and continue to help in work on the mother's land. It should also be noted that Khasi women work with their husbands on the land. Also they are keen traders and money may be earned in this way before as well as after marriage.²

An administrator or legislator, unacquainted with Khasi culture may consider the extra share of inheritance by the youngest daughter as unfair. Actually the youngest daughter has certain special duties and responsibilities. Khasi dead are cremated and their bones ceremonially disposed of, first in a family stone chamber for these remains, and finally in the clan ossuary. At each stage, the youngest daughter of the group has to bear the expenses of the ritual. She has also to maintain destitute members of her extended family (or wider group, as the case may be). The extra share has been ordained

by custom, very equitably, as a fair return for her responsibilities.

We may now consider the mode of inheritance of self-acquired property among the Khasis and Syntengs. A woman before marriage stays in the mother's house (or of a similar relation, in the clan), and the maintenance comes from the income of that social group. Hence "her earnings are considered as part of the family earnings. If she dies, leaving any property which can be distinguished as separate", the mother, and her female heirs in the family and the clan take it. This is also the Garo rule. Property acquired by a woman after marriage is not however in this class; it passes to daughters, as noted earlier. If such earnings were joint, in the sense that husband and wife worked together, the widower among Khasis is entitled to maintenance. The husband can remain in the house of the deceased wife and "the children have no power to take all the jointly earned property and to drive away the father". Among the Garos, the widower is generally given another wife to take the place of the deceased woman. She owns the property and her husband thereby continues the right to manage it.

As regards property earned prior to marriage, the Khasi rule for men is that it goes to the mother and her heiresses. It is not material whether such savings by the man were kept apart until death. It may even be that the man retained such property after marriage. In all these cases the mother's social group is entitled to take it. Property given to a man at marriage by his mother and her family to help him to set up house will go back to them, out of any estate left by a man. If a man and his wife earn together, on the wife's capital, the wife takes the whole estate on the death of the husband. If there are no children, a portion of the earnings are made over to the mother's group who have to bear the expenses of the elaborate funeral ceremony and bone disposal rites. It is held, that notwithstanding such earnings having been joint, since there are no children, the man's share should go, partly at least to the mother's group, with whom the ties persist even after death. This belief of the Khasis in the unity of all men and women of a clan, with the ancestors of the clan has profoundly affected their social rules. The regulation of marriage and exogamy among them rests on this basis. It may be noted here, again, that the bones of all the men and all the women of the entire social group (clan) eventually rest in the same ossuary. The wife's bones and the children's bones go to a different ossuary from that of the husband and father. When there are no children, death dissolves the bond between husband and wife completely (subject to the performance of a rite at the end of a year from death.³) In the case of childless marriages, the Khasi wife can

not claim the whole of the estate acquired by the husband by his own efforts (without using any capital of the wife). She can however, if her own property is inadequate, get maintenance according to one view. In the opinion of others, she can take half the estate. The rest of the property goes to the mother or her heirs. The difficulty is sometimes obviated by a man in his life time by depositing a good portion of his surplus income (self acquired) with his mother's family. In such case, the question of a division does not arise. A strong section among Khasis hold that no man wants to amass property for enjoyment of it by the members of another clan or by the children of his widow by another husband. Hence, they say, self-acquired property cannot vest absolutely in the widow. As noted before, there are differences in customs in different areas. Among Syntengs, the husband lives apart from his wife, in his mother's house and merely visits his spouse. Hence all property acquired before or after marriage passes to the mother and her heiresses. There is however an exception. If a woman undertakes not to remarry, and retains the bones of her husband, she inherits a part of the property. The bones are placed in her own clan ossuary. Permission of the mother of the husband has to be obtained ceremonially, for enjoying the income of the husband during his lifetime and for retention of the bones after his death.

It is clear from the foregoing statement of Garo and Khasi rules of inheritance, that these customs are intimately related to certain fundamental beliefs underlying their culture. If any attempt is made to alter these rules, to any large extent, the cultural bases will also be modified. It is also evident that rules of inheritance are also an expression of the type of economic and social co-operation among individuals, families and wider groups, prevalent among these tribes.

I shall now describe the customs of a patrilineal people, the Santals. Among this tribe, the wife normally goes to live in the husband's house. A small payment is made to her father at the time of marriage, and she receives a small gift of cattle which remains in her possession. Apart from this last gift, she cannot hold any property. On the death of her husband, she may be taken over by his younger brother by the custom of levitation; or she may remain in the house looking after her children. She may also return to her father's house with her own property (cattle) received at marriage, and remarry. Her husband's property goes to the sons. Daughters are maintained and given away in marriage. If there are no children, the brother's sons and agnates of the extended family inherit. If there are daughters and no special arrangements had been made by the father in his lifetime for them, they receive only

maintenance until they are married. If they are married, the daughters get nothing. It is however common, in such cases, for the father to notify his villagers and heirs, that he proposes to bring a son-in-law home as ghar-di-jawae, mentioning a particular daughter. If such a marriage takes place in his lifetime, the daughter and son-in-law get half the property. The rest goes to the usual heirs. The grandson born of such a daughter takes his name, though not his clan, instead of being named after the father's father according to the usual Santal custom. In the Santal Parganas, some missionaries have advocated that when a man has daughters but no sons, the whole of the property should go to them and not to the brother's sons. In some of the feudatory States, where the Santals live, such an award is made to daughters if a reference is made to a court of law, on the basis of Hindu law followed in such cases. But ordinarily, Santals do not refer to court even in those areas. The reasons are stated below.

When a Santal dies, his body is cremated, and the bones are collected and kept for subsequent rites. At the end of the agricultural year, the bones are ceremonially carried to a sacred river and disposed of in water. A ritual has also to be performed on return home. Finally before many years have elapsed, a very elaborate and expensive ceremony termed the *bhandan* has to be celebrated. Only the son or brother's son or an agnate of the extended family can perform all these rites. Neither the daughter nor her son (even of the ceremonially taken ghar-di-jawae) can undertake these duties. Unless these rites are performed, the soul of the Santal (it is believed) will not be united to those of his patrilineal ancestors, and he will not be happy. The final ceremony, it may be noted, is comparable to marriage in a sense, and actual marriage songs are sung to signify this union of souls on this occasion.⁴

It is clear that if the entire property is made over to daughters, nothing will be left for the expenses of the funeral and post funeral rites. A change in the Santal law of inheritance by legislation as urged by missionaries will eventually destroy the beliefs which underlie Santal village unity and traditional moral code. Such alterations are therefore not desirable until the Santals and their culture have changed largely through education and other factors.

It has been noted that a Santal daughter does not often refer to court, even when she can, to take her father's property. As she believes that her father's future welfare depends on the performance of the elaborate rituals, she does not make it impossible for the agnate and customary heir to carry them out. As an example of the opposite kind, it may be noted that Christian Khasis who do not cremate and whose bones do not rest in clan ossuaries have ceased to be influenced in their rules of inherit-

ance of self-acquired property by the Khasi belief in the need of care of the bones. A Khasi, who is not a Christian "would not, to spite his *Kurs* (clan members) or wife and children give his property to strangers owing to the risk of his bones being left uncared for. Among Christians, anxiety for the bones does not exist as they do not cremate . . . so the restraint of religion upon gifts outside the family has disappeared among them."

We may now consider the question of inheritance of property under the *dāyabhāga* rules, by Hindu women in Bengal. Among Hindus, in the old days, as at present, absolute right in property among women seems to have been limited to what is known as *stridhan*, consisting of gifts received at the time of marriage, and also subsequently from the parents, the brothers, the husband, and other near relations. Strictly speaking, these various gifts were not all termed *stridhan* in the ancient law books and commentaries; but the rights to them were the same. A woman could dispose of these properties as she desired (with some exceptions). On her death, these were inherited by her unmarried daughters in the first instance, and in their absence, by other daughters variously graded, and finally by the son. Of the father's property, a married daughter inherited nothing if there were brothers. Unmarried daughters received maintenance and marriage expenses. There were however directions for gifts at marriage equivalent to a share of the father's property.^{5a} The widow was held to be entitled to enjoyment of her husband's estate. There is some difference of opinion regarding the nature of the rights of the widow to her husband's property in those days. The law regarding inheritance among Hindus in British India was formulated on these traditions, and certain beliefs of judges and legislators regarding customs prevalent among Hindus. In Bengal, until the passing of the Hindu Women's Rights to Property Act of 1937 (and 1938), the above rules were followed in general, except that in the matter of *stridhan* the daughter's son was preferred as an heir to the son. Also in case of partition of the husband's estate, the widow was entitled to a share equal to that of the son. The rights in such a share were defined as of the limited kind known as a "Hindu Woman's estate".^{5b} If the estate is large, the whole income is not supposed to be spent; if it is very small, and the income insufficient to meet the necessities of life, the share can be sold. Under the law of 1937 (and 1938), the widow has been given the right to enforce a partition of her share on her own initiative. This new law however gives certain rights of inheritance (hitherto not enjoyed), to the widow of a predeceased son and also to the surviving spouse of a son's son. They are entitled under this Act, to inherit certain shares with the same limited rights as the widow

(ignoring a flaw in drafting). Prior to these enactments, the daughter had the right of inheritance of the father's property, in case of death of sons and grandsons (son's sons) before her father's decease. Her rights were not however absolute, but limited to the special kind of life interest already described. It was not *stridhan*. Her sons inherited the property absolutely on her decease. In a bill now under consideration it is proposed.

- (a) to give to women the absolute right to inherited and acquired property, abolishing the limited estate of a Hindu woman (variously described as "widow's estate" etc.).
- (b) to entitle daughters to inherit, along with sons, to the father's property.

As regards the estate inherited by a widow from her husband, if she does not make a will, it is to be inherited by the heirs of her husband as if he had died intestate and a widower. Other properties owned by her will pass to daughters, their daughters, the daughter's son and son in the order mentioned, as her *stridhan*. Such properties will include inheritances other than those coming from her husband. The daughters will take half a son's share from the father's property. The widow of the predeceased son or of the son's son, are not to have any special prior rights over any of the other heirs as enjoyed at present.

The arguments in favour of the bill put forward in the explanatory notes and the earlier reports⁶ discuss the question of justice in division of property, the hardships caused under the present law, and certain legal technicalities. Two important questions have been left out. One is the effect on the culture of the Hindus, and the other is the different conditions of marriage prevailing in different strata of Hindu society.

The Hindus believe that certain kin are entitled to perform the funeral rites of a man, in preference to others; also they are expected to offer oblations to them for their welfare in future life. The first *śrādh* ceremony involves a fair amount of expenditure and is usually celebrated on a scale commensurate with the position of the deceased. Subsequent rituals involve much less expenditure. In the case of the Khasis and Santals, it was pointed out, the position is different. The subsequent rites are more costly than the actual funeral and the first feast. Although the Hindus are patrilineal, the daughter performs a *śrādh* on the fourth day. Also her son has to offer oblations to her father and their ascendants for several generations at every ceremony where ancestors have to be invoked (as at marriage of children). In the Vedic period and also later a daughter's son could even function like a son's son

in certain circumstances.⁷ The law of inheritance in Bengal takes some cognisance of this religious basis of society. A daughter and her son inherit in the absence of sons. Since however the daughters perform the rituals on a limited scale even when there are male heirs, it cannot be said on religious grounds that they are debarred from inheritance along with sons.

We have now to consider the socio-economic aspect of the matter. A daughter on marriage goes to her husband's house, except in the rare cases where her husband comes to stay with her in her father's house. The sons bring home their wives, and unless there is a great disparity between the incomes of the brothers, they stay together in the father's lifetime, even at present, in most cases. In the vast majority of cases, a sharp disparity in income is absent. If the father's estate is not enough to meet the expenditure, the sons contribute. Also, any improvement of or addition to the estate by the father out of such joint income is held to have been made by the father out of his own income. The daughter, whether married or unmarried, normally contributes nothing to the father's estate (with one exception noted below).

Among the high castes, in their superior sections, and a small number of groups among other castes where sons have received education, no payment is made to the bride's father at marriage. On the contrary, a dowry is usually given to the daughter by her father. This gift is strictly speaking *stridhan*; but there are no adequate arrangements for safeguarding and keeping it intact for the woman as her future provision in case of mishap. This payment at the time of marriage is in one sense an anticipatory payment of the daughter's share of the father's property (as laid down in the *smritis*). Parallels from simple societies often help us to realise the exact nature of social forces, and the significance of social facts. The Veddah rule of inheritance is helpful in this connection as an illustration. Among this tribe who are hunters and collectors, a father makes over the right to hunt in certain territories and collect honeycombs in certain rocks, to his daughter's husband at the time of her marriage. It is a gift of the daughter's share of his property in anticipation, for the joint livelihood of the woman and her husband. Her husband, who so long has been staying with his father and helping him in the matter of food collection, now comes to stay with her in her father's house, and adds to the common store his share of game and honey. If he had no territory of his own where to gather food he would have been a dependant and less useful member of his father-in-law's household. When the woman's father dies, she does not get any further share. The remaining property is divided equally by sons and unmarried daughters.

The married sons, as noted before, stay in the wife's father's house. But if the father needs their help, it is invariably accorded, by diverting to his use, a part of the game or other food collected by them.⁸ It is clear from these facts, that rights and privileges in property carry with them definite social and economic responsibilities. It is also evident that the marriage gift to a daughter is a making over of the father's share of property in anticipation. Hence where such gifts have been made at marriage, the wedded daughters are on a different footing from the sons.

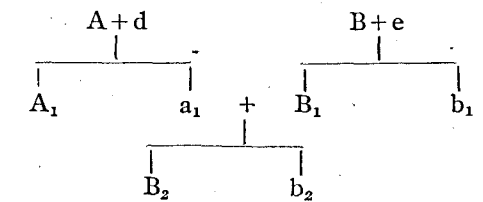
The case is different among our artisan and peasant castes, and also a large proportion of the lower sub-sections of our higher castes. Among them a fairly heavy payment has to be made at marriage, to the father of the bride. Elsewhere I have discussed the antisocial effects of this custom.⁹ The difference in age between husband and wife is increased seriously on account of this payment. Among people who marry their girls young, it leads to early widowhood. In the absence of widow marriage among these castes, other evils result. The bride-price (payment) made over to the girl's father goes to meet the expenses of the marriage in part. The rest of it is taken by him, presumably as compensation for the loss of his daughter. As I have pointed out in my paper, the amount charged is unduly high, and the alleged economic loss due to the daughter's departure, is at present negligible. Although the ancient lawbooks refer to this *śulka* as being the bride's *stridhan*, it is never made over to her by her parents. It is therefore only meet and proper that the daughter in such case should get a share of the paternal estate. As advocated in the paper, the bride-price should be reduced to a nominal amount (as is the case in Behar). It is regrettable that our educated women who belong to the higher section of our society have completely ignored this vital question. Like our legislators, they seem to think in terms of only the small group in Hindu society of which they are members.

In the case of the other division of Hindu society, of high castes—the dowry system often leads to undue pressure on and demands from the girl's father. It has been urged with justice that social changes to mitigate this hardship should be carried out. It may be noted here that an immediate payment at marriage may be avoided by giving the daughter a share in her father's property. Since however the right to exclude her from inheritance remains, it is doubtful how far a change in the law of inheritance as proposed, will help to afford such relief. Objections cannot however be raised to the proposed legislation on this ground, and a father who has made over a share of his property to the daughter as dowry, may exclude her from a further

share by will. The arguments put forward make it clear that an unmarried daughter is in any case entitled to a share of the father's property in the social group which makes over a dowry at marriage. Since however in this society, the daughter does not contribute to the family funds or property like the sons, her share of inheritance should be less than that of sons. The proposal in the bill of giving her a half share is equitable from this stand point. If the bride-price is reduced as suggested, no injustice will be done to the daughter in the other section of society as well, by such an award. Since the dowry as well as bride price are unconditional gifts, the share of the father's property to be given to a daughter should also vest absolutely in her.

It is not however clear on what principles, this inherited property along with other *stridhan* is proposed to be awarded to daughters, excluding sons. Presumably, the legislators think that some compensation must be given for the daughter's half share of inheritance. The preceding discussion ought to make it clear that the daughters should get less than sons as their responsibilities are less with regard to the father and his family. In the matter of the mother's property, daughters are not entitled to any exclusive inheritance by reason of any special duties or responsibilities. As the daughters will be inheriting the father's property, the sons ought to share the mother's property along with daughters. Here the division may be equal since the estate will now include heritage some of which would formerly have passed exclusively to sons and others to daughters. If the rules of division of property (including *stridhan*) noted in the bill pass into law, a simple calculation will show that, other things being equal, daughters in the second generation will possess a larger share of inherited property than sons, even after excluding entirely the widow's share of her husband's estate. For simplicity, only families with one son and one daughter will be considered. It is needless to add that the results will be applicable to all families with equal number of sons and daughters. According to the usual convention, capitals denote men and minors women, while the sign of addition denotes marriage. Let there be two families, of which the heads are A and B, both of whom own equal amounts P, of property. Let the wives be d and e and let them also have equal amounts, "s", of *stridhan*. Let each family have two children, a son and a daughter. Let B₁, the son of B marry a₁, the daughter of A and let them also have two children, a son and a daughter. Then A₁ on the death of his parents, will inherit (if in all cases the properties remain intact), " $\frac{2}{3}$ P", while a₁ will get " $\frac{1}{3}$ P+s". B₁ also will receive " $\frac{2}{3}$ P". In the next generation B₂ will inherit $\frac{2}{3} \times \frac{2}{3}$ P = $\frac{4}{9}$ P. But b₂ will inherit $(\frac{1}{3} \times \frac{2}{3}$ P) + $\frac{1}{3}$ P+s = $\frac{5}{9}$ P+s, as her share. Other things

being equal, this increase will be maintained in each generation.



As regards the widow, we have already noted that she now enjoys a share along with sons. The question to be decided is whether she should have an absolute right over her share. According to the Hindu concept of marriage, husband and wife are one and have to act together in all social and religious ceremonies. Her right to enjoy property left by her husband cannot therefore be questioned, on religious grounds. On the social and economic side, it is to be pointed out that the wife is as much an earner through her work in the household as any one else. We should not make the mistake of the Census Commissioners and classify her as a dependant. In the average middle class and poor families, the wife is housekeeper, cook, general worker as well as mistress of the house, and the money value of her services are comparable to the cash earnings of the husband, although they rarely approach equality. Some portion at least of the husband's earnings are therefore joint in this sense, and the widow is therefore entitled to an absolute share. It cannot however exceed half the estate. In the case of a widow with children, the natural affection of a mother will normally be a safeguard against unnecessary wastage, if the estate is large enough to leave such a margin.

The bill however proposes that a childless widow, and one who has lost her children, and has only daughter's children or son's daughters surviving, should take the entire estate of the deceased husband absolutely. Such an estate may have been inherited in part at least from his father by her husband. The childless widow, who at most can claim half of the estate of her husband, will be depriving for all times, the brother of the husband and his descendants who can rightly object to ancestral property going out of the family. If the estate is wholly self-acquired, (by the husband) such an objection would be invalid. But the direct descendants like the children of the daughter or the son's daughter cannot be excluded in such case. It is also not clear why when daughters are being given the right to inherit, the son's daughter is placed after the daughter's son in a separate sub-class. If her father had been alive, the daughter of the son would have inherited eventually a share equal to that of her cousin had the mother of the latter also been alive

at the time of the death of the grandfather. The widow without surviving sons or grandsons (son's sons) or daughters, may be allowed, rightly, to take half the husband's estate absolutely, since no other heirs are available of her standing to divide it into smaller portions. The balance of the estate should be made over to the next of kin as enumerated in the bill (with minor modifications suggested) on her decease or remarriage. Such an apportionment will be fair to the widow, provide for religious requirements and also fit in with the present economic basis of Hindu society in Bengal.

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- ⁵ (a) *Mānava Dharma Śāstra*—IX—118.
- (b) *The Yājñavalkya Samhitā* (II—117) favours absolute rights like *Stridhan* in such a share partitioned in the husband's life time.
- ⁶ (a) *Report of the Hindu Law Committee*, 1941.
- (b) A bill to amend and codify Hindu Law relating to intestate succession. Statement of objects and reasons. Explanatory notes.
- ⁷ (a) *The Brhaddevala*—IV—110, 112 (Harvard Oriental Series). See also *Rig Veda*—III—31 and *Yaska*, *Niruktam* III—4—4.
- (b) *Mānava Dharma Śāstra*—IX—128 *et seq.*
- ⁸ The Vedda's by C. G. Seligman, 1911.
- ⁹ Effect of bride price and dowry on marital conditions among Hindus of Bengal by K. P. Chattopadhyay, *Modern Review*, October, 1941.

THE PHYSICS OF THE INDUS RIVER AND ITS RELATION TO THE RECURRENCE OF FLOODS IN SIND

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INTRODUCTION

TWICE within a year and with a vengeance, the Indus River has broken the Begari Bund with its loop at Chak and Arian and caused devastating floods in Northern Sind. Great panic prevailed in the Sukkur Taluka which was in danger a second time. A terrific current was reported to be rushing south and southwestward. The Public Works Department has, therefore, been stirred up, Government having called upon them to find out the immediate causes of these floods and prevent their recurrence. The object of the present paper, apart from dealing with the administration of this ill-fated area, is but to search for the major causes of the floods with the application of *Geographical science* and to offer a permanent solution of this problem. Suffice it to say that the trouble is not so superficial as it appears to be. Merely opening the Barrage regulators and letting the precious water run to waste, or patching up the large breaches, now and then, will not be enough. It has been said that the Begari Bund is often breached in recent years. It is the Gordian Knot of Sind engineering. Its location just above the most precious engineering works in Sind, the Lloyd Barrage, is a very serious thing to consider.

It might endanger the largest irrigation project in India once for all. It is, therefore, necessary to go deep into the matter and, considering the physics of the river, to see if the position could be made safer for the future.

ACCOUNT OF LAST YEAR'S FLOOD

It is to be remembered that the floods, caused by the rise of water by a few feet in the river on its right bank in July and August last year, in this very part of the Province, were most disastrous. They covered nearly 16 Talukas in the three districts of Sukkur, Larkana and Dadu, altogether some 3,000 square miles, destroying portions of roads, railways, bridges and culverts and scores of small villages and threatening even larger towns like Shikarpur, Rato Dero, Garhi Yasin, Mehrar, Mirokhan, Larkana, Dadu and even Sehvan. Some four lakhs of homeless people had to be evacuated to safer places and nearly three crores of rupees worth of Kharif crops were also destroyed. Besides, there was no hope of raising any Rabi crops afterwards.

Three main breaches were caused in the Begari and Jhali Bunds, hundreds of feet wide, and it was

reported that a tremendous current (some 50,000 cusecs) with a fall of nearly 50 feet, was pouring itself out, carrying everything before it. As the authorities tried to divert this flow back into the river lower down and also the side canals, and as their capacities were limited to a few thousand cusecs only, the spill water rushed down even up to the Manchar Lake and breaking its very banks reached as far south as Sehvan and beyond. Besides, the retreating Aral river, carrying its load back into the Indus *even 150 miles below Sukkur*, was not able to relieve the pressure. The worst of all, the authorities instead of allowing the waters to pass through Kalar soils which would have been leached with advantage, helped them to wash off rich agricultural soil instead! That was in September last and again in January of this year, even while the river was at its lowest, with the coming of the winter rains in the Punjab and the closing of the Barrage gates, the calamity befell us again. The cost of repairs of the previous breaches alone was several lakhs of rupees. There is not sufficient earth to cover such breaches immediately, and in such a water-logged area, the transport problem is acute. Millions of cubic feet of material are needed to fill up the gaps and thousands of labourers and beasts of burden are required to work day and night to keep them under repairs.

HISTORY OF FLOODS IN SIND

Floods in Sind are, however, a common feature. According to Sir John Marshall, some of the worst floods occurred in the 14th century A.D. Heavy floods have been recorded in Sind especially in the following years:—1819, 1841, 1858, 1861, 1882, 1897, 1903, 1914, 1917, 1921, 1924, 1929-30.

At times the left bank and at other times the right bank, more especially the latter, is affected. These floods are proved to have devastated even pre-historic cities, such as Mohenjo Daro and Narujo Daru. Several reasons are assigned to them, *viz.*, excess of snow-fall in the Himalayas, blocking of the stream in the uplands by glaciers, such as the Shyok or the Gilgit, cyclonic rains and the resulting changes in the hydrography, and cutting off of the chord of a meander. The last is the most important for the present case and will be considered more thoroughly here. It occurs most certainly when "the forces of lateral corrasion exceed those of erosion or the *vis inertia* round a curve has reached its maximum." (Ref. "*A Study in Alluvial Rivers*" by Mr. N. A. Williamson, *Daily Gazette*, Karachi, February 1943).

PHYSIOGRAPHICAL LAWS GOVERNING THE RIVER INDUS

Such an alluvial river, in a flat country like the lower Indus valley, instead of running in a

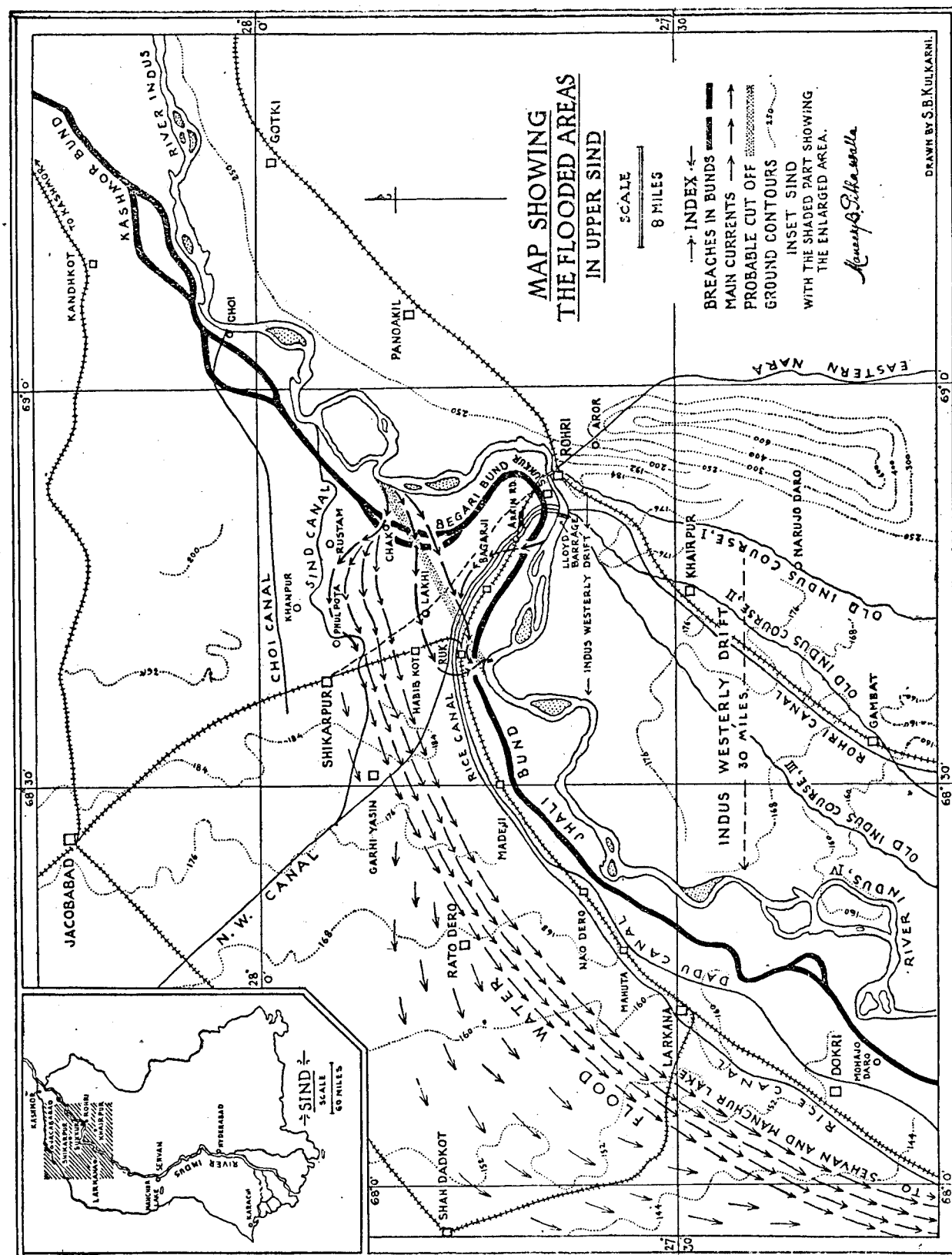
more or less straight course, owing to its varying velocity, treacherous banks, lateral corrasion etc., lengthens itself by bending, until its velocity tends to approach that at which caving and erosion would cease. (See "*River Training and Control*" by F. J. E. Spring Technical Paper 153, Simla, pp. 7-8).

If only the discharge of this wandering river were constant, which unfortunately is not the case in Sind, the regimen of the river would be stable. But due to the melting of the snows on the high mountains by April and the sporadic monsoon rains of July, there are two very irregular discharge curves of the inundation and so the conditions in Sind are always unstable. The discharge of the Indus is different from that of any other Indian river, in that it is not only a snow-fed river and the irregularity in snow-fall and glaciers affect it considerably, but also the rainfall in the whole basin is variable. This variability swings from 40 to 60 per cent in the entire region. There is, for instance, nothing like really normal rainfall figures for any station in Sind. At times a whole season's rain falls within a few days resulting in terrible floods in one year and severe drought in another. The cold season discharge particularly is the lowest in the lower Indus basin (See my "*Climatic Conditions in Sind*, 1937, pp. 20-28).

Scientists have advanced certain theories about the physics of this erratic river. According to Molloy's theory, this instability of the river-bed depends upon the inequalities in the range of rise and fall of the river, variations of discharge, disturbances of momentum and action of mid-stream bars or crossings. More recently, R. D. Oldham, the doyen of Indian Geology, after his investigations of the Indus at Dera Gazikhan in 1902, propounded another theory based upon the formation of 'reach' and 'fan' in turn, the increase and decrease of velocity of 'current' and the erosion of the 'bed and banks'. He, in his turn, has depended upon the principles of M. Dausse, a French geographer, according to whom a river, flowing over an alluvial plain of its own making and consequently in a state of equilibrium between its velocity and load, is actually collected into a deep channel and then spreads out in a shallow sheet, which ultimately splits up into several channels of varying gradients. Both these, 'reach' and 'fan', try again to encroach upon each other by erosion on the upstream side and deposition at the lower ends.

CHANGING HYDROGRAPHY

The Indus in Sind, besides, is running on a bed, made by its own silting, higher than the land which is falling on either side by over 50 feet in places, and the nearer it reaches the sea, the more are its



meanders and the larger the round bends, the stream gradient being only a few inches per mile. Even the subsoil water-table is very shallow, hardly 6 feet deep especially after the rainy season. In the area, which we are to consider, some 300 miles from the sea, the meanders are nearly 40 per cent. The floods, at times, particularly after the monsoon rains in Sind, are heavier than in the Punjab and the waters descend all the barren rocks suddenly. The changing conditions, during the flood and the time when the river falls later on, cause frequent scours, erosion of the bed and banks, and the worst of all, cut-offs of meanders, forming ox-bow lakes, etc.

The result is that the length of the stream is shortened by several miles and the excess of velocity of current, thus produced, causes the flooding of the surrounding fields. At Sukkur, luckily for the present at least, there is a narrow gorge called Bukker in the limestone rocks, producing rapids during the rainy seasons, and for about three miles below the gorge, the course of the Indus is constant in recent years. Hence it is supposed that the Barrage is safe at this place. But at other points, during the course of the river, both above and below the gorge, the banks are constantly undermined or degraded on the concave sides of the curves and aggraded on the convex sides of the wanderings, thus causing the maize of meanders. One such meander or loop is the most dangerous in this area (See the Map).

EFFECTS OF EARTHQUAKE, ETC.

Sind is within the danger zone of the earth and earthquakes do take place, but their effects on the river are *only local* and not extended on a vast scale. The whole valley, however, is rising in level due to the constant discharge and deposition of silt every season. This process of silting in Sind is a tremendous one; it changes the momentum of the stream, which, in its turn, causes bar crossings, spills leading to cut-offs and the consequent instability of the river regimen. The silt deposited being very fine, the bed and sides of the channel readily yield to flood attacks; the gradient, depth, velocity and course all change.

Besides, there is a distinct *westerling* tendency of the river in Sind. According to Parker's observation, and due to the rotation of the earth from west to east, in the northern hemisphere, rivers flowing from north to south attack the *right* bank. As a result, today we find the river lying against Kohistan like a deep "S" in Sind, and a large number of Dhoroos or starved streams and dry valleys spread all over the Eastern Valley Section (for further particulars see my "A Geographical Analysis of the Lower Indus Basin", Part I, pp. 337-344). Another great

peculiarity of the lower Indus is that it has no large tributaries as in the Punjab, but on the contrary, whenever a great flood comes, it *branches off*, both in its deltaic stage and in the valley, by *redistributing its own water*, and *tries to prevent its own floods*. Even in pre-historic times, the Indus in Sind has westered as can be seen from the numerous Dhoroos found beside the ruins of towns (See the Map). According to Oldham, the Indus has wandered distinctly over the plains surrounding the Khairpur hills east of the present course; later on, the river water actually passed through the Aror gorge at least partially; and still later on and westerling further, it has acquired the stable conditions in the Bukker gorge, for the present. Bukker has been mentioned to be an important place only since the Greek period, being the residence of the Sogdi (See my "Historical Geography of Sind, Part II, p. 54).

RIVER TRAINING WORKS

To stop the river from leaving its bed, and to confine its flow within its banks, during the British period particularly, protective Bunds or earthen embankments with sand cores are built on both the sides. When a Bund is found risky, it is reinforced by a loop. Some of these are as long as 50 or 75 miles long, but they have no bearing on the varying hydrography of the valley. Again, it appears that although the engineers found that the river in places was trying to move westwards and they were constructing Bunds and loops one behind the other, there has been so far only haphazard improvement in these river-training works. *No comprehensive regional view* is taken of the propensities of the river, as a whole. Only a geographical examination of the region could disclose its maladies.

HISTORICAL EVIDENCE

The Indus has given the same kind of trouble to the people of Mohenjo Daro which was thrice and perhaps more times destroyed by its floods. The people went on raising the level of their dwellings, and the drains and wells were built on higher and higher ground, until it was once more wholly destroyed and the population migrated. Excavations had, therefore, to be carried out as deep as possible. So was the fate of Narujo Daro and also of Chanhudaro. So is the presence in Sind of mounds, containing precious archaeological relics, all repeating the story of the devastations caused by floods.

In historic times, great cities such as Aror, Patala and Debal have similarly disappeared. All this is due to the changing hydrography of this very awkward river. Even earlier than the Chalcolithic period and in the Stone Age, the river must have been more unbearable because of the floods and of

greater rainfall in Sind, of which there are distinct proofs. Settlements, then, were made in Kohistan proper on still higher levels, along certain perennial springs and streams such as, Naig and Badhni. The fact that these early Stone-Age settlements were not re-occupied, but that the Mancher lake area and later on the river valley itself were occupied shows that the hydrographical conditions in Sind were constantly changing. (See, N. C. Majumdar's "Explorations in Sind", pp. 145-154). Hence the instability of human occupations and human life in the entire valley for all ages. It is, however, to be noted that such catastrophes are also of common occurrence in other parts of the world, but the Sind conditions are rather peculiar as shown above.

TRIPLE THEORY OF SIND FLOODS

Thus, according to the nature of the earth in this region and based on the principles of physical geography, there are three chief causes of the Sind floods, which threaten the region at present:—

1. The westerling tendency of the river.
2. The rise of level due to silting.
3. The consequent corrosion, branching off of the stream and avulsion or short circuit.

1. *The Westerling Tendency of the River.*—This has been marked most prominently in the very area, which we are now considering. As the river is caught in its neck, so to say, in the Bukker gorge and the Sukkur Barrage, it has to take a deep curve round Rohri before it can wander away in almost a westerly direction to nearly 20 miles and then turn round another loop and move southwards. The same is the case with the river course above the gorge and to almost the same distance. *But for the gorge, the river would have assumed the shorter course which it has now been trying to take by pressing against the right bank and retreating through the Begari Bund and loop in the form of a flood.*

If the Indus once flowed, as it has been believed, in its course past Aror and Narujo Daro in Khairpur and the Nara Taluka in earlier times, then the westerly drift of the river in Sind can be reckoned to be about 30 miles. In Middle Sind, it can no longer move towards the west owing to the protrusion of Kohistan restricting its pattern, but again in Lower Sind and in the delta, the Indus has exhibited this westerly drift during the earlier periods, and now its tail is showing an easterly trend, but this is really due to the hydrography of the river in the deltaic parts being different from that of the upper areas. (For further information see my "Settlements in the Lower Indus Basin", P. 342 ff). An examination of the surface contours in this region also shows that there is a gradual east-west fall from 200 feet to 176 feet within 24 miles. This gives a gradient

of one foot per mile on the right bank and helps the river in its westerling process considerably. Even the wind for the greater part of the year and especially during the monsoon season blows from the south-east to the north-west and pushes the waves against the right bank.

2. *The Rise of Level in Sind.*—As stated above, the whole of the Lower Indus Valley is aggraded due to silting and the level has been steadily rising, owing to the deposit year by year, all throughout the ages. It is this continuous process of silting that is also responsible for the instability of the river course to a very great extent. Very patient research has already been done by the Indus River Commission since 1901, and it has been estimated that "the silt lost between Sukkur and Kotri during the 29 years amounts to about 35,000 million cubic feet". This is equivalent to about 1,300 square mile feet. Taking this as the data, I have calculated the total depth of the alluvial deposit, since the time of Mohenjo Daro (5000 years), as under:—

1 Square mile foot = 27.88 mil. cubic ft.
Loss of silt between Sukkur and Rohri
= 35,000 mil. cubic ft. in 29 years
= 1,206 mil. cubic ft. in one year
= 43.25 square mile ft. in one year
or 216,250 square mile ft. in 5000 years.

This on 6,000 square miles (the area of the valley portion) = 36 ft. And this nearly tallies with the total depth of the ruins reached by the archaeologists at Mohenjo Daro viz., 35 ft. The excavations could not be carried by them further down, owing to the rise of subsoil water.* Let us assume that deposition decreases uniformly from the river and is nil at the limit of area; then at river deposition would be double the mean, say 72 feet. Now as the Indus has moved through a wide area of the country, something between the two extremes is possible, that is 54 feet.

Thus, if in 5000 years the level has risen to 54 ft. the average rise per century is 1.08 ft. In the opinion of Mr C. C. Inglis, the present Director of the Central Irrigation and Hydro-dynamic Research Station, this historic rate is a fair estimate. *A foot per century* is, indeed, a good rise for the river to be extremely unstable. It must swing from one side to another, as R. D. Oldham has discovered, as time goes on. (For further particulars see *Jour. Asia. Soc. Beng.* 1886, Vol. LV, Part 2).

* Dr E. J. H. Mackay, in a trial trench which he got excavated to the lowest level that was possible in a specially selected locality, found the buildings of the site extending as far down as 42 feet below the datum line and yet not materially differing, in their archaeological character and age, from those found in the strata above. (See "Further Excavations at Mohenjo Daro"—1927-31—Vol. I, 1938, p. 44).

Raising the level of the soil on either bank, it often breaks away in a low ground on one side or another; and so, by degrees, it raises the level on every point. If this raised level, again, happens to be in a level with a gap anywhere, the water of the river at once finds an outlet through it, as it happened in the case of the Aror and the Bukker gorges. At times, slopes are smoothed off by floods and levels are lowered, so that there is no part of the valley which remains permanently the same. Such is the geomorphology of the region. Even the slightest obstruction, as a stone, would upset the normal flow of the channel. Impediments due to excessive silting near the very gates of the Barrage in spite of the dividing walls, are enough to upset the flow on the upstream side. It is a fact that whenever the gates are closed, enormous silt accumulates on the upstream side, though a portion of it is washed off during the next flood season. In recent years there has been much accretion gone undetected due to low floods. Human actions, such as cutting down of forests, constructing more and more canals which do not carry their share of silt etc., have helped many rivers to deposit silt and to raise their beds even upto 6 feet per century.

Here in this particular locality and so near the colossal Barrage works, the whole course of the Indus may not change; but the river is likely to bifurcate, as it has been doing during the course of centuries, near the Choi Canal, like the western Nara, thus depriving the Barrage of its usual quota of water. This is a very serious matter for the engineers to consider and the situation has worsened since the opening of the Barrage in 1932. A geographical survey of the region should have preceded its construction.

It may be stated in passing that due to this usual process of silting, formation of bars etc., the Indus delta is also growing continuously. From various historical data, I have estimated that the delta has grown by 36 miles on an average since the age of Mohenjo Daro. Today it grows only by about 4 yards per year. But even with such a deltaic growth it is not true to say that this prehistoric city was a sea port. It was definitely a river port many miles distant from the sea and was destroyed by floods. At the same time, this growing delta is also a continuous menace to the river discharges at places higher up.

3. *Possibility of a Cut-off.*—Reference has already been made to the regular processes of erosion of banks (degrading action) and deposition (aggrading action) alternatively in the meanders, the formation of ox-bow lakes, cut-offs, and consequent changes in the velocity of the current.

The most risky meander at present, which tends to suffer from an avulsion, is the big bend from Chak to Ruk, nearly 36 miles long, with the

Bukker gorge as its mid-point. (See the Map). This is bound to happen later on, if not now, if something is not done to prevent the cut-off along this chord about 15 miles long.

REMEDIES SUGGESTED

"Dig deep the ditch, keep low the dikes", says a Chinese proverb and it would be a folly if the level of the Bunds and loops is raised more and more with the rise of the river bed. It is essential to lower the bed by scooping as far as possible.

The readings of the Attock gauge in the Upper Indus valley should be depended upon and constantly watched; but at the same time, local factors, such as rainfall in the Lower Indus basin, highlands including, should make a great difference. Usually a rise of one foot at Attock is taken equal to 1 foot at the loop Bund after an interval of eight days. But below Attock and again locally in Sind, the river will also receive other streams and rain water and even the wind and wave action on the banks will be felt remarkably in the affected area. All this must be taken into account.

Since the most delicate part of the river course is the Chak-Ruk loop and since the Begari and Jhali Bunds and loops in all their crookedness already exist, the most effective remedy is to stabilise the river flow through the present channel. No half-hearted measures would do. By patient research at the Central Research Station, the river will have to be severely trained and the avulsion averted by means of (1) shock absorbers or reservoirs for absorbing overflow water above the Bukker gorge, (2) a system of revetment or levees on slopes made of boulders, (3) groynes or spurs for patting the current here and there, (4) good silt separators and (5) renewal of loops which are at present badly constructed. The sharpest corner near Chak, especially, needs consolidation.

No attempt at canalising the flood waters at any stage above the Barrage would be advisable, as Sind especially Lower Sind, cannot afford to lose any of them. She has struggled long with the Punjab Government to spare for her all the waters the engineers can for her own existing canal system and future projects. All the available quantity must be made to pass through the Bukker gorge at any cost, especially in the Rabi season, when the level is so low. Otherwise, the position of the Lloyd Barrage will be greatly jeopardised. For, after all, the locality selected for the colossal irrigation works has proved to be dangerous and the department has to combat with the river patiently in this locality.

Apart from the natural physical causes of the floods enumerated above, there are other minor ones due to the weakness of the Bunds and loops themselves. The first and foremost is the extreme fine-

ness and pliability of the silt and the sandy and porous nature of the building materials. There are also Kalar soils, which, because of the presence of the soluble salts in them, promote permeability. Animals like rats can burrow enormous holes in such Bunds, through which water can enter and widen breaches.

Alternate wetness and dryness of the sides due to the rise and the fall of the water level respectively, cause swelling and shrinkage of the Bund materials, resulting in cracks and fissures. These can be remedied only by replanning and reconstructing the Bunds.

CONCLUSION

The story of the Sind floods is the eternal story of the struggle between Man and Nature. What men try to do, Nature tries to upset. Men try to defeat

Nature by overcoming natural obstacles and handicaps but Nature then reasserts her power and gains mastery over them.

In regard to the prevention of floods themselves, it is not possible for our engineers to do anything to stop the first two causes, viz., the westering tendency of this mighty river and the rising of its bed by accretion. It is by studying other geographical aspects and treating the third malady of scouring and preventing an avulsion, with more solid and carefully planned river-training works, that it will be possible to avert the dreadful catastrophe of the river breaking once for all through the particular Begari loop region and the Barrage losing its share of the river waters, which are so precious, both in the Kharif and in the Rabi seasons. A thorough geographical survey is the most essential pre-requisite of all such engineering works in our country.

A TREK INTO LADAKH

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ONE of the most wonderful and unique things which India possesses is the Himalayas. Every year its charms lure hundreds of people from every corner of the world over thousands of miles. At least three nations of the world have made elaborate and concerted attempts to conquer its peaks. To the ancient Hindus, Himalayas was not simply charming but holy and for thousands of years they regarded its sublime heights as the abode of Gods. Modern India knows very little about the Himalayas, even as about the rest of India. The spirit of travel and adventure—a dominant aspect of the present youth movement in modern nations of the world is altogether lacking in this country. Lots of serious minded people brush aside this question as of no consequence, but it is a matter which has a profound influence upon character and mental attitude, the need for the development of which along right lines, no thinking person in India can deny.

During the summer of 1942, a few members of the University Chemical Laboratories, Lahore planned and undertook a trek into Ladakh. The purpose of the trek was partly scientific, namely the collection of scientific materials particularly indigenous medicinal plants and minerals, though deep in their minds was the irresistible lure of the Himalayas. Starting in the first week of August from Srinagar, the party trekked part of the way along the Treaty High Road *via* Ganderbal, Son-

marg, Zojila, Dras, Kargil and penetrated deep into the country of Ladakh. The present article is based on their observations and experience.

Ladakh is a large tract of mountainous country in the east of Kashmir, lying between 73° to 80° East and $32^{\circ}5'$ to $36^{\circ}5'$ North where the routes from three great Empires, India, China and Russia meet.

It is a plateau with extremely small rainfall, the first and the second ranges of the Himalayas acting as barriers for monsoon which brings rain all over India. As one crosses the Zojila, a pass through the second Himalayan range which separates the fertile valley of Kashmir from Ladakh, the change is rather striking. From the top of a hill in the pass one can see the verdure of the Pine and Fir covered slopes of the Sind valley on one side and the barren ruggedness of Ladakh on the other. This scene is continued as one rounds one hill after another across the pass or crosses the mountain ranges which lie across the heart of Ladakh. Three of these great ranges the Karakoram, the Kailash and the Zaskar, run almost parallel to each other covering the surface area of Ladakh. Valleys of the great Shyok river and the Indus separate these mountain ranges.

Zojila, a beautiful narrow pass, is the gateway to Ladakh. It is some ten miles in length offering views of rugged snow clad peaks, a few camping grounds by the side of gentle springs and streams

August, 1943

A TREK INTO LADAKH

which only later develop the nature of stormy torrents. The narrow pass is often visited by cold piercing winds even in summer. Beyond the pass one enters imperceptibly into the country of Ladakh beginning with the beautiful valley of Dras.

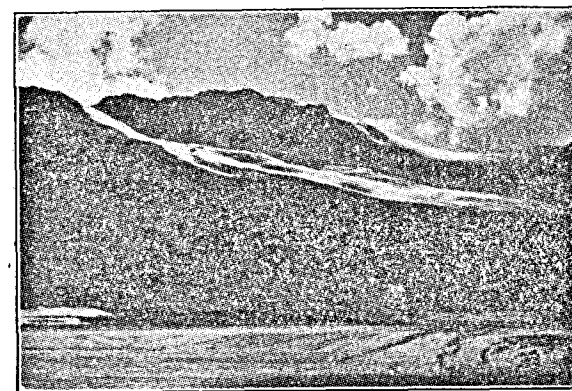


FIG. 1. BEYOND ZOJILA.

Dras, after the difficult ascent and the way through the pass, gives the impression of an oasis set in a desert of rugged granite peaks and ridges. It is a long valley studded with numerous villages, a couple of miles apart, surrounded by fertile fields of barley and buck-wheat and inhabited by a gentle folk. The flowing fields are irrigated by carefully built and carefully maintained channels of clear sparkling water and in the middle of August the crop begins to ripe. By the side of the fields in small enclosures stand the Zho, a hybrid animal between the cow and the yak, which plough these fields. Beyond the fields on the gentle slopes graze herds of sheep and beyond that are the red, brown and chocolate hills, standing out in peaks and ridges in great beauty and splendour. Still beyond are the mountain ranges sprinkled and capped with snow rising to heights of 17-21 thousand feet. It is said that in the lower hills, the markhor, ibex, red bear, wild sheep and the snow leopard live. They are much looked for by adventurous sportsmen but hard to find.

During the summer day in the valley the thermometer registers some times 100° but it is cool in the shade and the nights are cold. The village homes are built of mud and stone, plastered with mud from within and without. They are small and dark, to keep out cold in winter and darkened still further by the soot from dung fires. In a corner stand sacks of barley and in another is a small raised platform where the family eats and sleeps. Among the cooking utensils is a big wooden churn in which butter tea is made. Tea, milk, butter, sugar and salt are mixed together and churned in a long

wooden cylinder with a wooden rod. A thick emulsion is finally obtained which is a valued drink.

In these homes live simple folk, well-built but somewhat short, and of Mongolian feature with high cheek bones, slanting eyes and scanty hair on the face. They are of Tibetan stock; cheerful, honest, and willing to work. They are gentle and carry heavy loads to great heights and in the face of severe cold.

This is the impression one obtains of the valley of Dras and its simple life. It is a valley easily accessible but disturbed only by a telegraph wire, a postal service and an occasional visitor from the outside. It has a primary and a middle school. Some of the people of this valley have visited Srinagar, the capital, but majority of them remain innocent of the machine, the electric current and the railway train, the symbols of modern civilization.

Beyond the Dras valley one travels again through the multicoloured, rugged, rolling hills, by the banks of noisy torrents, some 35 miles east to the valley of Kargil. This valley is somewhat narrow and small but full of orchards of apricot, mulberry and apple. The apricot ripen in August, are small reddish orange in colour and exceedingly sweet.



FIG. 2. A WANDERING LAMA.

Kargil, one of the three *tahsils* of Ladakh, the other two being Leh and Skardu, is situated somewhere near the centre of the district and is a busy centre of trade. Salt, tobacco, sugar, tea, cotton goods, wool and furs pass through this place up or down.

Further down, the character of the country changes. A sandy plateau is passed and the path goes up and down ravines. It passes largely

through barren country, sometimes stony, often sandy and through villages with old historic monasteries, till one reaches Leh, the capital of the district of Ladakh. The capital is situated in the Indus valley at an altitude of some 11,000 ft. and has a characteristic beauty of its own. It is even a more important centre of trade where routes to Yarkand, Tibet and Turkestan meet. The most striking feature of the capital however lies in its being a centre of Lamaism. This cult seems to be a compromise between Buddhism and the demon worship. Every Ladakhi is anxious to keep away the evil spirits and many antidemon devices are painted on doors or hung from the tops of the houses. Even in the monasteries where the Lamas live long poles are fixed from which hang streamers of Yak tails and other things potent against the demons. Lamas are both the priests and the doctors of the people.

Such is briefly the character of Ladakh—the highest inhabited district of the world, bigger in area than the States of Jammu and Kashmir combined but with a population under 200,000—barren, desolate and utterly devoid of verdure and vegetation, nevertheless with peculiar charm of its own. This lies in its brown, red and chocolate hills, the lofty tops and ridges of its mountain ranges capped with snow, its sandy plains and plateau, and its characteristic valleys with wild roses and scented herbs. It is a charm which once experienced can never be forgotten. It leaves on the mind an im-

pression of grandeur and beauty which is at once elevating and inspiring, making one feel so different after the experience. It is an intimate experience of the immensity of things in Nature.

It will be of some interest for travellers in these parts to describe a route to the top of Amar Nath which has not been described in books written on Kashmir and its mountains. The route branches off from the Zojila pass, a mile and a half beyond Machoi, eastwards along the Sukhnala ravine. About five miles are covered up the ravine, first two on the right bank and then three on the left, after crossing a snow bridge. Right in front one has a magnificent view of the Sukhnar peak. The route then sharply turns south along the Kinnala ravine which soon widens out into a beautiful valley. A distance of 4 miles brings one to the bottom of a glacier which can be climbed along its right bank. It is an exceedingly steep climb of about two miles to the ridge touching the edge of the vast glacier, some five miles in length three miles in width lying north-east and south-west, over 16,000 feet above sea level. The glacier can be easily crossed at its waist and on the other side about two thousand feet below is the frozen bed of Amarganga, five miles down the right bank of which lies the temple of Amar Nath cave. The mighty glacier so easily accessible, offers splendid opportunity of mountaineering and snow climbing. It has many branches with peaks of mountains butting out, some of which are exceedingly difficult to climb.

Notes and News

BOARD OF SCIENTIFIC AND INDUSTRIAL RESEARCH

It appears that the second paragraph of our Editorial on "Proposal for reform of the Government organisation for Scientific and Industrial Research" in the July 1943 number (Vol. ix, No. 1) of SCIENCE AND CULTURE has given rise to some misunderstanding. We are aware that the Board of Scientific and Industrial Research has done work of considerable value for the supply of materials needed for purposes of war and that many small scale industries have been developed or established as a result of the researches carried out under the auspices of the Board. We intended, however, to convey the impression that so far as organisation of industrial research on a long range plan is concerned, the Board within the three years of its existence had not been able to accomplish much. We intended also to stress the need for establishing at a very early date, National

Research Laboratories to tackle fundamental industrial problems in the country:—for example, National Physical Laboratory, National Chemical Laboratory, National Metallurgical Laboratory, Glass Research Institute, Radio Research Institute, etc. We regret, if our emphasis on the need for this latter kind of long range development may have created the impression that we are unmindful of the valuable investigations which the Board has carried out especially in relation to war work.

The columns of SCIENCE AND CULTURE are always open to any just criticism of the views expressed either in editorials or in contributed articles, and we shall welcome expression of such views from our readers.

BUDGET FOR SCIENCE

MR P. DUNSHEATH, Chief of the Research Department of Henley's Telegraph's Works, has given an

idea of the amount of national income being spent on industrial research in U. S. S. R., U. S. A. and Great Britain during his recent lecture on industrial research before the Royal Society of Arts. He has shown that of the three leading countries mentioned U. S. S. R. alone has so far come forward with something like a generous fund for the promotion of scientific and industrial research in the country, her budget estimate for science being ten times as great as that of Great Britain. Thus the Soviet Union's budget for science amounts to one per cent of the national income, while U. S. A. and Great Britain spend only three-tenth and one-tenth of one per cent of their national income respectively. These are precisely the percentages supplied also by Prof. J. D. Bernal in his book "The Social Function of Science" in which he has placed the Soviet budget for science in 1934 at about one thousand million roubles. It is needless to point out that in the present age of science and technology a country's progress can be fairly judged from the extent of fund available for scientific and industrial research. Scientific research in the industrial laboratories has now become a potential factor in ensuring the economic progress of a country. The electrical industry in Great Britain is reported to have spent of late at the rate of £1,000,000 a year. The creation of the Department of Scientific and Industrial Research to initiate research on a national scale has marked a new era of technological progress in Great Britain. Mr Dunsheath has, however, criticised the insufficiency of the funds available for research, which should be increased several times if the full value of research for industrial development is to be realised and further referred to the deplorable lack of contact and co-ordination between the various research organisations, which is in the main responsible for 'the gap between discovery and application' and the unnecessarily 'long period which elapses between the birth of knowledge and its availability for use.' It is to be noted that such criticisms are not new and have recently been recorded on several occasions. Their repetition only goes to confirm the fact that the inadequacy of budget for science and the lack of proper co-ordination have now become a matter of undisputed public opinion which cannot be ignored or lightly dismissed any longer.

AGRICULTURAL RESEARCH IN BRITAIN

THE report of the Agricultural Research Council, of which a short summary has appeared in the *Economist*, February 20, 1943, has produced a useful survey of the recent progress in agricultural research in Great Britain and has outlined the details of the research programme now being carried out in various subjects. The Agricultural Research Council is the central Government organisation created under the Lord President of the Council along with two other

bodies, namely the Department of Scientific and Industrial Research and the Medical Research Council, with which it maintains a close contact. The Council helps the Ministry of Agriculture and the Scottish Agricultural Department in propagating useful knowledge and experience gained from research among the cultivators. It also provides grants to the universities and agricultural colleges for the training of young scientists and the promotion of agricultural research. The Council is further responsible for the organisation and co-ordination of a large number of research institutes which are mostly independent bodies financed by Government grants. Mention may be made of the Rothamsted Experimental Station, the East Malling Research Station, and the various research stations and institutes at Cambridge, all largely depending on the Council for general policy and direction. The research programme initiated by the Council comprises the study of various subjects, such as soil fertilisers, crop physiology and husbandry, plant breeding and genetics, grassland management, animal nutrition, dairying, storage and processing, pest control and forest products. The Agricultural Research Council has been instrumental in instituting recently a national wire-worm survey to combat this veritable pest which is calculated to have brought about a loss of 250,000 tons of food in each of the three years of war. Active steps have already been taken to bring the pest under control.

The war-time problems relating to increased productivity and the control of pests and diseases in crops and animals have now occupied the major portion of agricultural research, as the food front is of no less strategic importance in the ultimate decision of the war. However, the post-war agricultural problems have not been completely relegated to the background. The Agricultural Economics Research Institute at Oxford has recently carried on a preliminary survey of the existing conditions of farms and field boundaries and the farming methods and found several antiquated farming units where none of the facilities of the modern agricultural practices exist. A more thorough survey is urgently needed in the immediate future to devise ways and means to introduce modern farm practices and also to consider the possible physical and social changes which such agricultural reforms might entail. It is stated that the Institute is already planning to undertake sample surveys in specific areas.

THE BETATRON

THE betatron or induction accelerator, developed by Professor Donald W. Kerst, of the University of Illinois, has opened up new possibilities of research and investigation before the physicists as well as the medical men. The betatron is a compact apparatus of the size of an office desk with a control panel,

condenser bank and a motor generator. In fact, it is smaller than many X-ray machines of considerably less voltage and requires about the same amount of power. The flexibility of output energy is perhaps one of the most important improvements the induction accelerator has undergone. The electrons leaving a gun or injector circulate about the dough-nut-shaped vacuum tube and are accelerated by the increasing flux linkage produced within the orbit by the alternating current. The beam can be directed against the X-ray target at any stage of acceleration. The electrons make as many as 200,000 revolutions, while the magnetic field increases from a very small value to its peak value. The original betatron designed and built at the University of Illinois had an output energy of 2.3 million volts. Soon after Dr Kerst introduced some important modifications in the design and constructed the 20 million volt betatron at the General Electric Works, which is the most powerful betatron so far constructed.

The new atom-smashing apparatus, as Professor Kerst himself reported to the Radiological Society of North America in its recent meeting, bids fair to be a very powerful instrument at the hand of medical men in their campaign against deep malignant tissue for which no suitable therapy was available until recently. High voltage X-ray machines working at about 400,000 volts, have been in use for deep therapy in recent years. The disadvantage of the X-ray methods consists in the complete penetration of the radiation with the consequent damage done throughout the tissue. For this purpose high energy electrons from the betatron capable of required penetration are made use of. Destructive effect over the length of penetration is, however, present even in the case of electron beam, but it is hardly serious.

Actual experiments with living tissues have not yet been performed; but preliminary and indirect experiments regarding the penetration of the electron beams through material equivalent to tissues in absorbing powers have been carried out by Dr Kerst and his associates, Phillip Morrison and H. W. Koch, with varying degrees of success. From these experiments it is expected that the maximum effect will probably be produced within a few inches below the surface of the body. In the present X-ray therapy with 400,000 volt machine the effect is mainly located at the surface. So far the betatron has been capable of producing 20 million volt electrons which are calculated to effect a maximum penetration of about 10 centimeters (nearly 4 inches) below the surface of the body, and a generation of 25 or 30 million volt electrons, ideal for the treatment of malignant tissues, does not appear improbable in the near future.

It is of considerable interest for the physicists to note that the betatron promisingly lends itself to the

study of interesting problems, such as the nuclear photo-effect and the interaction of electrons and photons with matter. It is known that a neutron can be removed from the nucleus of an element by the photo-disintegration process as a result of impact due to a high energy X-ray or photon. Betatron may make available definite knowledge about the exact threshold energy at which the photo-disintegration of the nucleus sets in and about the masses of the new nuclei formed, and may prove an important source of neutrons of variable energy. Betatron has further made possible the generation of high energy electrons of the order of 20 million electron volts, so far available only from cosmic rays and radio-active substances, and as such problems associated with high energy electrons can be henceforward more conveniently studied.

PYRETHRUM CULTIVATION IN INDIA

A REVIEW of the recent attempts to introduce the cultivation of pyrethrum in India has appeared in a recent issue of the *Chemical Age*. The Imperial Council of Agricultural Research first thought of introducing the crop into India in 1937 and accordingly obtained seeds from the India Office for distribution among different provinces and States. The Council obtained further seeds from Dalmatia at the beginning of 1940. Experiments carried out with these seeds in different agricultural departments to ascertain the climatic conditions suitable for its cultivation have been attended with varying degrees of success. Certain parts of India offer climatic conditions under which the cultivation of pyrethrum is considered promising. Thus the Punjab, Assam, Kashmir, certain parts of Nilgiris and N. W. Frontier Province have been found to be suitable places to encourage its cultivation. Bombay, United Provinces, Sind and Mysore, however, appear unsuitable. It has been found in general from the experiments performed so far that the cultivation of pyrethrum can be successfully undertaken in India at places lying at an altitude of about 4,000 feet and above and having a comparatively dry climate and a well-drained light soil in which the crop grows best. Already in some places yields have amounted to about 400 lb. of dried flowers per acre.

The pyrethrum content of the flower samples from different parts of India has been examined and analysed. Kashmir and the Punjab samples contain '95 and '96 per cent of pyrethrum respectively. The pyrethrum content of samples collected from N. W. Frontier Province varies from '61 to 1'11 per cent. Samples obtained from Assam, however, indicate the best percentage so far as Indian varieties are concerned. Pyrethrum content in Indian varieties still falls short of the level of pyrethrum concentration in samples obtained from Kenya or Japan. This is,

however, hardly discouraging in view of the fact that its cultivation is still in its infancy in India and that there is yet enough scope for improved cultivation. Hopes are already entertained that Assam samples with little more improvements in their cultivation may be able to compete with those from Japan and Kenya in not very distant future.

THORIUM IN THE SUN

DR CHARLOTTE E. MOORE, of the Princeton University Observatory, and Dr Arthur S. King, of the Spectroscopic Laboratory at Mt. Wilson, have recently announced the discovery of thorium in the sun, according to a news appearing in a recent issue of *Science*. Search for thorium has been continued with great interest since 1938. But the discovery was not so long forthcoming on account of a lack of suitable knowledge regarding the spectrum of this radio-active element, which has become recently available through experimental work done in the laboratory under varied conditions of temperature and magnetic field strength. The ultimate lines *i.e.*, the strongest lines of the element, which can be most easily produced in the laboratory, have been carefully studied and are now known with exactitude. The existence of thorium in the sun has been confirmed by the recognition of some of the ultimate lines of this radio-active element. Thus the strongest ultimate line of thorium has been identified with a faint line in the solar spectrum, which could not be so long accounted for. It is to be noted, however, that the line in question is characteristic of ionised thorium. Some other strong lines of the ionised element have also been tentatively identified, and yet there are several others which could not be found in the solar spectrum owing probably to the lack of intensity. The results therefore amply indicate the presence of thorium in the sun in the ionised state.

It was further observed that two of the strongest lines of neutral thorium coincided in wave-length with the lines of the solar spectrum. If the observed lines of the solar spectrum are really due to neutral thorium atoms they are expected to gain considerably in intensity in the spectrum of the sun spots which should contain a greater proportion of the neutral thorium atoms on account of the comparatively low temperature of the sunspots. Failure to observe this increased intensity of the lines in the spectrum of sunspots, however, led the investigators to declare such coincidence accidental and so far without significance.

CRYSTALLINE LIMESTONE DEPOSIT NEAR SANKARIDRUG

A REPORT of the study of the crystalline limestone deposits in the vicinity of Sankaridrug in the Salem district, as undertaken by M. S. Krishnan,

of the Geological Survey of India, has recently appeared in a leaflet issued from the Geological Survey of India. The investigation was taken up in 1939 for the purpose of ascertaining whether there was enough high-calcium limestone in the area to supply material for the manufacture of bleaching powder. The limestone occurs in a series of nearly parallel bands and stretches from Manjakkalpatti and Devakkavundanur on the north-west, through Vettuvateruvu, Avarangalpalaiyam, Kulakkarundanur, Mavelipalaiyam, Pachchappatti and Annadanappatti towards Chettipatti and Kolikkalnatham on the south-east, as revealed from investigations of Dr Krishnan.

The total quantity of limestone expected from this area has been roughly estimated at about 100,000 tons. The estimates, in the present investigation, refer in all cases to an assumed depth of 10 ft. from the surface, though there is every possibility that the deposits extend to at least a depth of 50 ft. The work was more or less of the nature of preliminary prospecting, collections being confined only to more important exposures and it was not possible to undertake excavations necessary for detailed prospecting. The above figure therefore represents the most conservative estimate, and it may be safely asserted that detailed prospecting will indicate a far greater reserve of limestone than is known at present.

In order to test the quality of the limestone deposits some 65 samples were collected from various parts and subjected to detailed analysis carried on mostly by the Agricultural Chemist at Coimbatore in the laboratories of the Geological Survey of India and Imperial Chemical Industries (India) Ltd. The results of the analysis have been given in the form of tables along with the report. The majority of the samples analysed indicate a very high percentage of calcium carbonate and small amounts of impurities. In twenty-two cases the content of the magnesia is higher than 2 per cent. The insolubles and ferric oxide are also consistently low in most cases. About fifteen of the samples possess a composition unsuitable for the purpose in view.

The analysis of the limestone samples collected from the Iveli-Annadanappatti area shows that there is suitable material for the manufacture of bleaching powder, though more detailed prospecting is necessary to ascertain which of the bands are more suitable and more uniform in composition than others. There is little doubt that the quantity is enough for a moderate production over a period of several years. Being close to the railway and to an important road the area is favourably situated so far as transport is concerned.

POTASH SUPPLY

THE war emergency has brought about profound changes in the supply of potash, an important ferti-

liser. As a result of these changes, as the *Economist* has recently pointed out, Germany now fails to command the monopoly in the supply of potash, which she used to wield until 1919, the direction of the supply gradually turning decidedly in favour of the Allied countries. The development of new sources in the United States, Russia, Palestine, Spain and some other countries which have become important producers of potash in recent years followed the impetus created in the last World War which found the Allied countries in considerable difficulties with regard to its supply. The new Russian deposits in the Urals appear to constitute the most important source, but the Palestine deposits (the Dead Sea) are probably the cheapest to exploit. Notable changes have taken place in the potash supply of the United States which has now become an exporting country, though, a decade ago, she was the largest importer of this fertiliser. The present U. S. production of potash is mainly concentrated in California, Maryland, New Mexico and Utah, and is estimated at 986,458 short-tons of crude salts with a K_2O content of 524,875 for the year 1941, according to the statistics published in the U. S. Bureau of Mines. The rapidity of the U. S. potash production is reflected in the fact that the output rose from under 5,000 short tons of crude potash salts with K_2O content of under 2,000 tons in 1915 to 534,945 short tons containing 316,951 tons of K_2O in 1938. By 1940 the U. S. potash production scored a level of production fairly greater than her requirements, leaving a surplus for export. This increased Allied production, besides having an important bearing on the final issue of the war, is destined to play a vital role in the promotion of international agriculture in future.

BIOGRAPHY OF SIR P. C. RAY

THE Editorial Board of 'SCIENCE AND CULTURE' proposes to undertake the publication of an authoritative biography of Sir P. C. Ray. Within the active period of life extending up to sixty years he was connected with numerous educational institutions, relief organisations, industrial concerns and nation-building works and public bodies. He has delivered addresses on education, industry and on different aspects of national problems and nation building. He has written illuminating letters to private persons which have an abiding interest. These materials are of great value in the compilation of the biography. We shall be glad if the copies of his addresses, lectures and other information are kindly sent by our subscribers and others. Due acknowledgments will be made of them in the biography. These will be returned after the publication of the biography is over. A separate section in our office is in charge for storage and safe custody of all such materials.

ANNOUNCEMENT

We offer our hearty congratulations to Prof. J. N. Mukherjee, D.Sc., F.N.I., F.C.S., F.R.A.S.B., on the occasion of the conferment of the Birthday Honour of the Commander of the British Empire, Prof. Mukherjee has made fundamental researches in Physical and Colloid Chemistry and Soil Science and is one of the earliest leaders in the study of Colloid Chemistry in India. He has created an active school of Colloid Chemists and Soil Scientists in the University College of Science, Calcutta. The distinction though long overdue is a fitting recognition of his scientific work.

SCIENCE IN INDUSTRY

DUCTILITY OF LOW-ALLOY STEEL AND HIGH-STRENGTH ALUMINIUM ALLOY

THE development of low-alloy steel and high-strength aluminium alloy has called the attention of engineers to the somewhat lower ductility of these materials as compared to carbon steel. They generally have higher ratios of yield strength to ultimate strength. This is the field of inquiry approached by Leon S. Moisseiff, E. C. Hartmann and R. L. Moore in a paper appearing in the January "Proceedings" of the American Society of Civil Engineers. The title of the paper is "Riveted and Pin-Connected Joints of Steel and Aluminium Alloys".

Apprehension has been felt that differences in physical properties would affect the distribution of stresses in members built of low-alloy steels and high-strength aluminium alloys, especially at the connection. This belief is reflected by the fact that in some instances organizations responsible for design specifications have set an upper limit for their ratio of yield strength to ultimate strength. In recent years substantial advances have been made in the metallurgy of metals and in the production of numerous metallic alloys of various physical qualities. This development has led engineers to scrutinize the meaning and value of the information obtained from

the commonly accepted standard tests. Parallel queries have also developed as to the significance of terms commonly used in classifying such metals. For example, is there a true elastic limit? What is the true meaning of yield strength? What is ductility and does elongation determine its value? How much ductility is needed for a given purpose and what is its value?

The approach of the investigators to an answer to these questions involved a programme of tests of riveted and pin-connected joints with five metals, two of them being steel and three aluminium alloys. These tests had a fairly wide range of ductility and ratios of yield stress to ultimate strength. The most significant conclusion advanced is that the behaviour of all the large riveted and pin-connected joints was entirely consistent with the basic function generally made in design. Although inequalities in load distribution between multiple rivet rows were clearly indicated within the elastic range, this distribution apparently had no bearing upon static ultimate strength whether failures occurred by shear in the rivet or by tension in the plate. The amount of plastic yielding necessary to level off high-strength concentration and to effect a uniform distribution of load among the rivets was noted to be relatively small. Essentially, the same behaviour was obtained for all the different combinations of the materials investigated.

SYNTHETIC BRISTLES FROM NYLON

THE *Scientific American* reports in its February issue the successful preparation of synthetic bristles from tapered nylon, which have the taper, resiliency and toughness of the natural product. The development of a synthetic bristle material which can replace the natural variety engaged the attention of chemists for nearly twenty-five years, in course of which chemists are reported to have tried every type of resin material for the purpose. The suitability of nylon was at last realised in 1938, and since then it has been used in most of the quality toilet brushes as well as brushes for 22 different kinds of industries.

Five years ago the Du Pont Laboratories initiated research in the preparation of synthetic bristles and specially concentrated on the development of tapered nylon for the manufacture of paint brushes. Unlike spinning a level filament of tough, resilient nylon, the spinning of a tapered nylon appeared to be an extremely difficult task, and all kinds of ingenious spinning devices proved abortive. Continuous nylon filaments were spun by drawing them from a special spinneret at a controlled variable speed. After spinning, nylon filaments require to be drawn to several times their length to impart strength and resiliency to the filaments. The technique involved

in the drawing of the tapered filaments to several times their length without snapping them at the thinnest sections resulted from intensive research carried on for months together. Methods for conditioning the filaments, necessary to prevent the appearance of curls, bugs and kinks, and for automatic sizing of the same have been successfully developed. It is claimed that the tapered nylon bristles wear at least three times longer than natural bristles. In fact, the synthetic preparation has proved a superior material in respect of various properties and is already meeting large demands, military as well as civil.

MAGNESIUM PRODUCTION IN ITALY

THE Italian technicians have recently developed a new technique for the production of magnesium from dolomite, the double carbonate of magnesium and calcium, in whose supply Italy enjoys a very favourable position. Though she commanded unlimited supply of dolomite, production of magnesium in Italy was hardly satisfactory until recently. The development of new and improved methods has now enabled her to reach an important industrial level of production and meet her entire war-time demand for the metal.

Italy is not very favourably placed with regard to her supply of coal. This had forced her to utilise the native lignite as fuel, which is now being used with considerable success. The reduction of magnesium oxide, obtained after preliminary calcination, to the magnesium metal at first offered great difficulties. The use of coal as a reducing agent appeared unsuitable, as it necessitated the operation to take place at high temperature, such as 1100°C at which the metal is diffused in the gaseous state and is condensed only with difficulty. The Italian technologists, notably Dr Huigi Amati, made a significant advance by suggesting the use of aluminium, calcium carbide, ferrosilicon etc. as reducing agents and ultimately employed ferrosilicon in their process. The mixture is heated under vacuum in electric muffle furnaces at 1300°C. Metallic magnesium is set free from the mixture in the gaseous state and is condensed in the form of a compact crystalline mass. The mass is collected by mechanical blowers under heat, a process which prevents reoxidation of magnesium by atmospheric oxygen, and is melted down in electric furnaces to be finally collected in ingots.

Magnesium metal is obtained in this way in an exceptionally pure form. The percentage of impurity in the ingot metal amounts to 0.035, while it is only 0.0104 in the crude magnesium metal. Such purity of the magnesium metal is largely responsible for the superior quality of the extra-light alloys produced from magnesium, that are now being

manufactured in Italy. The first plant operating according to the Amati process, as the method is now called, was located near Bolzano in the Tyrol. The method has recently received further investigation in relation to its applicability to raw materials and conditions different from those which led to the construction of the Bolzano plant.

USE OF LACQUER IN STRAIN ANALYSIS

THE use of brittle lacquer coating on the surface of a stressed member for the determination of induced strains represents a novel departure from the usual common methods of strain measurement. The first recognised work on the use of brittle coatings was made as far back as in 1932 by O. Dietrich and E. Lehr. ("Des Dehnungslinienverfahren", *Zeit. Ver. Ing.* v. 76, 1932). Their work was purely qualitative in showing the areas of highest strain and pointing to the direction of principal tension. It was only in 1937 that work on the quantitative determination of strain values was started by A. V. deForest, G. Ellis and others at the Massachusetts Institute of Technology, which has resulted in the formulation of this new brittle lacquer coating device, termed the "Stresscoat" method.

The technique of this method consists in spraying an under-coating and 15 minutes later the lacquer coating proper over the surface of the part to be analysed and allowing it to dry "for about 5 hours. After the drying is completed, if the part under investigation is slowly loaded, it is found that cracks start appearing on the lacquer surface, which follow the direction normal to the principal tensile strain. If now the loads are reduced, further cracks start appearing but in a direction at right angles to the former. These represent cracks due to the induced compressive strains. Thus when the part of the specimen under question is brought back to its original condition (*i.e.* no stress being present) two sets of isostatics can be observed over the coating, one set indicating the zones of tensile strain and the other set, zones of compressive strain. The cracks first appear at the points of maximum strain and go on developing as the other points on the structure reach the same maximum strain. By following their order and spacing, and then comparing them with a member of known stress distribution, which is generally a calibrated specimen of a cantilever beam, values of the actual strains within 10 per cent can be obtained the accuracy depending on the efficiency in spraying the lacquer and in the actual observations taken.

Regarding the quality of lacquer to be used, wide variations are presented, out of which the ideal is one that adheres properly to the structural part to be tested, does not crack with slight changes in temperature and humidity, gets brittle on hardening after about 4 to 6 hours, ruptures at a strain below the yield point of the specimen under investigation, and dries "bubble-free" without the necessity of heating the coated surface. Experiments have indicated that for strain measurements within the elastic range, a good lacquer coat should require at least 3 hours to dry before any strain indications of the value of 0.0020 inch per inch can be obtained on an average coating thickness of 0.0045 inch. In the case of large structures the coat is applied on small scale models of bakelite or lucite or any one of the several synthetic resins. Such models reduce the testing cost considerably and because of their low modulus of elasticity in relations to the limit of proportionality, reveal a larger area for analysis and a corresponding larger number of isostatics as compared with their prototypes. In applying lacquer to these photoelastic models, no intermediate coating is required. However, before the isostatics are photographed in a polariscope, the model is washed with a solution of oil and gasoline or sometimes with gasoline only. As a good lacquer coat does not crack for strains below 0.00050 inch per inch this method of analysis is not applicable for very small strains. In a bakelite model, it is found from calculations that this minimum strain figure corresponds to a minimum stress value of 500 lbs./sq. inch.

The brittle lacquer coating method of strain analysis, because of its simple nature, absence of complicated apparatus, and nondestructive type of test, is found to succeed invariably for any 3 dimensional problem in the elastic range where other methods have either failed or proved too costly. The only field that remains to be fully investigated is in the use of these coatings in the plastic range *i.e.*, where the stresses exceed the yield point of the material. The experiments carried out in this range of stress, only reveal that the lacquer coating flakes off as soon as the yield point is reached, the initiation of this flaking being assumed to be directly correlated with the amount of compression strain present and independent of the nature of loading. Additional work is still necessary to bring this subject in a line with the ones in the elastic range in order to enable further progress in strain analysis to be made. Such a line of investigation is now being followed at the Massachusetts Institute of Technology.

S. K. G.

VACUUM FUMIGATION—A NEW TECHNIQUE OF PRESERVING RECORDS

S. CHAKRAVORTI

IMPERIAL RECORD DEPARTMENT, NEW DELHI

INTRODUCTION

INSECT infestation is frequently a problem of considerable importance in the storage of commodities. In order to protect stored commodities from the depredation of insects and fungi the high mobility of a gas is taken advantage of and four methods of fumigation are generally practised: (1) The general large scale fumigation of warehouses and mills, (2) bin fumigation, (3) vault fumigation and (4) vacuum fumigation. Each method is adapted to a certain type of work but in connection with the preservation of records only the methods of vault and vacuum fumigation need be discussed in detail.

TEMPERATURE

It is desirable to maintain a fairly high temperature in the vault or chamber during the period of fumigation. Insects are not active at temperatures below 60°F and they become more or less dormant at 50°F or below. In the dormant state it is extremely difficult to kill them with fumigants. At 75°F they are active and their susceptibility to the gases increases as the temperature rises. For good results a temperature of at least 75°F, and preferably somewhat higher, should be maintained throughout the fumigation. The temperature need not ordinarily be higher than 120°F (49°C).

CHOICE OF A FUMIGANT

In choosing a fumigant all factors must be considered. If a building or chamber is modern and almost gas-tight, several fumigants can be used with success and a choice is governed by such items as cost, efficiency, availability, safety and effect upon the commodity to be fumigated. If the building is not fairly air-tight it will be difficult to maintain a strong concentration of any gas for a long period and only a quick-acting gas will be effective. HCN is the only gas available that will kill quickly, but its use is limited by its extremely poisonous character to human beings as well.

The quantity of a fumigant to be used will vary according to the length of exposure, the temperature, the tightness of the room, the amount of absorption and adsorption by the commodities to be fumigated and by the walls and floor of the room itself, and to the specific immunity of the insects to be extirpated. The shorter the exposure, the lower

the temperature, the greater the adsorption; and the more resistant the insects, the greater must be the concentration of the gas used.

The following fumigants at the concentrations stated below are 100 per cent effective in killing all storage insect pests within 24 hours and have no deleterious effect on paper, ink and other record components:

Fumigant	Concentration per 1000 Cu.ft.	Price in U. S. A.
1. HCN	from 1 lb. of NaCN <i>i.e.</i> 288 c.c. liq. HCN	NaCN @ 20 cents per lb. in 100-lb. lots. Liquid HCN @ 5s. 3d. per lb. in 75-lb. net cylinders <i>f.o.b.</i> Durban.
2. CS ₂	6 lb.	6 cents per lb. in 500-lb. lots.
3. Ethylene Chloride-Carbon tetrachloride (3:1 by wt.)	14 lb.	6.44 cents per lb. in 590-lb. lot contained in 55-gallon drums.
4. Carboxide <i>i.e.</i> Ethylene Oxide-Carbon dioxide (1:9 by wt.)	30 lb.	16 cents per lb. in 30- or 60-lb. cylinders.
5. Ethylene Oxide	2 lb.	42 cents per lb. in 75- or 195-lb. lots.
6. Methyl formate-Carbon dioxide	28 lb.	10 cents per lb. in 60-lb. lots.

Ethylene Oxide as a Fumigant.—In the vacuum fumigation of records a mixture of 1 part of Ethylene oxide and 9 parts of Carbondioxide by weight has been found to be the most suitable because of the non-inflammability of the mixture and specific toxicity for insects. So this will be dealt with in detail.

Ethylene oxide is made from Ethylene chlorohydrine (CH₂OH.CH₂Cl) and KOH solution. At the ordinary temperatures it is a colourless gas; at low temperatures it is a mobile colourless liquid boiling at 10.5°C. The specific gravity of liquid Ethylene oxide is 0.887 at 7°/4°C. The empirical formula is C₂H₄O.

The molecular weight is 44.031. It is miscible with water in all proportions and is soluble in the usual organic solvents. On heating it mixes with water to form ethylene glycol (CH₂OH.CH₂OH). Ethylene oxide is very reactive and combines with

all compounds having a labile hydrogen atom, such as water, alcohol, ammonia, and acids.

The concentrated vapours of C_2H_4O are inflammable but concentrations lethal to insects can be used with safety. C_2H_4O is not highly toxic to man, but when inhaled for a long time it produces a cyanosis which however is counteracted by the use of CO_2 gas. Cotton and Young demonstrated that the presence of CO_2 practically doubled the insecticidal action of Ethylene oxide as a result apparently of acceleration of the respiration of the insects. In vault fumigation the minimum lethal dose for most insects is 1 lb. per 1000 cu. ft. but for commercial purposes 2 lb./1000 cu. ft. is recommended. Vaults of modern tight construction can be fumigated with 'Carboxide' which is a mixture of Ethylene oxide and Carbondioxide. This mixture is supplied in cylinders in the proportion of 1 part of C_2H_4O to 9 parts CO_2 by weight. It is non-inflammable and not sufficiently toxic to human beings to make its application very unpleasant and dangerous. The mixture is sold in 30- and 60-pound cylinders @ 16 cents per lb. f.o.b. the factory. Ethylene oxide (not mixed with CO_2) can be purchased in cylinders containing $3\frac{1}{2}$, $18\frac{1}{2}$, 75 or 195 lbs. In the two largest containers this fumigant costs 42 cents per lb., f.o.b. the factory.

The toxicity of C_2H_4O is of the same order as NH_3 . The maximum amount of C_2H_4O allowable without causing serious harm to guinea pigs when exposed for several hours is 0.025 lb. per 1000 cu. ft.

Kobert reported that 0.13 to 0.16 ounce of HCN per 1000 cu. ft. was dangerous in 30 to 60 minutes exposure. Waite, Patty, and Yant found that 4.8 to 9.6 ounces was the corresponding figure for C_2H_4O for the same period of time. HCN is therefore approximately 37 to 60 times more toxic than C_2H_4O .

VAULT FUMIGATION

Fumigation of materials in small vaults is widely practised. Such a vault may be constructed of any material that can be made gastight or reasonably so. Excellent metal vaults ready for assembling can be purchased. Highly satisfactory vaults can be constructed of concrete, brick or hollow tile.

All types of vaults should be equipped with a safe type of door, well gasketed to make it gastight. A ventilating system capable of quickly removing the fumigant from the vault after the fumigation is essential. If the vault is set up inside a building, the ventilating stack must extend outside the building and preferably above the roof. The effect of fumigation is enhanced by keeping the inside gaseous atmosphere of a vault stirred. It is desirable to install an electrical heating unit, controlled by a thermostat, so that a constant high temperature can

be maintained throughout the fumigation if the normal temperature is very low.

In fumigating old records and books in an ordinary vault it will be necessary to keep the inside temperature of the vault constant within the range $80^{\circ}F(27^{\circ}C)$ to $120^{\circ}F(49^{\circ}C)$. This can be achieved either by providing steam coils or closed electrical heating coils inside the vault. As a result of careful experiments it has been determined that a concentration of 3 to 4 pounds of Ethylene oxide—Carbondioxide mixture (1:9) per 1000 cu. ft. kills all insects within 24 to 48 hours. The disadvantages of a vault compared to a vacuum fumigatorium, so far as the fumigation of combustible and invaluable records is concerned, are: higher consumption of active fumigant, greater duration, difficulty in the penetration of records kept in bundles, greater chance of leakage and consequent danger to operators and greater delay in ventilating and refilling the vaults. In vault fumigation it is difficult to remove the adsorbed fumigant. It is to be observed that the humidity of the air inside a vault is to be as low as possible, otherwise Ethylene oxide is liable to decompose. In the wet season therefore the air inside a vault will have to be dehumidified and this is a great disadvantage. To expose records, which keep best in a humidity of 45 per cent to 50 per cent, for a long time to comparative desiccation is not without a certain amount of risk. In vacuum fumigation, however, the duration is brief and so lack of moisture exercises little deleterious effect.

VACUUM FUMIGATION

In vacuum fumigation commodities are placed in a gastight steel chamber, and a large proportion of air is removed and replaced with a gas lethal to insects. It is the most effective because the fumigant penetrates into pores and interstices of papers and kills the insects and their larvae and eggs within a short time. Encapsulated eggs often break under the action of external vacuum and this effect speeds up penetration. Lack of oxygen renders the insects more susceptible to a lethal gas. The bundles which presumably contain brittle records need not be opened, as they have to be, during vault fumigation. This permit smaller dosages and shorter exposures than under atmospheric conditions. With certain insects the period of exposure may be reduced to so short a period as 1 hr., a feature that has an appeal in cases where speed is essential, as in the handling of easily perishable goods. For treating a huge quantity of records that rapidly perishes owing to attack from insects and fungi vacuum fumigation is ideal.

In addition to reducing the dosage and length of exposure, this method of fumigation offers further

advantages. At the end of a fumigation, the removal of the fumigants can be speeded up by the process known as air washing, which consists in drawing a high vacuum and breaking it with air. High concentration of adsorbed gas for the workers while unloading is thereby prevented. The fumigants are necessarily poisonous, but the use of a vacuum fumigatorium makes the detection of any leakage rather easy. As the leakage is due to the penetration of outside air into the chamber, operators are quite safe.

HCN, SC_2 , Ethylene chloride—Carbontetrachloride, Ethylene oxide-carbondioxide, Methyl formate-carbondioxide—all these fumigants are 100 per cent effective in killing all book storage insects in $3\frac{1}{2}$ hours. A rectangular fumigation chamber ($11' \times 4\frac{1}{2}' \times 5\frac{1}{2}' = 275$ cu. ft.) suitable for vacuum

The method, however, possesses all the complications of vacuum fumigation and all equipments will have to be provided except that the construction of the chamber or vault will be easier and a smaller vacuum pump will be required. We do not know at present what the effect on insects will be of a gaseous mixture (under a pressure of 24" mercury) of which 1 part by weight is composed of Ethylene oxide and 9 parts air. If the destructive effect is comparable with Ethylene oxide—Carbondioxide mixture (1:9) the initial expenditure as also recurring operating expenses of a semi-vacuum chamber or vault will be much less.

EQUIPMENT FOR VACUUM FUMIGATION

Rectangular chambers are more suited to the treatment of records for greater space can be utilised

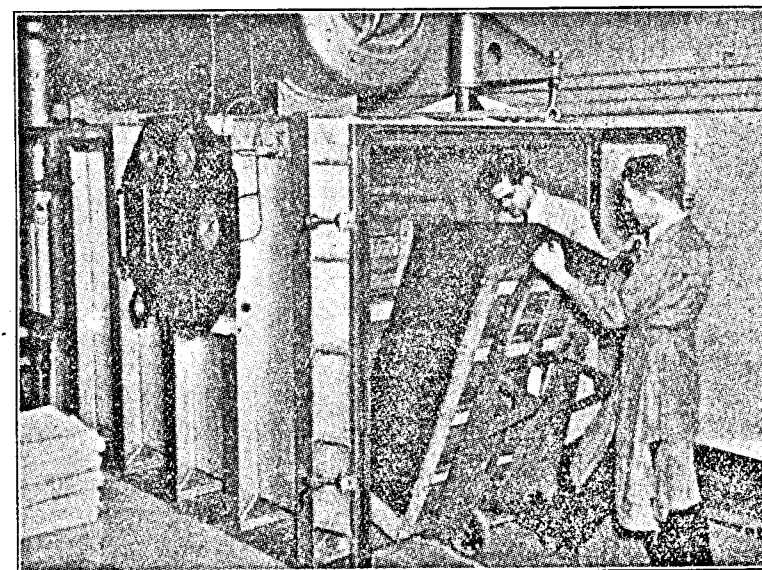


FIG. 1. 275 cu. ft. Vacuum Fumigation Chamber installed in the National Archives, Washington, D. C. (with acknowledgment to the Guardite Corporation, Chicago).

fumigation of records can be obtained from the Guardite Corporation, Chicago, Illinois at a cost of \$3,600 including freight charges. The operation of the chamber is easy and inexpensive though this must be done under expert supervision.

SEMI-VACUUM FUMIGATION

This is in principle the same as vacuum fumigation. Instead of drawing almost complete vacuum the pressure is reduced partially, say, to one half atmosphere. Subsequent operations remain the same.

compared to cylindrical chambers which, however, are easier of construction. The chambers are usually installed in such a way as to allow small trucks or skids to be run into them.

The door of the vacuum tank should be so balanced and hung that it can be quickly opened and closed by one man. The gaskets should be durable and at the same time provide a gastight seal. The efficiency of a tank depends largely on its freedom from leaks. A well-built tank should hold a vacuum without perceptible loss throughout the average fumigation period.

Each installation requires a vacuum pump capable of drawing a 28" vacuum in fifteen minutes or less.

Recent work has demonstrated that it is advantageous to introduce the fumigant into all parts of the tank at once instead of through one inlet. Rectangular tanks are now being supplied with multiple gas inlets, complete with baffle walls spaced evenly along the four longitudinal sides. Baffle walled nozzles may be provided to minimize any harm due to sudden pressure on brittle records.

It has also been demonstrated that by circulating the gas in a tank the dosage can be reduced 25 per cent by virtue of the better distribution obtained. By means of a by-pass from the exhaust to the multiple gas-inlet system the vacuum pump can be utilised to circulate the gas in the tank.

The use of a vaporizer increases the efficiency of a vacuum fumigation chamber by insuring the entrance of the fumigant in a gaseous state. The most common type of vaporizer consists of a steel tank in which steam is generated by electric heating elements. A copper coil, through which the fumigant is conducted runs through this steam heated tank and is so designed that the fumigant is in the gaseous form by the time it reaches the vacuum chamber. Ethylene oxide can, however, be used without a vaporizer.

In some modern vacuum outfits an accumulator tank is utilised to vaporize and heat the fumigant before drawing it into the vacuum chamber. It consists of an electrically heated cylindrical pressure vessel, built according to the boiler code specifications, into which the dosage is drawn and in which it can be held until ready for use.

PROCEDURE

Records to be fumigated are loaded into the vacuum tank, the door is closed and air is removed until the vacuum gauge registers 28 or 29 inches. The proper dosage of fumigant is then admitted through the vaporizer or accumulator.

If the tank is equipped with multiple gas inlets and a gas circulating system the fumigant should be pumped from the accumulator tank into the vacuum tank through the circulating system. When all the fumigant is in the tank and the vacuum gauge indicates 22 inches or so, the valve to the accumulator tank should be closed and the necessary valve adjustments made to allow the gas to be circulated in the vacuum tank. By holding the remaining vacuum without change for the duration of the fumigation, better results are obtained than by breaking the vacuum with air. If the instrument panel is equipped with a recording device, a chart record can be made of each fumigation for future reference.

The dosage is usually measured by weighing the fumigant into the tank or vaporizer, by measuring it volumetrically, or by dropping the vacuum a given number of inches with the fumigant. The first two methods are accurate. The accuracy of the third method is limited by the capacity for adsorption and absorption of different materials. It is, however, possible to standardise the method with respect to similar types of material with the help of the control chamber and for routine operations on a commercial basis the last method offers many advantages.

At the end of the fumigation the gas is pumped out of the tank and the vacuum is broken with air. If desired, the fumigated products can be "air-washed" several times by alternately drawing and breaking a vacuum of about 27 inches. The latest experiments have shown that for insects infesting records, 30 lbs. of 'Carboxide' ($C_2H_4O + CO_2$) per 1000 cu. ft. will give a complete kill in $3\frac{1}{2}$ hours.

Ethylene oxide is not known to be manufactured in India. Imported Ethylene oxide would cost Rs. 2/12/- per lb. Compressed CO_2 is obtainable from local firms at the present price of -/8/- annas per lb. in returnable cylinders. In one vacuum fumigation in a 300 cu. ft. chamber the cost of C_2H_4O and CO_2 would be about Rs. 4/8/-. In one year of 300 working days of one shift a day, at least 45,000 cu. ft. of records can be treated at an expense of Rs. 1,350/- only for fumigants. A vault fumigatorium of the same size working for the same number of days will be able to treat not more than 15,000 cu. ft. of records owing to the difficulty of utilising space in a vault and to the longer exposure necessary for satisfactory penetration. The working capacity of a vacuum fumigation chamber is quite flexible because the output of fumigated record can, if necessary, be easily doubled or trebled by working two or three shifts a day.

Ethylene oxide and other fumigants may be obtained from the Carbide and Carbon Chemicals Corporation, 30 East Forty-second Street, New York. For vacuum fumigation it is more convenient to use liquid HCN instead of generating the gas from NaCN, 'Zyklon' or other cyanide products. Amongst others, liquid HCN is manufactured by the African Explosives and Industries Ltd. and the fumigant can be obtained in 275 lb. cylinders containing 75 lbs. of liquid hydrocyanic acid. This extremely poisonous gas can be led from outside to multiple spray nozzles placed in any part of a large vault or building with the help of $\frac{3}{4}$ inch flexible copper tubing.

A mask must be put on as a precaution while working with liquid HCN and at least two fumigators must work jointly so that one can help the other in case of accident. Even when fumigation is being carried on with a toxic but not highly dangerous gas,

one or two tested masks should always be kept ready in order to tackle accidents.

It should be noted that insects are quite active when first removed from the chamber after vacuum fumigation with 'carboxide' for the short period recommended but they die within a few hours. What is the exact physiological effect upon the insects has not been determined.

CYCLIC VACUUM FUMIGATION

Many commercial firms prefer to have two vacuum fumigation chambers worked by one set of equipment, i.e. vacuum pump and accumulator. When one chamber is under fumigation the other can be loaded or unloaded and the team of fumigation operators can be kept continuously busy. Thus working in a cycle it is also possible to utilise the worked fumigants instead of running them to waste. The same fumigant may be used over again, introducing fresh fumigant to compensate leakage only. The cost of fumigant will be kept so low that it would be possible to use quite costly fumigants if necessary. But until now not a single vacuum fumigation unit operates on this regenerative principle. Perhaps, the comparatively low cost of fumigants acts as a deterrent. But this system will undoubtedly be found more suitable and economical for places where fumigants are to be imported from abroad and heavy transport charges are to be paid for the cylinders.

CONTROL

Whatever system is adopted it is essential that preliminary experiments are carried out to ascertain the optimum conditions. With all large fumigatoriums, therefore, are attached a 'control' unit meant for experimental purposes or for study in case of any particular difficulty. Such experimental 'control' units generally range from 1 to 20 cu. ft. in capacity. Attached to the 'control' unit shall be a separate panel of measuring gauges, the other equipments remaining the same. The control unit may also be adapted for accelerated aging tests and for studying the effect of fumigants on paper and other materials if additional heating and cooling coils and measuring instruments are provided.

Thus we find that the advantages of vacuum fumigation of books and records over other types of fumigation are so outstanding that there should not be any hesitation in incurring the high initial expenditure which, it may be pointed out, would be saved many times over in the long run on account of the low working expenses and the remarkable decrease in replacement, repairing and rebinding costs.

Though I have taken old and irreplaceable records as the material to be fumigated, vacuum fumigation is equally applicable to other stored materials such as cereals, grains, foodstuffs, clothes, tobacco, furs etc. which are liable to insect infestation. The Department of Agriculture of the Canadian Government a few years back installed at Montreal a 1200 cu. ft. vacuum fumigation unit to treat imports which may be infested before permitting them to enter the country. The unit is also available to shippers for custom service and for experiments in combating foreign pest invasion. Besides commercial firms, vacuum fumigation plants of different capacities have also been installed by the Huntington Library, San Marino, California; the National Archives of the U. S. A.; the British Museum; the Nordiska Museum, Stockholm and the National Museum, Copenhagen. It is unfortunate that this excellent technique of dealing with insect pests has not yet been introduced in India though in a tropical climate insects multiply profusely and destroy stored commodities at an astonishing rate.

The preservation of records and books is important from the sentimental, historical and administrative point of view. But more important from an economic point is the incalculable destruction by insect pests of cereals, foodstuffs, clothes etc. of which, incidentally, an alarming shortage exists at the present moment. The construction of vault and vacuum fumigation plants is not a difficult job and there is every reason to believe that these plants can be fabricated more economically by manufacturing firms in India. But the task of popularising this new technique of fighting insect pests must rest with the economic entomologists, cereal chemists, librarians and archivists. The war should not discourage the installation of new fumigation plants because insects are not amenable to food rationing in spite of the war.

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MEDICINE AND PUBLIC HEALTH

DURATION OF IMMUNITY FOLLOWING YELLOW FEVER VACCINATION

RELATIVELY safe vaccination against yellow fever by means of attenuated yellow fever virus unaccompanied by immune serum has been possible since 1937, when the development was announced of a modified strain (17D) which no longer produced the visceral lesions of yellow fever or fatal encephalitis in rhesus monkeys. A paper in the January, 1943 issue of *American Journal of Hygiene* (later quoted by *Science News* latter) reports further large-scale observations of the duration of immunity to yellow fever over a period of four years after vaccination with 17D virus, as indicated by mouse protection tests. Altogether 926 persons were studied. The results obtained by the controlled re-examination of the sera made it evident that marked differences existed in the duration of the immunity produced in several large vaccination groups. The evidence available indicated that these differences were due, not to previously unrecognized differences in the antigenicity of the 17D substrains concerned, but to the different age compositions of the vaccination groups. Thus, of sera collected four years after vaccination from groups chiefly composed of adults, only four (2 per cent) failed to show some indication of protective activity. In contrast, of sera collected two or three years after vaccination from groups largely composed of young individuals, thirty-six (nearly 10 per cent) exhibited no protective power. Sera which showed no protective action in the routine tests were re-examined by a more sensitive technique. By this means detectable antibodies were revealed in eighty-six (61.8 per cent) of the one hundred thirty-nine sera re-examined. While even more sensitive techniques might reveal the presence of anti-bodies in some of the remaining sera, these observations suggest that serologically demonstrable immunity against yellow fever, induced by living 17D virus, may completely disappear in at least some cases.

The question of the significance of low degrees of serological immunity was also considered, and evidence was presented to show that such low level immunity probably is sufficient to prevent reinfection with the 17D strain to which, in spite of its admitted lack of virulence, man is highly susceptible. Finally, the observations on the duration of immunity following vaccination are of obvious significance with respect to the systematic prophylaxis of yellow fever. It would appear that the vaccination of adult populations with a virus of established antigenicity results

in the persistence of an immune state which is clearly satisfactory from the group standpoint for at least four years and probably for much longer, since the rate of continued decline is very small. In children, after vaccination, the level of protective antibody does not rise so high as in adults and tends to fall more rapidly. Whether or not the immunity of children conferred by vaccination is relatively lower in degree and whether, therefore, the vaccination needs to be repeated after a shorter interval of time, remains to be determined.

EXTERNAL TEMPERATURE IN CASE OF BURNS

EXPERIMENTS done in America with dogs and cats indicate that the outcome of severe burns is influenced by the temperature of the patient's environment during the first 24 hours. Important in the case of war burns, it was found that the most favourable environmental temperature is about 75 degrees Fahrenheit. At this temperature the lowest mortality was found among rats. All burned animals kept in rooms at 32° and 99° Fahrenheit died within 24 hours after being burned. It is suggested, therefore, that in the tropics it is important to lower the temperature of the patients' rooms.

THE USE OF SEDIMENT IN BLOOD PLASMA

THE discovery that the red blood corpuscles, hitherto discarded as waste in the making of blood plasma, may be used to cure ulcers, infected wounds, and burns. The response to treatment is prompt. Pain disappears almost immediately. Purulent ooze subsides under the protective film. Granulation tissue rapidly develops. The red-cell solution has also proved to be a remarkable aid in the treatment of various types of anaemia. This is a great step forward in the utilization of blood for "banks" now considered indispensable for transfusion both on the battlefield and in civilian life.

BACTERIOSTATIC ACTION OF PENATIN

THE discovery of a second and more potent weapon against disease germs is the mold *Penicillium notatum*, which has already yielded penicillin. The second substance from mold is called penatin. It is reported to be more powerful than penicillin and also active against disease germs which are hardly

affected by penicillin. Of 50 disease-causing and non-disease causing organisms tested, none has been found which would resist the bacteriostatic action of penatin in dilutions of not less than one to 10,000,000. Penatin not only stops the growth of organisms but

also, though to a lesser extent, can kill them. At dilutions of one to 12,500,000, in test tube experiments, penatin stopped the growth of diphtheria, anthrax, undulant fever, pneumonia, typhoid, paratyphoid, and pus germs, among others.

MALARIA—FROM THE TREATMENT POINT OF VIEW*

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OF the many problems that confront the medical man in this country, particularly in the rural areas, there is none so important as the problem of combating malaria. India is easily the most malarious country in the world and Bengal, the most malarious province in India. Malaria causes not only an enormous amount of ill health but also collects a heavy toll of human lives every year. It has been estimated that annually as many as 100 million people suffer from malaria in this country and that about 2 million people die as a direct or indirect result of the disease. The economic loss to the country, attributable to malaria, has been estimated by several eminent authorities as being well over 50 crores of rupees per annum. It is, therefore, justifiably considered to be the most important of Indians' rural health problems. If this is the case in normal times it is likely to worsen hereafter when, with the war coming to our very doors, the threat of wide spread outbreaks of malaria occurring in the rural areas has been greatly increased. With the large movements of population, taking place at present from one area to another, with the daily decrease of the purchasing power of the rupee and the consequent lowering of the economic status of the people and the enhanced risk of exposure to various adverse conditions of environment, the population of some rural areas are having to face conditions hitherto unheard of. The subject of malaria is thus a very pressing one. The present discussion will be confined to the treatment aspect of malaria in which our primary interest lies.

There are many ways in which the subject of malaria treatment can be presented. The purpose of this discussion will be best served if certain questions pertaining to the subject together with their answers are placed before the reader. The

following are some of the important questions that naturally come up for consideration:

- (1) What facts about malaria have a bearing on treatment.
- (2) What all drugs are available for the treatment of malaria and how are they used.
- (3) What are all the different purposes for which anti-malarial drugs are generally administered.
- (4) How to choose the right drug for any specific purpose.
- (5) How has the present war affected the availability of anti-malarial drugs in India.
- (6) What should be India's policy with regard to anti-malarial drugs now and for the future.

Taking up the first question, the facts about malaria that have a bearing on treatment may be considered under seven heads: (i) Species of parasite, (ii) strain or race of parasite, (iii) developmental stages of the parasite, (iv) intensity of infecting dose, (v) stage of disease, (vi) clinical and parasitological findings and (vii) host resistance.

Species of parasite.—It is common knowledge that there are four species of plasmodium affecting man, e.g., *P. vivax*, *P. malariae*, *P. falciparum*, *P. ovale*. (A fifth *P. tenue* has been described but is not universally accepted). The therapeutic effect of anti-malarial drugs on the different species of parasite is not the same. While some species respond to treatment readily, others do so more slowly. For example, *P. ovale* is cured readily by one or two doses of quinine while the other species require longer treatment with larger doses. Also treatment of an attack of M. T. requires a higher dosage of quinine than treatment of a similar attack of B.T. or quartan. It is, therefore, always helpful to know the exact species of malaria causing the disease in the patient who comes for treatment. Such know-

* Adapted from a lecture delivered under the Maharaja-dhiraj of Burdwan Fund on the 12th January, 1943.

ledge enables us to administer the proper dose and course best suited to the case and to obtain effective and quick therapeutic results.

Races of parasite.—It is generally accepted that in one and the same species more than one race of parasite may be present. These races not only cause disease of varying degrees of severity but also offer different degrees of resistance to anti-malarial drugs. For example, it has been found that *P. falciparum* infections contracted in certain areas are more amenable to treatment than those contracted in other areas. In induced malaria it has been observed that cases infected with the Rome strain of *P. falciparum* require eight times as much quinine as those infected with the Indian strain. Thus for success in treatment it would be an advantage to know the peculiarities of the race of the parasite one is dealing with. Unfortunately sufficient data regarding the peculiarities of the races of parasites met with in the different provinces of India are not available. It is up to the practitioners in malarious areas to collect the necessary information on the subject and to publish such information for the benefit of others.

Developmental stages of the parasite.—From the treatment point of view three stages of the parasite may be considered: (a) the sporozites, (b) the asexual forms and (c) the sexual forms. Antimalarial drugs vary in their action on these three forms. For example, quinine has no action on the sporozites, but it destroys the asexual and sexual forms of B.T. and quartan. With regard to M.T. it destroys the asexual forms but not the sexual forms. Plasmoquine on the other hand destroys the sexual forms of all species and particularly of M.T., but it has little or no action on the asexual forms.

Intensity of infecting dose.—It is generally believed that in induced malaria primary attacks caused by bites of many infected mosquitoes are sometimes more difficult to cure than primary attacks caused by the bite of only one or two infected mosquitoes.

Stage of disease.—From the treatment point of view at least four stages of the disease may be recognised: (a) incubation, (b) primary attack, (c) latency and (d) relapse. The efficacy of anti-malarial drugs varies in the different stages. For example, quinine when given during the incubation period merely delays the onset of the disease. It acts better after the patient has had a few bouts of fever than when he has had only one or two. It acts still better during relapse and recurrence than during the primary attack or latency. It acts best when given during natural decline of the disease or when its maximum concentration in blood coincides with the sporulation of the parasite. This is so because anti-malarial drugs generally act partly directly and partly through the natural defence mechanism

of the body. The common view that the earlier one begins specific treatment the better the result is not wholly true in malaria. In the clinically severe cases or those showing heavy parasitisation prompt treatment is urgently needed. A little delay in treatment of B. T. and quartan infections may at times be helpful rather than harmful. But the general consensus of opinion is that in M. T. malaria treatment should always be begun at once.

Clinical and parasitological findings.—As guides to treatment, it is generally recognised that both findings should be taken into account. For, in malaria three types of cases occur, namely (a) those showing clinical symptoms but no parasites, (b) those showing parasites but no clinical symptoms and (c) those showing both clinical symptoms and parasites. Only through a proper assessment of these two findings can a correct line of treatment be chalked out for any particular case. But where laboratory facilities are not available, clinical findings have proved a fairly safe guide. The modern tendency is to administer drugs till clinical cure is established and to repeat treatment when relapse or recurrence occurs. It is now realised more than ever before, that the chief feature of malaria is its tendency to relapse and this tendency is to a large extent independent of dosage given or duration of treatment and that excessive drugging long after subsidence of clinical symptoms adversely affects the defence mechanism of the body on which the ultimate cure chiefly depends.

Host resistance.—It is important to realise that quinine and other antimalarial drugs act only partly directly and that their main action is indirect through the natural body defences. In this defence the main brunt is borne by the cells of the reticuloendothelial system. These cells are not only capable of phagocytosing and destroying the malarial parasites but also in elaborating specific antibodies which play a helpful rôle in the defence mechanism. The specific antimalarial drugs appear to stimulate the mobilisation, proliferation and functional activation of the phagocytic cells of the reticuloendothelial system (Krishnan 1933). There is no doubt that the best stimulus for the activation of the system is the stimulus of infection. Only when this primary natural stimulus has been at work that anti-malarial drugs are able to further heighten the stimulation and to bring about an effective control of the malarial infection. A point of great importance to remember in treatment, therefore, is that only by judicious administration of drugs can the natural defence mechanism be aided; excessive drugging may lead to excessive stimulation and depression of the mechanism and no clinical improvement. Here, however, it should be pointed out that individual patients show great variation in their reaction to

malarial infection and in their response to any particular course of treatment. Only through careful observation and study of each case and through effecting suitable variations in treatment best suited to the case that uniformly successful results can be obtained.

Thus the various facts relating to malaria that influence the therapeutic action of antimalarial drugs have been briefly indicated, and now the second question, namely the antimalarial remedies will be considered. Medical men are aware that the list of remedies for malaria is a long one. Being the oldest and the most wide spread of all human diseases, all kinds of drugs have been tried and developed with varying degrees of success. It is impossible to enumerate these drugs and to go into the merits and demerits of all of them. It can, however, be said that the ideal drug for the treatment of malaria has not yet been evolved. One may define an ideal drug as a cheap, tasteless, non-toxic drug, quick in action, capable of preventing relapses and killing all species, races and forms of the malarial parasite including the sporozoites. A drug with all the above mentioned qualities is not available. Yet from among the long list of remedies one can pick up a few outstanding ones whose therapeutic usefulness has been established beyond question and which may reasonably be called the best specifics available. These are quinine, cinchona febrifuge, plasmoquine and atebirin. These will now be discussed in detail.

Quinine.—This is an alkaloid derived from the cinchona bark. It can be administered by mouth or by injection (intramuscular or intravenous). By mouth, it is best given in solution. To avoid its bitter taste, it may be given as cachets, tablets or pills; but these are not quite so effective as the solution. Only in urgent and severe cases quinine is to be administered by injection. In whatever way quinine is administered to a case, it is absorbed quickly and it circulates in the blood as a quinine base. The time of circulation is short, as the drug is partly deposited in the liver, spleen and other tissues and partly excreted in the urine. The drug has no action on the sporozoites or on the gametocytes of M. T. It causes, when suitable doses are given, the disappearance of all other forms in about a week. One thing that has come out from recent researches on quinine administration is that there is no advantage either in prescribing massive doses or in administering the drug over prolonged periods as was the practice some years ago. Smaller doses and shorter courses repeated frequently at intervals give better results (League of Nations 1937). Larger doses and prolonged courses have been actually found to retard the development of the natural defence mechanism on which the cure mainly depends, and

as such are not recommended now. Quinine is tolerated well by children in doses proportional to their age. When its bitter taste is objected to equinine may be substituted for quinine. Pregnancy in malarial subjects is no bar to the administration of quinine. Acute malaria in them, if left untreated may cause abortion whereas small doses of quinine given frequently will cure malaria and prevent abortion. For black water fever cases quinine is contraindicated. If fever and parasites are present atebirin (=mepacrine) should be given.

Cinchona febrifuge.—This is the powdered bark of the cinchona plant. This plant was originally found in South America growing on the slopes of the Andes. But now it has been successfully cultivated in many other countries including India. About 40 species of the plant are known and of these two, *C. officinalis* and *C. succirubra* grow best. The cinchona bark contains as many as 20 alkaloids, some crystallizable others amorphous. Of these only four alkaloids, quinine, quinidine, cinchonine and cinchonidine occur in large quantities. The proportion of quinine is about half the total alkaloids and it is the most powerful constituent as regards antimalarial properties. The powdered bark has been used since 1638 in the treatment of malaria. It is given by mouth in the form of a mixture or as tablet. Its efficacy depends on the percentage of total alkaloid content and particularly quinine. As different preparations vary in their composition greatly, attempts have recently been made to standardise these. A preparation under the name of Totiquina containing 70 per cent total alkaloid of which not less than 15 per cent is quinine has been put in the market. Its action on the malarial parasite resembles that of quinine, and it is only very slightly inferior to that drug in efficacy. This leads to the suggestion that the use of cinchona febrifuge should be encouraged. It is cheap compared to quinine.

Plasmoquine.—It is a synthetic drug prepared from methylene blue and having a quinoline structure. It was first made in Germany by Schulemann in 1924-26, but now it is being prepared in other countries as well. The British name is "Pamaquin". It is given by mouth in the form of tablets of 0.01 grm. or 0.02 grm., the maximum daily dosage being 0.03 grm. Though it is tasteless, it is more expensive and toxic than quinine. On the latter account, it cannot be administered for long periods. Usually 3 to 5 day courses are given. It has specific action on the sexual forms of all species and it destroys M.T. crescents very rapidly. It has, however, little or no action on the asexual forms. Thus its main uses are for destroying crescents of M.T. for which no other drug is available, and for reducing the number of relapses specially of B. T. and quartan.

Plasmoquine combined with quinine under the name of "Quinoplasmine" and "Plasmoquine compound" are also in the market. As their names indicate, they are combinations of plasmoquine with quinine. They are put up in tablet form for oral administration. These are said to be less toxic and more effective in reducing relapse rate in all forms of malaria.

Atebrin.—Like plasmoquine it is a synthetic drug evolved originally by German effort (in 1932) and is an acridine derivative. It has since been made in Russia under the name of "acriquine", in Britain under the name of "mepacrine" and in India by Sir Upendra Nath Brahmachari under the name of "acridine X". The foreign preparations of atebrin are usually put up in two forms, (i) as tablets for oral administration and (ii) as powder in sterile ampoules for intramuscular or intravenous injection. The powder is dissolved in 1 to 2 cc. of sterile-distilled water before use and injected immediately after preparation. For the treatment of malaria generally atebrin has proved quite effective. It brings down the fever and the relapse rate like quinine. Quinine has an antipyretic effect and so reduces the length of the fever apart from any direct action on the parasite. That is why it is given for the first 2 days in any treatment. Atebrin has a more powerful action on certain strains of M.T. than quinine but in others the reverse is the case. The same remark applies to relapses of B.T. On the whole there are perhaps fewer relapses with atebrin but some people (*e.g.* Komp and Clarke in Panama) have reported the reverse. Atebrin is a safer drug than quinine for use in black water fever. Its action on the various species and stages of the malarial parasite is like quinine. It acts on all forms of B.T. and quartan and on the asexual forms of M.T. but has very little action on the sexual forms of M.T. It has also no action on the sporozoites as injected by the mosquito. Being a dye, it gives rise to yellow pigmentation of the skin simulating jaundice. It is retained in the body for a much longer time than quinine as it is excreted slowly. It has a slight bitter taste and is more expensive and toxic than quinine and cannot be administered for long periods in full therapeutic doses. Its toxicity is, however, very much less than that of plasmoquine. Another point about atebrin is that combined administration of atebrin and plasmoquine is dangerous. The toxicity of each drug is increased and fatal results have at times occurred. To avoid this what is generally recommended is a course of atebrin for 5 days followed after a break of 1 or 2 days, by a 3 to 5 days course

of plasmoquine. This in many hands has given more favourable results.

"Atebrin musonate" is the form used for intramuscular and not intravenous injection and its British equivalent is "mepacrine methane sulpho-nate". It has the advantage over quinine for intramuscular injection in that it does not cause muscle necrosis. It cannot replace intravenous quinine, though it may reinforce it or be substituted for it where for technical or other reasons intravenous injections are not possible. These preparations are recommended for use in cases of heavy infections causing alarming symptoms.

As regards the third and fourth questions, in medical and public health work antimalarial drugs are administered for different purposes. These purposes have been given special names such as (i) causal prophylaxis (ii) clinical prophylaxis (iii) clinical cure (iv) prevention of relapse (v) prevention of gametocyte formation (vi) sterilisation of infection and (vii) mass treatment. These are discussed separately below.

Causal prophylaxis.—This means the administration of drugs for preventing infection occurring in a healthy person exposed to the bite of infected mosquitoes. For this purpose the drug must be capable of destroying the sporozoites as injected by the mosquito. Quinine and atebrin have no action on sporozoites and as such are useless for this purpose. Plasmoquine is said to have some slight effect when given in large doses but as this is too risky due to the toxicity of the drug and as at best it merely delays the onset of fever it is not used. There are some people who even now believe in the prophylactic value of a daily dose of quinine. They argue that although the drug has no action on the sporozoites, its presence in the blood would tend to check asexual multiplication and clinical manifestation. While this may be true, such a view will give a false sense of security. For such practice while being incapable of preventing infection would merely suppress the symptoms of the disease for a time and really come under the next category of clinical prophylaxis.

Clinical prophylaxis.—This means the administration of drugs to a person who is already infected with the object of preventing illness in him. This is also known as "Suppressive treatment". For this quinine and atebrin have been tried and the evidence so far obtained is slightly in favour of atebrin. Quinine is not far inferior to it.

(To be Concluded)

LETTERS TO THE EDITOR

[The editors are not responsible for the views expressed in the letters.]

TOXIC EFFECT OF GASES ON PLANTS

In three previous communications¹⁻³ have been reported the results of experiments confirming that exposure to coal smoke causes 'black-tip' injury of the mango fruit, which is known to occur in orchards near which brick-kilns are found to work during the season.* It remains, however, yet to determine which of the constituent gases of coal smoke is responsible for the injury, and what is its mechanism.

Coal smoke is well known to have injurious effects on plants, and of its constituent gases SO₂, C₂H₄, and CO are known to be harmful to plants—SO₂ being the most toxic of all. In connection with the aforesaid 'black-tip' injury, it was, therefore, considered to be of interest to study the effect of these three gases on the mango fruit.

Fruits growing on the trees were exposed, during the period of their development in size (21st. April

to 20th May, 1943), to various concentrations of these gases, for varying periods, in glass jars. Necessary controls were provided for all the treatments. It was not, however, possible to use fruits of the same varieties of mango for all the three gases, for want of sufficient materials. Four different varieties were used in all,—SO₂ on Sakerchina and Champakelwa, C₂H₄ on Champakelwa and Aman Prince, and CO on Aman Dasher, Sakerchina and Champakelwa.

The results show some interesting features of gas effects on plants and appear to be suggestive with regard to the mechanism of the 'black-tip' effect.

Sulphur dioxide.—Pure gas bleaches the fruit readily and kills it. When exposed to dilute gas the injury is found to initiate in the form of spots round lenticels⁴—the effect increases with increasing concentrations of gas and time of exposure (Table I). The effect of intermittent exposure with 0.5 per

TABLE I
EFFECT OF SO₂ GAS ON MANGO FRUIT (VAR. SAKERCHINA)

CONCENTRATION OF GAS				
Pure	10%	2.5%	1%	0.5%
(1) 10 mins.—complete bleaching during treatment—shrivelling within 2 hours, complete collapse in 12 hrs.	(1) 1 hr.—distinct blackish spots round lenticels within 12 hours. Spots gradually spread and the whole fruit blackened within 3 days. The fruit hardened without shrivelling and dropped in another 2—3 days.	(1) 1 hr.—visible spots round lenticels within 2 hours, spots increase in size and become distinct in another 2 days but do not spread enough to discolour the whole fruit. Fruit persisting on tree and even showing slight increase in size since treatment.	(1) 3 hrs.—distinct brick-red and blackish spots round lenticels within 24 hours. Spots increase in size and coalesce in many places forming blackish patches in 6 days. Fruits persist on tree and even show some growth since treatment.	(1) 3 hrs.—minute spot sparingly scattered on the skin visible within 48 hrs. Spots show very slight further increase, remain pinkish to brick-red. Fruit persists on tree and show fair growth.
(2) 5 mins.—bleaching complete within ½ hour. Shrivelling within 3 hours, complete collapse in 24 hours.			(2) 2 hrs.—visible brick-red spots round lenticels within 24 hours—spots turn black and also show some further increase in size for another 1 or 2 days and become distinct. Fruits persist and even show some increase since treatment.	(2) 1 hr.—No effect. The fruits growing as healthily as under controls.
(3) 1 min.—complete bleaching in 24 hours, complete collapse in 2 days.			(3) 1 hr.—minute pinkish spots round lenticels in 24 hrs., spots increase slightly and become just distinct in another day but do not show much further increase. Fruits persist on tree and show relatively better growth since treatment.	(3) Intermittent exposure for 1 hr. in the morning and 1 hr. in the evening per day, for a total period of 9 hrs.—No effect.
				(4) Intermittent exposure every alternate hours, during one day, for a total period of 6 hours—minute pinkish spots visible in 48 hours. Spots increase slightly in size during the next 2 days, fruits persist on tree and show fair growth.

cent gas, which was the lowest concentration of SO_2 used in these experiments, appears to be of significance. Continuous exposure showed the usual SO_2 -effect in 3 hours, but intermittent exposure for one hour in the morning (8-9) and one hour in the evening (5-6), per day, showed no effect at all even after exposure for a total period of 9 hours. Intermittent exposure for every alternate hour, during one day, for a total period of 6 hours, however, showed the toxic effects. It may be of interest, in connection with the 'black-tip' of the mango, to study the effect of prolonged and intermittent exposure to more and more dilute SO_2 on the fruit. Incidentally it may

Carbon monoxide—shows relatively little effect. Prolonged exposure to pure gas turns the skin pale but dilute gas has no effect (Table III).

Varietal differences.—Different plants are known to show differences in their susceptibility to gas injury. The mangoes also show varietal difference in their susceptibility to 'black-tip' injury caused by coal smoke. In these experiments as well the mangoes have shown varietal difference in their response to the action of the different gases.

As will be seen from above, the variety Champakelwa happened to be treated with all the three gases. It showed comparatively greater resistance than any

TABLE II

EFFECT OF C_2H_4 GAS ON MANGO FRUITS (VAR. AMAN PRINCE)

CONCENTRATION OF GAS			
1%	5%	25%	Pure
72 hrs.—Skin turning pale on the 2nd day of treatment, yellow on the 3rd day, within the next 1-2 days show blackish lesions here and there on the skin. The fruits becoming soft and dropping in another 2 to 3 days.	72 hrs.—Same effect as with 1% C_2H_4 but appearing comparatively slowly. Colour of lesions lighter, i.e., more brownish than blackish, than under 1% treatment.	72 hrs.—paleness of skin visible one day after completing treatment. No distinct yellow colour or lesion developed. Fruits persisting and showing growth.	72 hrs.—Slight paleness of skin visible 2-3 days after completing treatment. Fruits persisting and growing.

be mentioned that in the atmosphere round trees which were experimentally exposed to coal smoke and produced black-tip on their fruits, showed 0.0067 to 0.049 per cent SO_2 present in it while fresh air showed only 0.000196 per cent to 0.000986 per cent.

Ethylene.—Unlike SO_2 gas, C_2H_4 appears to show the less effect the higher its concentration.

of the other varieties to the toxic effect of the respective gases. With same concentration of SO_2 it took more time than Sakerchina to show a similar injury. It showed no effect after 72 hours' exposure to pure C_2H_4 while Aman Prince with a similar treatment showed toxic effect. With CO it showed no effect after 96 hours exposure to pure gas while Aman Dasherri showed effect after 72 hours.

TABLE III

EFFECT OF CO GAS ON MANGO FRUITS (VAR. AMAN DASHERRI)

CONCENTRATION OF GAS		
1%	5%	Pure
72 hrs.—No effect. Fruits growing as healthily as under control.	72 hrs.—Very slight paleness visible after 72 hours, no change thereafter. Fruits show growth.	72 hrs.—Yellowing of the skin after 72 hours. Fruits remain hard and persist on tree. Show check in growth.

Pure gas shows little or no effect, dilute gas turns the skin yellow and produces deep brown to black lesions here and there on the skin—the fruits becoming soft and dropping subsequently (Table II). The lowest concentration of gas used was 1 per cent. It would be of interest in this case as well to study the effect of prolonged exposure to higher dilutions of this gas.

Fruit Research Station,
Sabour, 2-6-1943.

P. K. SEN.
P. C. MALLIK.
P. K. ROY.

^{1,2} *Science and Culture*, 7, 56, 1941; 3, 91, 1937; 8, 343, 1943.

* Experiments on the effect of coal smoke on mango fruits have been repeated again during this season with Sakerchina and Safeda varieties. Both the varieties have shown the black-tip effect.

* Das Gupta and others, *Proc. Ind. Acad. Sci.*, 13, 71, 1941.

NEW BANDS IN THE FIRST NEGATIVE (OR VISIBLE) O_2 BAND-SYSTEM

The visible O_2 bands have been produced by high frequency (750–850 kc/sec) discharge in oxygen (out-put power less than 10 watt). They were photographed on a Fuess glass spectrograph. This method of excitation as opposed to the hot hollow cathode method appears to be particularly favourable for the detection of higher members of sequences. Thus Bozoky and Schmid¹ could fill in gaps in the v' , v'' table from their study of the bands excited by h.f. discharge. We find from our data that the table can be further considerably extended. The entire band system observed is displayed in the following table where only the wave-numbers of the first head due to the transition $^4\Sigma \rightarrow ^4\Pi_{-1}$ is included.

TABLE

 v' vac; (visual intensity)

v'/v''	0	1	2	3	4	5
0	16588 (10)	15573 (10)	(14581)	(13606) MS	(12669) MS	
1	17749 (10)	16728 (10) BS	15723 (10) BS	—	—	
2	18879 (9)	17866 (10) BS	16868 (9) BS	15889 (6) LS A	—	
3	19973 (2) MS	18955 (10) BS	17953 (6) BS	16994 (8) BS	16040 (3) LS	—
4		20000 (2) LS A	19009 (6) LS	18038 (2) BS	17095 (2) BS	16184 (3) LS
5			20024 (2) LS A	19038 (10) LS	18108 (2) LS	17194 (1) LS
6					19075 (8) LS	—
7						19098 (9) LS

Bands in brackets are not observed owing to limitations of the photo-plates used.

MS indicates, first reported by Mulliken and Stevens.²

BS indicates, first reported by Bozoky and Schmid.

LS indicates newly reported now.

A indicates, also recorded in spectrograms of a mild condensed discharge in oxygen taken by Dr Asundi.

On account of the relatively small change in v' and ω'' values accompanied by a relatively large change in $\omega'x'$ and $\omega''x''$ values for this system³, the sequences are apt to converge. Calculation on existing data shows that the sequences $\Delta v = +2$ and $+3$ should converge for $v' = 9$ and 7 respectively. Such a phenomenon does indeed seem to exist. The former sequence is now traced to $v' = 7$ and the latter to $v' = 5$. It is not improbable that these are the convergence values for the sequences and that the higher

members are masked by the large number of subsidiary heads of which each band consists.

We record our thanks to Dr R. K. Asundi for suggestions and discussion and to Dr S. S. Joshi for permitting us to use the Fuess spectrograph.

NANDA LAL SINGH
LALJI LAL.

College of Science,
Benares Hindu University,
Benares, 10-6-1943.

¹ Bozoky and Schmid, *Phys. Rev.*, 48, 465, 1935.

² Mulliken and Stevens, *Phys. Rev.*, 44, 720, 1933.

³ Jevons: Report.

INVESTIGATIONS ON THE ISOLATION AND CONSTITUTION OF THE TANNIN FROM INDIAN TERIPODS

THOUGH Teripods (*caesalpinia Digyna*) are known to contain a tannin no attempt has yet been made to isolate the tannin in the pure state and as yet no work has appeared on the determination of its chemical constitution.

The author has succeeded in isolating pure tannin from the teripods and he has also been able to prove its identity with the tannin derived from the gall nuts.

A few ripe pods were taken, the reddish upper layer of the ripe dry pods was carefully scraped off, and then the pulp was powdered, seeds removed and it was (10.5 g) extracted with absolute alcohol in the Soxhlet apparatus. From the reddish coloured extract the alcohol was removed. The residue was dissolved in water, treated with animal charcoal in the hot and filtered. The filtrate was evaporated to dryness in vacuum. Yield 4.5 g.

The tannin thus obtained was dissolved in a little water, made slightly alkaline to litmus with sodium bicarbonate and then thoroughly extracted with freshly distilled ethylacetate. The ethylacetate extract was washed with water, dried over anhydrous sodium sulphate and the ethylacetate was then removed. The residue was dissolved in water, warmed with the addition of a little decolorising charcoal, and filtered. The filtrate was evaporated to dryness in vacuum and the residue powdered, dried in a steam bath and put in a vacuum desiccator for several days. The completely dry stuff melted at 205–212°C with decomposition and the melting point showed no depression when mixed with an equal quantity of the pure gall nut tannin. On hydrolysis, this tannic acid has been found to give gallic acid in the proportion which corresponds with the constitution of gallo-tannic acid (penta digalloyl glucose).

The experimental details will be published elsewhere.

My best thanks are due to Mr S. J. Das Gupta and the authorities of the firm.

H. G. BISWAS.

Sir Prafulla Research Laboratory,
Bengal Chemical & Ph. Works Ltd.,
Calcutta, 11-6-1943.

MONSOON CYCLONES

FOR the last 3 or 4 years an investigation on the "Mechanism of Monsoon Cyclones in the Bay of Bengal and of the March of Seasons in India" has been carried out in Karachi and the paper on the subject is now nearing completion. As a matter of fact, the present investigation may be considered to be an elaboration of the previous work on the subject, for example that published in "SCIENCE AND CULTURE" in March, 1938, and reprinted in the "Bulletin of the American Meteorological Society" in February, 1942.

Rayleigh contemplated that a cyclone was a free vortex and that it would be born in a region of vorticity where fluid could be 'annihilated'. This is the starting point of the present paper.

The hypothesis, on which this investigation is based, is as follows:—

- The atmosphere consists of vortex streets which are more or less well defined below the 'free convection threshold' in the equatorial air. This floor divides the troposphere approximately into two halves. The upper shell, which is supposed to guide the movement of the tops of cyclones, is called the 'directive shell', and the lower shell, in which the cyclones are born, is called the 'generative shell'.
- There is vorticity in any region that separates two solid rotations in the atmosphere. The dilatation axis of a deformation field is found to be a 'bluff body' and the vortex layers, arising at the two edges of the moving or tilting axis, are sorted out into cyclonic and anticyclonic in circumscribed areas. These are represented by the cyclonic and the anticyclonic lobes of a deformation field in the equatorial air.
- A humidity wave, running in an equatorial vortex street between the tropical and the equatorial, enters the cyclonic lobe, which is then called the cyclogenesis lobe. The cyclonic vorticity in the street itself is most-

ly convected upwards just before entering a cyclonic solid rotation. In the neighbourhood of the cyclogenesis lobe, this convection gives rise to heavy thunderstorm precipitation liberating latent heat of vaporisation. The reduction in density in the cyclogenesis lobe, arising out of the injection of heat and moisture, is equivalent to an 'annihilation of fluid'. A cyclone is thus born.

An atmospheric engine is proposed, the cycles of which account for the birth and death of cyclones.

Some seasonal features are discussed with special reference to the march of the seasons and the changing spacing ratio of the equatorial vortex street.

S. N. SEN

Meteorological Office,
Clifton, Karachi Sadar,
16-6-1943.

CO-ORDINATION COMPOUNDS OF BIVALENT METALS WITH PROPYLENE DIAMINE BIS ACETYL ACETONE

PROPYLENE diamine has been condensed with acetyl acetone to obtain propylene diamine bis acetyl acetone $C_{13}H_{22}N_2O_2$ corresponding to ethylene diamine bis acetyl acetone (*ec*) prepared by Combes.¹ The condensed product behaves like *ec* towards bivalent copper, nickel and cobalt forming complex salts. The copper compound $C_{13}H_{20}N_2O_2Cu$ is violet and forms addition compounds with water and propylene diamine hydrate forming respectively the dark coloured compound $C_{13}H_{20}N_2O_2Cu, H_2O$ and the green compound $C_{13}H_{20}N_2O_2Cu, OHNH_3C_3H_7NH_2$. Two molecules of the latter give on dehydration a new salt $(C_{13}H_{20}N_2O_2Cu)_2, C_3H_7(NH_2)_2$. In all these additive compounds, the co-ordination number of copper is 5 as in the corresponding compounds with *ec* prepared from Combes's salt² $C_{12}H_{18}N_2O_2Cu$ by Morgan and Smith.³ Complex cobalt and nickel compounds will be described later.

Chemical Laboratory,
Presidency College,
Calcutta, 17-6-1943.

KANAI LAL MANDAL.

¹ Combes, *Compt. Rend.*, 108, 1252, 1889.

² *Loc. cit.*

³ Morgan and Smith, *J. C. S.*, 912, 1926.

ON THE RAMAN SPECTRA OF METHYL-AND ETHYL SULPHIDE IN THE SOLID STATE

It is well known that the Raman spectra of some organic compounds which are in the liquid or gaseous state at the room temperature undergo some changes when these substances are solidified. These changes

are mainly of two types, viz., (a) some new lines appear in the low frequency region besides the splitting up of some of the lines in a few cases and (b) in the case of some aliphatic compounds large numbers of Raman lines disappear in the solid state. The lines in the low frequency region are very intense in some cases and are absent in other cases. The hypothesis that these lines are due to lattice oscillations¹ cannot account for such abnormal intensities. This was pointed out by Sirkar² who suggested that a new type of bond might appear in the solid state in these cases. The significance of the second type of change was first pointed out by Mizushima *et al.*³ who explained the disappearance of some of the Raman lines in the solid state on the hypothesis that in the liquid state these substances contain a mixture of two types of molecules, one of the trans form and the other either of the cis or of the gauche form and that in the solid state all the molecules are of one of these forms only. On closer examination of the Raman frequencies observed in some of these substances it is found, however, that some of the Raman lines observed can not be accounted for by the hypothesis mentioned above. It would be of interest, therefore, to study the Raman spectra of a large number of such substances in the solid and liquid states so that the results might throw some new light on the true nature of the changes undergone by the molecules in passing from the liquid to the solid state.

A programme of work in these lines has been started by the present authors and in the preliminary stage the Raman spectra of a few alkyl sulphides in the solid state at the temperature of liquid oxygen have been studied and compared with those for the

TABLE I
METHYL SULPHIDE

Liquid at about 32°C.			Solid at about -180°C.	
$\Delta\nu$ in cm ⁻¹	Int.	Polarisation	$\Delta\nu$ in cm ⁻¹	Int.
			70	1
			84	1
			338	1
			402	0
282	2d	D	691	3s
693	8s	P	740	2s
740	3d	D		
1335	0d	?	1450	1s
1424	2d	D		
2844	1d	P	2915	2d
2915	10s	P	2970	2dd
2990	5d	D		

liquid state. The polarisation of the lines for the liquid state has also been investigated. The results obtained for methyl sulphide and ethyl sulphide are

given briefly in tables I and II. In these tables the letters P and D represent polarised and depolarised ($\rho \sim 6/7$) respectively and the letters d and s represent diffuse and sharp respectively.

TABLE II
ETHYL SULPHIDE

Liquid at about 32°C.			Solid at about -180°C.	
$\Delta\nu$ in cm ⁻¹	Int.	Polarisation	$\Delta\nu$ in cm ⁻¹	Int.
302	0	P	88	2d
336	0	P		
391	0	P		
640	2	P		
657	2	P		
690	2	D	690	2s
976	1	D		
1048	0	P		
1426	2	D	1426	1d
1456	2	D	1456	1d
2874	2	P	2874	1d
2930	6	P	2930	2d
2970	3	D	2970	2

It will be seen from tables I and II that solid methyl sulphide gives two new lines at 70 and 84 cm⁻¹ respectively and the line at 282 cm⁻¹ for the liquid splits up into two lines at 338 and 403 cm⁻¹ respectively in the solid state. In the case of ethyl sulphide one new band appears at 88 cm⁻¹ and the lines at 640 and 657 cm⁻¹ disappear completely in the solid state. The significance of these results as well as the results obtained for propyl sulphide and butyl sulphide will be discussed elsewhere.

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Indian Association for Cultivation of Science,
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Calcutta, 7-7-1943.

¹ Gross and Vuks, *Nature*, 135, 100, 431, 998, 1935.

² Sirkar, S. C., *Ind. J. Phys.*, 9, 343, 1937.

³ Mizushima *et al.*, *Sci. Papers, Inst. Phys. Chem. Research (Tokyo)*, 29, 63, 188, 1936.

THIOSULFATES OF THE RARE EARTHS

OUR knowledge of the thiosulfates of the rare earths is very meagre. While working with gadolinium Dr P. B. Sarkar observed that gadolinium thiosulfate is not obtained by double decomposition between the calculated quantity of gadolinium sulfate and barium thiosulfate. On evaporation on

water-bath or over H_2SO_4 , the product decomposes. A concentrated solution, on being precipitated with alcohol, gives a micro-crystalline precipitate which is very unstable. On keeping in air it loses the crystalline form and becomes insoluble in water. Analysis showed the presence of a mixture of gadolinium sulfite and sulfur; $\text{Gd}_2(\text{S}_2\text{O}_3)_3 = \text{Gd}_2(\text{SO}_3)_3 + 3\text{S}$. This observation is equally applicable to the elements of the cerium group. Their thiosulfates are stable only in solution and in the presence of large excess of sodium thiosulphate. This stability in presence of excess of thiosulfate suggests the formation of double thiosulfates in solution. Bismuth, a metal with which the rare-earths show close resemblances, forms several double thiosulfates. Experiments were carried out to investigate the formation of these double salts by physico-chemical methods.

(1) Method of variation: Electrical conductivities of solutions of different compositions were measured. Here a curve A was obtained with two maxima—one in the region $\text{R}:\text{S}_2\text{O}_3''=2:3$, corresponding to $\text{R}_2(\text{S}_2\text{O}_3)_3$, the normal thiosulfates and the other in the region $\text{R}:\text{S}_2\text{O}_3''=1:4$ corresponding to the complex ion $[\text{R}(\text{S}_2\text{O}_3)_4]'''$.

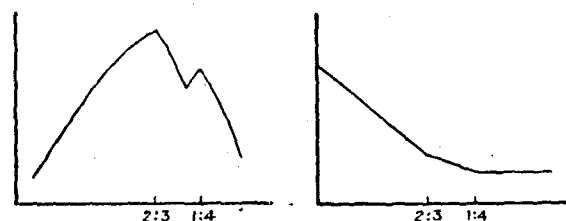


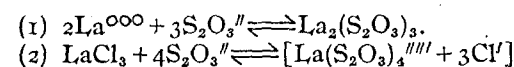
FIG. 1. Curve A.

FIG. 2. Curve B.

(2) Thermometric titration: Here the rare-earth solution was taken in a Dewar flask kept within a second Dewar flask. Sodium thiosulfate solution was then added c.c. by c.c. at regular intervals and changes in temperature were noted. These changes in temperature were then plotted against the c.c. of thiosulfate added. Here again a curve B was obtained with two breaks; one corresponding to $\text{R}_2(\text{S}_2\text{O}_3)_3$ and the other to $[\text{R}(\text{S}_2\text{O}_3)_4]'''$ using sodium thiosulfate. With potassium thiosulfate and ammonium thiosulfate, however, the curves are slightly different. The positions of the first break are identical, those of the second break, here however, lie in the region $\text{R}:\text{S}_2\text{O}_3''=1:3$ corresponding to those of the bismuth series $\text{K}_3\text{Bi}(\text{S}_2\text{O}_3)_3$.

The dissociation constants of these normal thiosulfates and the double thiosulfates of La, Ce, Pr, Nd, Sm have been measured by the method of "Variations Continues" of Prof. Job³. Of the various alternative courses by which the two series of salts, normal and double, may be formed, the following are

taken as the most probable, since the corresponding mathematical expressions give good constants.



In the case of the double salts, it is the undissociated portion of the rare-earth salts that reacts.

It has been observed that the stability of the complexes follows the basicity order of the rare-earths. As the basicity diminishes in the series La, Ce, Pr, Nd, Sm, the stability of the complex increases.

The following double thiosulfates have been isolated. (Cf. Bismuth double thiosulfates).⁴



For the preparation of the sodium salts, rare-earth perchlorates and for the potassium salts the acetates were taken, since sodium perchlorate and potassium acetate are soluble in alcohol. To an ice-cold solution of the rare-earth salt was added an ice-cold solution of the thiosulfate. To this solution was then added a large volume of 95% alcohol also ice-cold, under constant stirring, when the salts were obtained as fine crystalline precipitate.

Further work is in progress. Full details will be published elsewhere.

My best thanks are due to Dr P. B. Sarkar for his kind advice and interest in the progress of the work and all laboratory facilities.

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¹ Sarkar, P. B., *Annales de Chimie*, p. 252, 1927.

² Dutoit, J. *de Chim. Phys.*, Tome, 19, 324, 1921.

³ Job, *Comptes Rendus*, 180, 928, 1925.

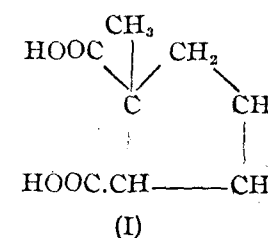
⁴ Vanino and Mussung, *Arch. der Pharmazie*, Band, 257 264, 1919.

DERIVATIVES OF CYCLOPENTANE CLOSELY ALLIED TO WIELAND'S TRICARBOXYLIC ACID, $\text{C}_{11}\text{H}_{20}\text{O}_6$.

THE synthesis of the mono-cyclic tricarboxylic acid, $\text{C}_{11}\text{H}_{20}\text{O}_6$, isolated by Wieland and his co-workers,¹ in the course of their classical researches on bile acids, still remains to be achieved. Substituted cyclopentane acids, such as these, are peculiarly difficult to make. The present communication, how-

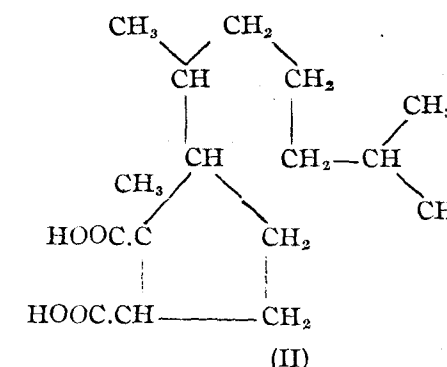
ever, deals with a convenient general method for the synthesis of the acids of this series. Briefly stated, the method is as follows:

Ethyl α -methyl- α' -dibromopimelate b.p. $164-65^\circ/4$ mm., prepared from α -methyl pimelic acid by direct bromination of its acid chloride,² was treated with sodium cyanide in absolute alcohol according to the method of Fuson and Kao,³ to give ethyl 2-methyl cyclopentane-1-cyano-1:2-dicarboxylate b.p. $130-32^\circ/4$ mm. This on hydrolysis with concentrated hydrochloric acid furnished 1-methyl cyclopentane-1:2-dicarboxylic acid (I), evidently as a mixture of *cis*-, and *trans*-forms. The *trans*-acid, however, readily crystallised from water, melting at 144° . The crude acid on being heated with acetic anhydride in a sealed tube furnished the *cis*-anhydride which when boiled with water gave the *cis*-acid, crystallising easily from a concentrated aqueous solution and melting at 131° . (Bachmann and Strive³ give m.p. $142-43.5^\circ$ for the *trans*-acid, and m.p. $128-29^\circ$ for the *cis*-acid). A mixture of equal proportions of the *cis*-, and *trans*-acids showed mutual depression of melting point.



The work is being extended in several directions and the preparations of α -methyl- β -iso-octyl pimelic

acid has already been achieved. The preparation of the cyclopentane derivative (II) by following the method outlined above, is being actively pursued with every hope of ultimate success. This acid on oxidation with chromic acid according to the method



of Windaus and his co-workers,⁴ is expected to furnish the tricarboxylic acid, $\text{C}_{11}\text{H}_{20}\text{O}_6$. The results will, however form the subject of a later communication.

The author desires to express his best thanks to Dr J. C. Bardhan for his kind interest in the progress of this work.

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¹ *Z. Physiol. Chem.*, 134, 276, 1924; *ibid.*, 216, 91, 1933.

² *J. Amer. Chem. Soc.*, 51, 1536, 1929; *ibid.*, 60, 1237, 1938.

³ *J. Amer. Chem. Soc.*, 63, 1262, 1941.

⁴ *Z. Physiol. Chem.*, 117, 146, 1921.

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FLOOD

THE flood in the Damodar River which has come in the wake of the Famine in Bengal has now focussed the attention of the public and the Government on this river. The Damodar floods are not unexpected events. Almost every year this river is in flood during the months of July and August, and sometimes even in September and October, but catastrophic floods are rare. According to available statistics, they occur with a frequency of two per centum (*vide* article following). The last great catastrophic flood, memory of which still lingers in the minds of the Calcutta people, occurred in 1913. According to available information, the present flood has only attained half the intensity of the 1913 flood,* but the damage done appears to be on the same scale. This points unmistakably to a progressive deterioration of protective measures hitherto adopted and as our contributor points out, this is fraught with the gravest menace to the existence of the city of Calcutta in addition to the menaces to other interests already existing.

The full story of the Damodar and of its floods has been recounted at length by Mr. K. Ray, in the following article. The reader will perceive from a perusal of this article that four major interests are involved in the Damodar River. These are:—

(1) *Interest of the Rural Population.*—A rural population of about 3 millions live in the districts of Burdwan, Hooghly, and partly of Howrah and Midnapore. Though the whole of this population does not live in the Damodar basin, they are all

* In the 1913 flood, the maximum discharge was 6.5 lakh cusecs for about 6 days. In the present flood according to available information, the discharge has been 3.5 lakh cusecs only extending over approximately the same interval of time. There have been two distinct floods this year one occurring on July 18, the other about August 5. It will be interesting to see whether the two floods are due to heavy precipitation in the two catchment areas (Damodar and Barakar) occurring at intervals of about a fortnight, and whether the 1913 flood was due to the precipitations occurring in the two areas simultaneously.

vitaly concerned in the river. Our contributor has shown from original records that in spite of occasional floods this region was one of the most prosperous and healthy tracts of India up to 1850, because as a result of experience extending over thousands of years, the people had evolved a method of properly utilising the flood water,—and enriching their fields with it, and protecting themselves against occasional heavy floods, in other words, of living happily with the river. This state of affairs was put to an end in 1850, when railways were opened, embankments were interfered with, and the people's right of utilising the flood waters for irrigation was curbed by special orders and legislation, all with a view to protecting the railways lines. The full tale of woe of the unfortunate residents in these districts is recounted in our third article.

(2) *The Railway Interests.*—Through the Damodar basin, pass the arterial railway lines connecting the city of Calcutta with Upper India, and also the Grand Trunk Road.

These railways and roads are in constant danger from the floods and in spite of protective measures which have been undertaken at great cost, breaches have frequently occurred in the past, and the traffic of Calcutta with Upper India and the coal districts has been suspended for long periods.

(3) *The interest of the coal-miners, and other growing industries in the Upper Damodar valley.*—Along their upper reaches the Damodar and its tributaries pass through the most important coal fields, where more than 80 per cent of India's total coal is raised. This interest has likewise grown only since 1850. The coal-miners have shown themselves averse to any measures which might interfere with their interests. This district is rapidly growing to be a great manufacturing centre owing to the discovery of Bauxite, Mica and other minerals.

(4) *The City of Calcutta.*—The city of Calcutta, as a great port and industrial centre, is of course

greatly interested in keeping her communications intact with the rest of the country, particularly with Upper India, and the mining districts of Chotanagpur. But even this factor is not so vital, as the question of her very existence which is threatened by the possible diversion of the Damodar towards the east, which would cause an enormous amount of flood-water to be discharged north of the city into the Hooghly. Mr Addams-Williams emphasized this point in his report to the Bengal Government in June, 1920.

Many persons have been inclined to regard this view as merely "seeing daggers in the air". But in our opinion, Mr Addams Williams' arguments require very careful examination. A perusal of the relevant literature shows that all engineers who have dealt with the problem have been aware of this danger. In fact, when the Damodar took a turn about 1855 towards the east by the course known as the Kana Nadee, and began to discharge its waters some thirty miles up Calcutta, the engineers got frightened, and got it closed by a dam near its source at Selimabad. But how long can this movement be resisted? This year, the breach has taken place over a stretch on the left embankment, and the flood waters have spread over the low land north of the railway lines. It was fortunate that the flood was moderate; if it were on the scale of the 1913 flood, probably Addams Williams would have been hailed as a veritable Cassandra.*

The people of Calcutta may congratulate themselves on their escape from a disaster of unprecedented scale this time, but should they allow matters to rest there? The factors which are forcing the Damodar eastwards are unrelentingly at work. These are: continual raising of the unembanked right bank, continual decrease of spill-way on the right, and continuous raising of the river-bed by silt deposit. This is increasing the pressure on the left embankment and the situation is deteriorating every year. The measures which have so far been taken have been only 'ad hoc' and do not go to the root of things.

Already the level of Calcutta is below the level of the surrounding country, and the carrying capacity of the Hooghly has been so diminished by encroachments on her bed that she is hardly able to carry her present maximum of half a million cusecs of flood water. If the Damodar cuts out a new channel to the east, and another flood on the 1913 scale occurs, the city may be swept by the flood waters, and a large part may be buried under silt. This will spell disaster to the whole city and of manufacturing areas on both sides of the river.

Such disaster seldom occur, but they do happen

* Cassandra—Daughter of King Priam who always prophesied correctly, but was never believed.

and when they happen, it is always with a finality. History is full of such instances, especially when cities were situated on the banks of rivers, and as in ancient times, this was always the case. We have many instances of such occurrences in ancient times.

Irrigation and flood control have always gone hand in hand with civilization. The ancient seats of civilization on the Indus, the Nile and the Euphrates and the Tigris basins tell us the same story. The archaeological evidences show that all these ancient civilizations on mighty river basins suffered from occasional inundations, and there are cases when cities were totally buried under thick layers of silt of heavy flood. Remains of the ancient cities of Ur of the Chaldees about 3000 B.C. in the lower Euphrates basin, Mohenjodaro in the Indus basin, Pataliputra at the confluence of the Ganges, the Son and the Gandak have been unearthed from the thick sediments of earth indicating abnormal inundations which probably caused complete destruction of these cities. According to certain archeologists excavations in Ur of the Chaldees have shown that the older layers of the city were completely buried under the silt of a heavy flood of the Euphrates and this might be the basis of the story of Noah's Deluge described in the Bible.

But let not our readers be under the impression that such occurrences are entirely things of the past. Such events have taken place even in modern times. In March 1913, the Miami valley in the Ohio State, U. S. A. was swept for five days by a steady down-pour of rain, resulting in a great flood which rushed through the streets of two small cities Dayton and Hamilton. When the flood receded, Dayton and Hamilton were covered with mud and debris. Not only many lives were lost, but enormous damage was done to property; martial law had to be declared and spread of pestilences was prevented by adoption of extraordinary measures; power houses were completely buried under debris, and had to be located by geophysical prospecting methods.

A radical solution to the problems raised by the Damodar floods was suggested by Messrs Glass and Addams-Williams in 1920, as a result of intensive field work extending over a number of years. These measures are described in the next article. In our opinion, if these measures were given effect to, the fury of the flood would have been curbed, and there would be far less danger to the railways and the roads. The threatened diversion of the Damodar towards the east would have been averted, thus ensuring for ever the safety of Calcutta. And above all, the Damodar would have been converted into a perennial river, and the peasant would have been able to raise two to three crops in course of the year, as has been rendered possible in Egypt by the construction of the Assuan Dam over the Nile. The

dead rivers of Eastern Burdwan would have again come into life, and malaria which has claimed millions of victims in this region since 1854, and is still a scourge would have disappeared.

It now appears that the Government had almost decided to built the reservoir dams at Parjori on the Damodar and at Palkia on the Barakar and preliminary works had already been started when a small bird appears to have whispered into ears of the coal-magnates of Calcutta that if these reservoirs were constructed, they would spoil their mines. A critical study of the opinions of the experts on the subject shows that there were by no means unanimity on this point even amongst geologists and though the Government was justified in suspending the operations temporarily, they had no justification in dropping them altogether, as they actually did. After the operations were dropped in 1920, nothing had been done except the construction of the Anderson Weir and Dam, which was, in our opinion, a very ill-considered project, as subsequent events have shown. This was done more as a sop to the agricultural population than as any radical remedy for the Damodar floods.

In our opinion, the suggestion that water would percolate through the faults in the rocks and spoil the coal mines is extremely vague, and should not have been accepted without further examination. The Mohne Dam in Germany, which was recently destroyed by allied bombing, is in the midst of the Ruhr coal area, and there are possibly other dams, in similar areas but it has not been generally known that coal mines have been spoilt by percolation from reservoir water. At any rate, percolation and artesian action would have only a limited range, and it was probably a lesser evil to sacrifice a few mines than to endanger a whole countryside peopled by three million men, expose important railway lines to frequent danger and above all endanger the existence of the great city of Calcutta. Probably other sites for reservoirs could have been found in the Damodar valley where storage dams could have been

constructed without causing any damage to the coal mines.

Since the great Miami flood in 1913, the U. S. A. Government has undertaken and completed a large number of storage dams and river-training works in different parts of that vast country. The underlying policy has been to regard the whole river basin as a unitary area, and coordinate plans of flood control with those of irrigation, development of backward agricultural areas, development of hydroelectric power, and improvement of navigation, for according to *Scientific American*:—

"The greatest total public benefit is not attained through piecemeal development. It is come by through treatment of a drainage basin as a whole, through co-ordinated operation of strategically placed plants. And it is entirely possible that comprehensive development requires fewer structures than piecemeal development."

In course of these works, enormous amount of scientific work has been done, e.g., claims of storage dams, and afforestation have been correctly estimated, new desilting devices have been discovered and put into operation, and a complete service for prediction of floods, and for giving flood warning has been elaborated. All projected works were first tested by means of model in river laboratories before they were actually carried. Twenty five years have passed since Addams Williams and Glass submitted their report—it is now necessary that the problems be again surveyed and latest developments in technique be utilised in their solution.

What is to be done now? We are of opinion that the Government should tackle the problem courageously, and with a determination to push through radical measures. They can do no better than follow the example of the U. S. A. Government, which immediately after the great flood of 1913, appointed a Miami Conservancy Board and carried out thorough and radical measures, with the result that threats of floods have been completely eliminated.

DETENTION-DAMS Vs. AFFORESTATION

Large claims are being made in certain quarters in favour of afforestation of the upper catchment area, and the impression has been produced that afforestation might render construction of flood detention dams superfluous. Regarding these claims, the following extract from *Scientific American* (154, 326, 1936) will be interesting:—

"Through the work of the Civilian Conservation Corps, many areas have been reforested recently. The new forest cover on formerly barren hills and slopes has done much to retard the melting of snow and prevent a rapid run-off of water. Other control measures taken under the super-

vision of the Soil Conservation Service, Department of Agriculture have aided further. Mr H. H. Bennett, Chief of that Service, says that: 'Our work the last two years in 141 watersheds throughout the country indicates that the volume of run-off water can be reduced 20 to 25 per cent through the use of erosion control methods. This is the margin, in most cases between mere high water and destructive floods.'

Detention dams, dykes and similar engineering measures are essential to complete flood control in localities where the hazard is unusually severe (italics are ours). This control starts with the proper preparation of the cultivated field, and terracing is being resorted to in many localities where, formerly, heavy rainfall has scoured out entire hill-sides."

THE DAMODAR RIVER

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THE river Damodar in Western Bengal has been notorious for its devastating floods. It is not a perennial river, but a typical hill-stream. During the winter months, the bed is almost dry, but with the outbreak of the monsoons it rises with all the fury of a mountain stream, though the maximum devastating power of the river is usually spread over only a few days. The floods of the Damodar are one of the gravest problems of Western Bengal causing, as they do, great damage to the agricultural population almost every year, and catastrophic disasters at irregular intervals. The threat appears to be on the increase with time, and, as will be shown, in spite of repeated warnings by competent authorities,^{1,2} no steps have yet been taken to tame the river by systematic scientific measures. Attention has been once more focussed on the river by this year's flood which, according to Government communiqué caused on July 20 a breach of about 1,000 feet wide in the protective embankment, resulting in serious breaches in the E. I. Rly. lines and seriously dislocating the traffic of Calcutta with Upper India. The flood of July 18 was followed by another surge on August 5, causing further breaches, and inundating the country north of the railway lines up to Kalna. The total extent of the disaster is still only imperfectly known, but it is obvious that though the flood appears to be far less severe than that of 1913, the damage caused appears to be on the same scale.

The present article has been compiled with a view to acquaint our readers with the nature of the problems and to suggest permanent remedies.

THE RIVER, ITS CATCHMENT AREA AND COURSE

As the reader will perceive from the map, the river rises in the hills of Chotanagpur about 50 miles to the north-west of Ranchi, and at an elevation of 2,000 feet. It flows generally in a south-easterly direction over a total length of 337 miles before it empties itself, at present partly into the Hooghly 30 miles south of Calcutta and partly into the Rupnarayan above Kolaghat. The most important affluent is the Barakar, another hill-stream, which rises likewise in the North Chotanagpur plateau and flows into the Damodar near the Barakar station on E. I. Rly., about 11 miles up Asansol.

For 200 miles from the source up to the town of Raniganj, the Damodar is a typical hill-stream. The flow is extremely variable; it is scarcely 50

cusecs (*i.e.*, cubic feet per second) in the dry season, but during heavy floods the flow may become even ten thousand fold (half a million cusecs). Even in normal years the flow multiplies nearly five thousand fold, and this generally lasts for weeks. The banks are rocky for about two hundred miles, the bed is deep and the courses are more or less permanent. The slope of the bed is 8 ft. per mile near the source but falls to about 3 ft. per mile near Raniganj. During flood, enormous loads of sand and silt are brought down by the river, which must be deposited along the course, thus raising, possibly, the bed level and altering the slope. The major effect of erosion and of the bringing down of huge quantities of sand is, however, the raising of the bed of the river in the lower region when the velocity slows down and the formation of deltas at the mouth of the river. This factor obviously tends to choke the flow and divert the course at the lower reaches.

In their upper course both the Damodar and the Barakar flow through areas containing the richest deposits of coal in India. The coal fields are shown⁴ on the map by shaded patches which are numbered as follows: (1) Raniganj, (2) Jharia, (3) Bokaro, (4) Ramgarh, (5) Karanpura, (6) Giridih, (7) Jainti, (8) Sahajuri and Chandrapura, (9) Kundit Karaia, (10) Itkhor, etc. The upper Damodar catchment covers an area of 4200 sq. miles, the Barakar catchment 2650 sq. miles, the hilly part of the middle Damodar 350 sq. miles and the lower Damodar 1,000 sq. miles. The coal fields are being operated in more recent dates and before that time the region, having not much agricultural value, was only sparsely inhabited by aboriginal tribes. The tract however is not cultivated extensively nor there exists any notable forest which might keep the detritus from sliding into the streams and might hold more water in the soil. There remains sufficient scope for afforestation at the upper reaches to check the rapid erosion of land, to reduce the quantity of silt brought down by the rivers and retard the down rush of water to some extent. The opening of the coal fields and the discovery of mineral deposits, like those of bauxite, mica, etc., have already turned this region into a great industrial belt, and its importance is rapidly increasing.

THE LOWER BASIN

There are no coal fields below Raniganj along the Damodar, and in its lower course the river flows

through the once prosperous but at present decadent agricultural districts of Burdwan and Hooghly. Nearly hundred years ago, when the coal fields were not discovered the lower deltaic areas, on account of their fertility formed "veritable beehives of humanity", and protective embankments were in existence from time immemorial to keep the river in check during flood times. But during catastrophic floods, the river often burst its embankments and

to have been brought about by the year 1770 when probably due to a heavy flood, the Damodar took a sharp southerly bend some 12 miles down the town of Burdwan.

Besides this major change, the lower deltaic region has also seen several minor changes in the river course within recent times. As a matter of fact it flowed through a branch, now dead, from Selimabad about 7 miles below the bend. This

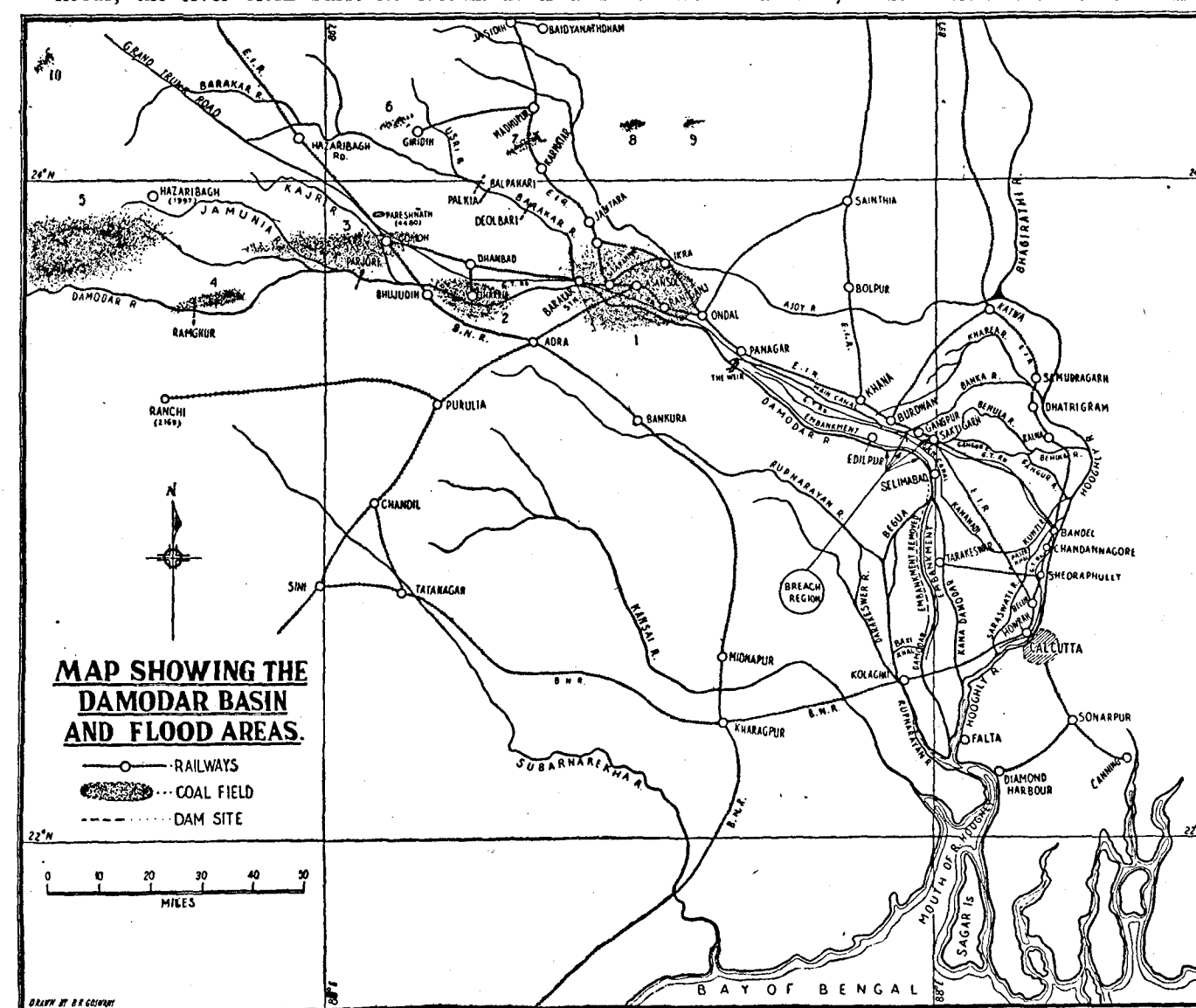


FIG. 1. Damodar Basin, Flood Areas and Coalfields.

struck out new channels. In fact the whole of the lower area is full of variable, decaying and dead river courses. Prior to 1770, the Damodar flowed into the Hooghly near the town of Kalna, 50 miles to the north of Calcutta; but now the main bulk of the water flows south into the Rupnarayan above Kolaghat. This major change in the course appears

branch curving in a south-easterly direction entered into the Hooghly some 20 miles below Calcutta, at a point opposite Falta. This dead branch is now known as Kana Damodar (*Kana*=Blind). Later on there opened a second branch almost from the same point, but it flowed more easterly and ultimately joined with the Hooghly through the Kunti some thirty miles

above Calcutta. This Kana Nadee, as it is called, was first closed by a bank in 1853 at its starting point near Selimabad probably because of a possible danger to Calcutta. The embankment breached in 1856 filling three old canals. In 1863 the Kana Nadee head was finally closed. In 1875 the Jamalpur head regulator was built again to supply water to these canals. The last great change was brought about in 1865 by the opening of the Begua. The Begua, unlike Kana Damodar and Kana Nadee, branches off through the right embankment of the Damodar at a point about 5 miles below Selimabad. It is a

The real flow starts with the monsoon in June. By the middle of July the river rises high, carrying from 2 to 3 lakhs of cusecs at average normal flood. Such floods are quite frequent and comprise about 55 per cent in the frequency of occurrence. Generally in August, the flood occasionally discharges from 3 to 5 lakhs, on rare occasions even 6½ lakhs of cusecs of water have been registered as in the great flood of 1913. The following table gives an idea of the types of flood in the Damodar recorded between Raniganj and Edilpore (near Burdwan), within the last few years.

TABLE I
CLASSIFICATION OF THE FLOODS IN DAMODAR

Type of Flood	Percentage of occurrence	Probable maximum peak discharge cusecs.	Probable duration above 100,000 cusecs.	Probable duration above 50,000 cusecs.	Probable volume in million cu. ft.	Corresponding run-off from 7,000 sq. miles.
Average normal flood ...	55%	250,000	Hrs. (Days)	Hrs. (Days)	58,000	3½ inch.
Maximum normal flood ...		300,000	84 (3¼)	144 (6)		6 inches.
Maximum abnormal flood ...	18%	450,000	132 (5½)	204 (8½)	100,000	7 inches.
Maximum extremely abnormal flood ...	2%	650,000	132 (5½)	204 (8½)	112,000	10½ inches.
			156 (6¼)	228 (9¼)	169,000	

The frequency of years of subnormal floods below 200,000 cusecs is nearly 25 per cent. A record of seven floods is shown in Table II.

well-defined river over a length of 8 miles. It bifurcates into the shape of deltaic split channels over 8 or 10 miles towards the end and falls into a stream known as the Mundeswari; the combined waters falling into the Rupnarayan above Kolaghat. This branch handles more flood water than the Damodar proper which flows into the lower Hooghly. In the flood of 1913 the peak discharge of 225,000 cusecs was recorded through this branch as compared against 50,000 cusecs down the Damodar itself.

The lower basin, comprising the districts of Burdwan, Hooghly and parts of Midnapur, is covered thoroughly with a net-work of active channels of the Mundeswari, the Darakeswar, the Rupnarayan, the Ratankar Khal, etc. They are now serving as a system of spill channels for carrying away the flood waters properly. There are in addition certain dead and decaying channels. All the channels on the north side of the river, viz., the Khareah, the Banka, the Behula, the Kunti are dead channels, and they pass through an intensely malarious and decadent district. If these beds can be resuscitated, this part of the country would return to its pristine prosperity.

NORMAL LIFE OF THE RIVER AND ITS FLOOD

During most part of the year the river does not flow at all or has a flow hardly exceeding 50 cusecs.

The discharge rate begins to fall in October, and by early December the flow practically ceases. The Damodar is thus a dead river from December to June, it is a powerful hill-stream in July, a "River of Sorrow" during the high flood month of August, while in September and October it is usually a rapidly decaying stream. (But floods have been known to occur even as late as October, see Table II).

The river, as it is to-day, can scarcely handle 250,000 cusecs with safety, as ascertained by Mr Addams Williams, Superintending Engineer and Mr Glass, Executive Engineer in 1920. The river bed is already higher than the surrounding land level at many places, and as the heavily laden flood water is confined within embankments, silt continues to be deposited and raises the level of the bed. As a consequence, the left embankment, which has been raised and raised, cannot now withstand even the pressure of normal floods of 2 to 3 lakhs of cusecs. To illustrate, the peak discharge during this year's flood scarcely exceeded 3½ lakhs cusecs, but it has caused apparently as much damage as that of 1913 when the discharge was as high as 6½ lakhs.

ANCIENT METHODS OF FLOOD CONTROL AND RIVER TRAINING

All the ancient civilizations dawned on the green valleys of the mighty rivers. The Indo-Gangetic

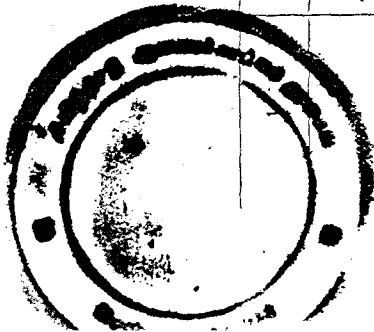
TABLE II
DAMODAR RIVER FLOODS
Details of seven rainstorms and of the resulting floods as observed at Raniganj.

2	3	4	5			6			7	8	9			10	11	12	13	14
Dates of occurrence of storm.	Dates of occurrence of flood.	Number of hours of run-off.	Total mean rainfall in inches.			Total rainfall in million cu. ft.			Total run-off in million cu. ft. from catchment of 7,200 sq. miles.	Percentage of run-off to rainfall.	Average rate of rainfall in thousand cusecs during total period of storm.			Mean rate of run-off during flood period.	Percentage of 10 to 9 (iii).	Highest rate of run-off in cusecs.	Probable contribution from Balpahari catchment.	Probable maximum contribution to run-off rate from remainder of catchment.
			On Balpahari catchment.	On remainder above Raniganj.	On total catchment above Raniganj.	On Balpahari catchment of 2,000 sq. miles.	On remainder of catchment above Raniganj of 5,200 sq. miles.	On total catchment of 7,200 sq. miles.			On Balpahari catchment of 2,000 sq. miles (i).	On remainder of catchment above Raniganj of 5,200 sq. miles (ii).	On total catchment of 7,200 sq. miles (iii).					
28th to 31st Aug., 1909.	31st Aug. to 1st Sept., 1909.	135	6.5	3.9	4.6	30,000	47,000	77,000	(?)*	(?)*	87	136	223	(?)	(?)	357,000	110,000	200,000
5th to 10th Aug., 1913.	6th to 14th Aug., 1913.	189	13.3	10.9	11.8	67,300	129,700	197,000	70	70	120	250	370	54	54	650,000	250,000	400,000
21st to 25th Sept., 1916.	22nd to 28th Sept., 1916.	138	7.6	6.0	6.4	35,300	73,000	108,300	63	63	68	141	209	65	65	393,000	125,000	275,000
1st to 5th Oct., 1936.	2nd to 9th Oct., 1916.	156	6.2	4.1	4.7	28,800	47,200	76,000	74	74	67	109	176	57	57	237,000	90,000	200,000
29th July to 2nd Aug., 1917.	30th July to 4th Aug., 1917.	144	12.3	8.5	9.6	60,000	102,000	162,000	54	54	139	236	375.9	45	45	285,000	75,000	250,000
30th Sept. to 7th Oct., 1917.	1st to 12th Oct., 1917.	258	11.3	9.2	9.8	52,000	108,000	160,000	84	84	75	156	231	63	63	385,000	135,000	275,000
29th to 31st Oct., 1917.	30th Oct. to 1st Nov., 1917.	60	1.6	3.2	2.7	8,000	38,000	46,000	57	57	30	150	180	67	67	214,000	40,000	200,000

These details show that it is not possible to control floods to a maximum discharge of 200,000 cusecs by Balpahari reservoir alone.

Detailed gauging at Raniganj not available. This is really the sum of run-offs of two consecutive floods. (iii) is less than 9 (iii) for this storm only.

Am 2.12.35
Nagpur



plain, the Nile basin and the Tigris-Euphrates basin have been very much alike from several standpoints. Most of the prosperous cities, such as Ur on the Euphrates, Mohenjodaro on the Indus or Pataliputra at the confluence of the Ganges, Gandak and Son suffered from devastating inundations. The people knew of occasional floods—some for their benefit and some for woe. The people in those days, therefore, had to face both the problems of irrigation as well as flood control.

On the Nile, a wide strip of land on either sides were embanked in order to confine the flood waters in the basin. The basin was fed with flood water, laden with fertilizing mud, through suitable canals, and the waters were allowed to run off through outlets after proper interval of holding. This old method of the 'basin irrigation' has now been much improved but the working principle was known in Egypt from very early days.³

In Bengal, notably in the Damodar basin, the 'over-flow' irrigation was usually practised. The river rose to a considerable height during flood months, and the over-flow canals were fed along the length of its course. The Damodar silt, unlike its coarse sand at the bottom, is a good fertilizer for agricultural land. The over-flow canals carried the finer suspended matter and provided manure for the cultivated lands of south-west Bengal. There were the protective embankments all the same, but not perfectly water-tight; there were sufficient number of over-flow canals and spill channels all along the river course.

The canal systems and a large number of small rivers and *khals* on the lower tracts facilitated perfect drainage of lands—washing off depressions and swamps which are the breeding places of mosquitoes. As the channels tend to get choked due to constant silting, they were periodically and systematically cleared. This "Desilting" operation was called "pulbandi".

The ancient people knew also how the bends and sinus loops of the river could be cut straight, or how two rivers could be connected by means of a *khal*. Speaking particularly on the lower Gangetic channels Sir William Willcocks* remarked⁵ that most of these looked more like human handiwork than mere natural spillways. According to him the

* Sir William Willcocks, a famous irrigation engineer, was for long associated with the Irrigation Department of the Egyptian Government. He planned and carried out construction of great storage dams on the Nile like the well-known Assouan Dam, which ultimately converted the Nile into a great perennial stream, and ensured the Egyptian peasantry of supply of water during dry seasons of the year. Willcocks was invited by the Calcutta University to deliver a course of readership lectures on irrigation problems of Bengal and these were published in the form of a book in 1930. Much of the information given in this paragraph has been taken from this book.

Ganges, in the ancient times, flowed east by the Padma course, and the Damodar with other Chotanagpur rivers flowed south-east over central Bengal. The Bhagirathi and most of the present Nadia rivers did not exist; they were all cut by people under the directions of zaminders and kings. Mr Willcocks went so far as to say that the story of Bhagirath's bringing down the Ganges is nothing but the mythological representation of the physical phenomenon of cutting out the new course which subsequently came to be known as the Bhagirathi from the Ganges to connect it to the Damodar and its branches. This interpretation may not find credence, but it cannot be denied as Willcocks insists that the river problems and the methods of river training were known in India from very early days of her civilization.

EFFECT OF RAILWAY AND OTHER EMBANKMENTS

The E. I. Railway system was constructed along the north bank of the Damodar by the middle of the last century, and this along with the older Grand Trunk Road forms the vital arterial communication of Calcutta with Upper India. There has always existed the threat that a flood in the Damodar may breach the Grand Trunk Road and the railway lines. The protection of the left embankment of the river, therefore, became a matter of extreme anxiety. In order to meet the threat, it was thought necessary to strengthen the left embankment. It was further found that the pressure on the left embankment would always be very great if the flood was not allowed to spill off some how somewhere else. In 1857 the Government decided to remove the right embankment (shown dotted on the map) to allow free spill of flood water across a country side which was not considered very important. This safety valve, however, has nearly ceased to operate in course of half a century owing to sedimentation and raising of the general level as predicted by engineers. Although in 1857 it was declared to be a temporary measure, no permanent steps have been taken up till now.

The fortification of the left embankment which provided no outlets for water on the northern tract, led to very harmful effect on the people and the land across it.^{6,7} About 1930 the Anderson Weir was constructed and the Damodar main canal (the so-called October canal of Willcocks) was opened to give some water to a small tract north of the embankments. But this work is no cure for floods, and even as a palliative for the rural population, its utility is limited, as it can deliver no water during winter when water is most needed.*

* The evil effects of interference with the life of the river especially in the district of Burdwan has been described in the subsequent article. (Ed.—*Science and Culture*).

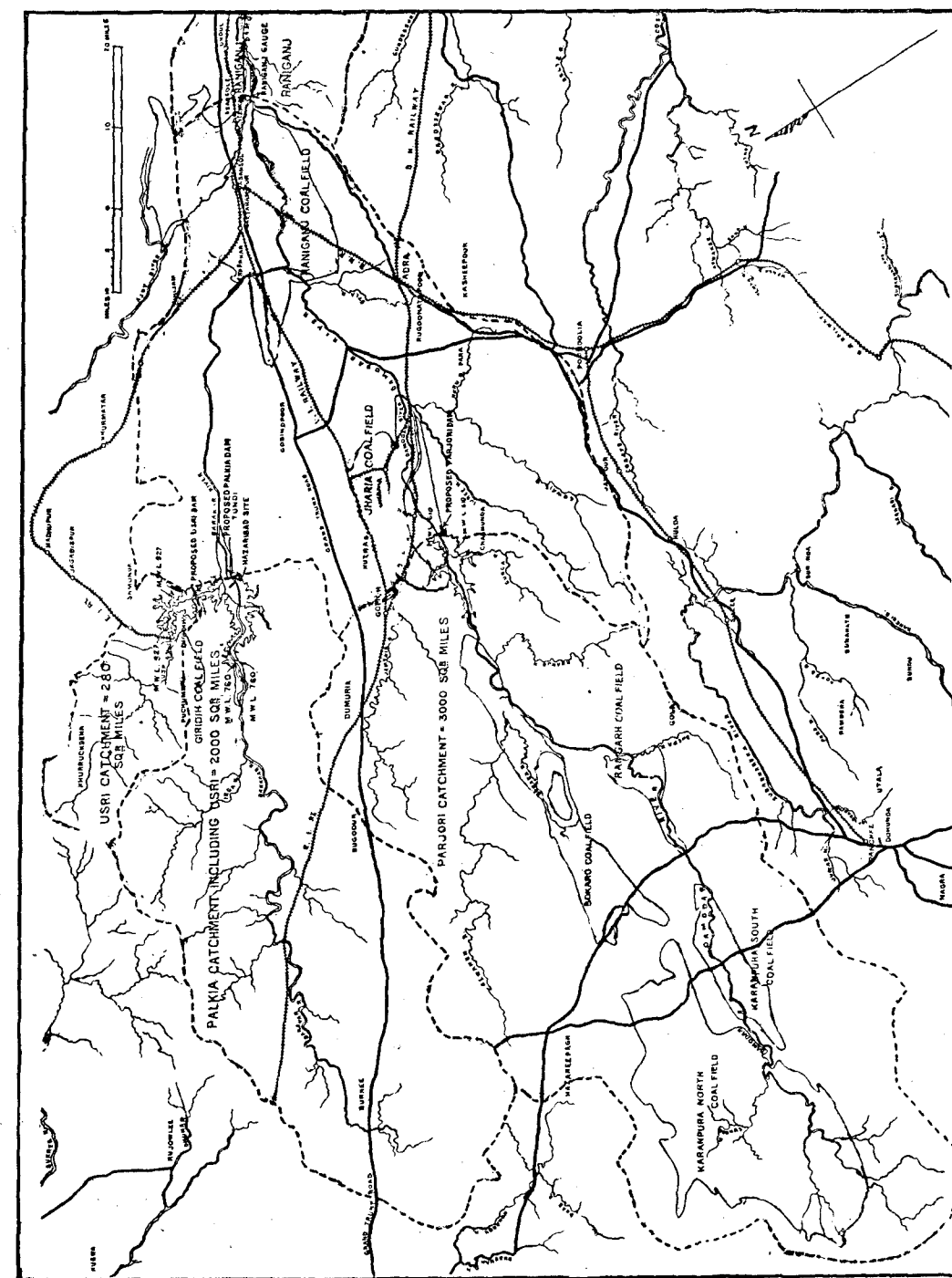


FIG. 2. Map by H. L. Glass, showing the upper catchment areas of Damodar and Barakar with the proposed Dam sites.

MODERN MEASURES RECOMMENDED FOR THE DAMODAR

The methods of flood control and river training in general, are now-a-days no longer a matter of the rule of thumb. Modern methods are based on scientific studies of the problem in well-equipped laboratories, coupled with extensive field operations and collection of systematic records taken over years. The solution of the problem, however, varies with the nature of the river: whether, for example, we have to deal with hill-streams or snow-fed rivers. It also depends upon the bed slopes, on the geology of the basin, etc. Even in the case of a single river the problem may be of a diverse nature at its different parts (e.g., its tidal and non-tidal portions, etc.). We shall however, confine our attention only to the problem of the Damodar with special reference to its notorious floods and their control.

What we have seen previously on the discussions of the catchment areas, rainfall, irrigation, etc., it is convincing that the problem should be primarily tackled at the upper reaches followed by the improvements at its lower courses through well-planned embankments and irrigation canals. Mr Addams-Williams, Superintending Engineer, on special duty in connection with the investigation of the Damodar floods, said:

"I am personally of the belief that a combination of partial control in the hills and quicker release of the floods in the plains is the best line of action to pursue."

The most striking feature of the Damodar flood is that it takes up a quick start immediately the upper catchment receives the heavy showers from the monsoon rain clouds. The meteorological phenomenon behind it can be predicted with fair accuracy, and the timely telephonic report of the rainfall may easily be utilised to control the subsequent flow provided that such controlling arrangements have been already in existence. With the help of the rainfall data observed on the stations situated over the catchment areas the time of arriving, the height and the discharge rate of the flood at any lower station can be predicted with remarkable accuracy. On some rivers like the Mississippi, the Danube, and the Po, the flood prediction services also serve for the dissemination of the information as to the conditions of navigation (e.g., on the Danube).

The first measure that has got to be adopted, as has been recommended by the experts in order to arrest the heavy rush of flood water, is to construct reservoirs and dams in the hill areas. The basin of the river at such regions are more or less bowl-shaped on the hill side, and sloping eastwards. The streams make their way either through the gorges or some other wider opening. A strong dam constructed across these sites would arrest a large

volume of water on the spot and this can be released into the stream through suitable opening or sluices. The problem of silting of the reservoir can be tackled by allowing the heavily silt laden water to escape and storing only the clearer water as in the case of the Assouan Dam on the Nile. Extensive afforestation of the catchment areas will also reduce the amount of silt, which will prolong the life of the dams as well as reduce the crest of the flood to some extent.

The proposal for the construction of dams on the Damodar and the Barakar sites was first mooted by Mr Horn, Superintending Engineer, in 1902. After the record flood of 1913, the Government requisitioned the special services of Mr E. L. Glass, Executive Engineer of C. P., who had extensive experience of construction of reservoir dams in C. P., and Mr C. Addams-Williams, Superintending Engineer, in collaboration with Mr. B. L. Subarwal, now Chief Engineer, Irrigation Department, Bengal. They carried out a very thorough survey of the sites and came to a definite conclusion. The survey party consisted of engineers, geologists and other experts and it was at first concluded that the construction of the dams, one near Balpahari on the Barakar and the other at Ramghur on the Damodar, would reduce the peak discharge to 50 per cent during a flood. A third dam on the Usri, a tributary of the Barakar, was also recommended to be constructed. It was further added that after the dams were constructed, hydro-electric projects could be added to get a direct return of the investment, for a small additional cost. These plans were however further modified and final plans were submitted by E. L. Glass on January 8, 1920, and are:

Parjori Dam on Upper Damodar ...	Rs. 68 lakhs
Palkia Dam on Barakar ...	" 59 "
Usri Dam (including Hydro-electric power scheme) ...	" 26 "

Total ... Rs. 153 lakhs

The schemes were further modified by Mr Addams-Williams and the figures are given in the next page.

UTILITY OF THE DAMS

To show analytically, (a) The reservoirs will primarily hold the water received on the catchment areas during a rain storm and at general monsoon showers. This will prevent the excessive rush of flow through the river which is incapable of handling more than 250,000 cusecs with safety. It may be recalled that out of a total annual rainfall of 50 inches, nearly 43 inches are received in course of 4 months (June—September) which means that a total volume of about 700,000 million cubic feet is

received during this period for the total catchment of the upper Damodar and Barakar. The total yearly rainfall of 50 inches corresponds to a precipitation of 800,000 million cubic feet.

SCHEME BY ADDAMS-WILLIAMS

Site	Storage (millions cu. ft.)	Catchment area (sq. mile)	Cost (lakhs Rs.)	Cost per million cu. ft. stored (Rs.)	Remarks
Parjori	15,000	3,000	85.63	571	Including a hydro-electric plant / total storage
Palkia	14,600	2,000	82.42	564	
Usri	5,000	...	...	453	
	2,600	280	22.63	869	
Total	34,600	5,280	190.68	551	Flood storage
	32,200			592	

The proposed dams would sufficiently delay the downrush and spread out the flow over a longer period and prevent the over-flow of the banks resulting in inundation.

(b) The next immediate consequence of this delaying action means that the flow of water would be sustained for a longer period to facilitate irrigation and possibly also of navigation. In fact, the idea of making this unruly hill stream into a tame perennial river always loomed large in the reservoir projects of the engineers. In the early days, improvement of navigation for general trade and communication was one of the main considerations, and a project for opening an important water-way from the coal fields of Jharia and Raniganj to Calcutta for easier transport and distribution of coal was very seriously considered for a long time. The argument still exists, for, the pressure on the railways and the roads, which are now too excessively booked, may be eased by the opening of these water-ways. Both Russia and Germany and other countries of Europe, in spite of their extensive railways, have improved their internal waterways immensely and these are being used extensively during the present exigency.*

* The reader may remember the frequent mention of Duisberg on the Rhine as one of the most bombed cities of Germany. This is because Duisberg forms the focus of the extensive waterways of Western Germany, and used to handle as much tonnage as London. Coal and iron ore form the chief commodities transported. Readers of SCIENCE AND CULTURE are aware of the phenomenal development of

While these countries and U. S. A. are still planning to widen the scope of their waterways, many useful rivers in India have been allowed to decay, nay, sometimes die an unnatural death due to total neglect, and interference from human agencies. This idea of widening the waterways would not have been appreciated by the Railways in the earlier days, when they were private concerns but as these are now mostly State property, there can be probably no clash of interests.

(c) The reservoirs would hold the water for a sufficiently long time and would continue to feed the irrigation canals so that second crops (rabi) and possibly sugar cane and cotton could be produced every year without fail in addition to paddy which is now almost the only crop. It may be remarked here that the Damodar canals have proved to be largely ineffective, as there is no water conserved at the upper reaches, which can feed them during dry months, when water is most needed.

(d) Most of the flood water containing coarse detritus, gravel and sand should be passed out through sluices as in the Assouan Dam and get spread over the river course, but the brown muds in fine suspension which are good fertilizers for the fields and is a disinfecting agent for the malarial bogs infested with mosquitoes and larvae, should be allowed to spread over the country. In spite of all precautions the process of sedimentation of sand and gravel cannot be stopped entirely, but if proper measures are taken (e.g., afforestation, etc.), a very long span of life, generally a century or more, can be ensured for a reservoir dam. Necessary alterations in the reservoir are then required only at intervals of a century or so. Many new 'desilting devices' have been developed in the U. S. A., and they should be examined with a view to find their applicability to Indian conditions.

It is, however, possible to lengthen the life of the dams by afforestation of the catchment areas. The vegetation and forests would protect the land from erosion and would arrest the earth, sand and soil from being washed away during the rains. This would, therefore, reduce the rate of filling the dams with detritus and thus prolong their life. Afforestation makes the soil hold more rain and takes a few inches from the total runoff.

(e) The control of flood, which is only possible through the construction of dams, will stop the loss of human lives and properties, increase the revenue considerably, mitigate the ravages of malaria and

Russian inland waterways during the last ten years, the opening of the Moscow-Volga canal, etc., which has made Moscow an inland port. But for these important waterways, which are used for long-haulage coal, Russia would have been out of the war much earlier.—Ed. Sc. & Cul.

will guarantee the prosperity of the Damodar basin for future years. The expense for the construction of dams and barrages would mean a sure insurance against the heavy recurring losses which a civilised nation should never tolerate.

(f) The reservoirs can very easily be utilized for the construction of hydro-electric generating plant at a small additional cost. This will give direct return for the investment. The country is rapidly passing from a mineral producing region into a manufacturing country. Development of cheap power will encourage growth of more industries in the locality to the great advantage of the people.

FUTURE THREATS FROM THE DAMODAR FLOOD

Mr Addams-Williams, after a thorough study of the river, apprehended a great danger which may come upon the country, resulting from the future high floods in Damodar. The danger lies chiefly in the diversion of the river itself into the upper Hooghly which would mean disaster to the city of Calcutta, its port and the industrial areas on its either banks. The apprehension, as we can see, is tending towards its realization. The present breaches near Burdwan has given a spill of about one-third the flood discharge of the Damodar. In chalking out the flood control projects, Mr Addams-Williams, the Superintending Engineer, pointed out clearly (dated 30th May, 1920).

"The object we are aiming at is to prolong the period during which the Damodar can be retained in its present course, that is to say, to prevent it changing back to the Hooghly above Calcutta: the critical point is above Burdwan town, at the head of the delta: should the river get beyond control at this point, it will destroy the town of Burdwan, and it will gorge the Hooghly at a time when the river may not only be carrying the full spill discharges of the Nadia rivers, but also floods from rivers on the west bank, such as the Adjai; if floods occur simultaneously, the position in Calcutta itself is likely to be of an extremely serious type, as the river, which has been extensively encroached upon during the last century, is now only half the width it was in 1793: a few velocity discharges have been taken by Mr H. G. Reaks, River Surveyor, just below Calcutta, the most important of which was that of the 6th September 1916, when the current continued down all day, the tide being overpowered by the freshets: the maximum ebb discharge was 226,000 cusecs and the mean 198,000 cusecs: on the 19th July 1916, a perigee spring tide, the maximum ebb discharge was 247,000 and mean 209,000 cusecs: these latter discharges included water carried up by the flood tide: a 650,000 cusecs flood in the Damodar at Raniganj would be reduced by reservoir action as it passed down and spilled over the country, but we know that, in spite of the retarding effect of the spill area and reservoir above the Buxi embankment, 225,000 cusecs discharged as a maximum into the Rupnarain in 1913 and 50,000 down the Damodar itself: the other rivers in this vicinity were not in flood, and therefore the Damodar had full use of the Buxi reservoir and the water even ran up beyond Ghatal. In

addition, a good deal of water never reached the Buxi basin, as 158,000 cusecs went out through breaches above Burdwan and an undetermined volume through the left embankment below Jamalpore, which was probably between 30,000 and 50,000 cusecs; so that it would not be an exaggerated figure to assume 400,000 to 450,000 cusecs arriving in the Hooghly should the whole of the Damodar be diverted in that direction: it is clear that the Hooghly could not carry this volume and much of it would therefore pass through Calcutta itself, and the towns on the banks of the river would suffer in the same way as Hamilton, Dayton, etc., in 1913 in the great Miami flood. *It is this aspect of the question which makes matters urgent, knowing, as we do, that flood levels near Burdwan are rapidly rising and I do not think the Mining Association and the Geological experts have fully grasped this side of the question (italics are ours):* I believe that by constructing the Hazaribad and Usri reservoirs, as proposed, flood heights at Burdwan will be reduced for few years within manageable limits, and that deltaic action will be retarded at the head of the delta: we may also expect an improvement in the narrower portions of the rivers at and below Jamalpore; but in time the same difficulties will arise as the delta fills up, and it will then be imperative to construct a further dam in the Damodar, and probably the Parjori site will have to be selected: the Damodar catchment is particularly wanting in good sites, and we shall have to make use of any that can be found."

It may be remarked here that the repeated breaches and patch-up works near the bend which have generally been the apex of diversion of the Damodar, the area beyond is being always inundated during the floods of the past few decades. No definite changes in course has, however, taken place as yet. It is at this moment too early to say if any definite new spillway or course has been formed at this present flood, until water subsides and surveys are made. Whether a flood or a diversion of course into the upper Hooghly, proves equally dangerous. As a matter of fact the river is showing stronger tendency towards its swinging off to a new easterly course, as apprehended by Mr Addams-Williams quoted above.*

It should be noted that the present condition of the Hooghly near Calcutta can scarcely handle a discharge more than 500,000 cusecs which limit is almost reached during high monsoons. The Ajoy is another hill-stream which flows into the Hooghly near Katwa. There are other rivers too discharging themselves into the Hooghly. If, in addition to these, the Damodar diverts into it, and if during any season it synchronises its flood with those of Ajoy and Hooghly itself, no amount of embankment

* The latest information is that nearly $\frac{3}{4}$ of the flood discharge is passing through the Banka. The water has spread over the low-lying country, and not much water has yet reached the Hooghly. But if the flood were of larger volume, the discharge through the Hooghly might have reached alarming figures. The danger for future years still remains as great as ever. The proposed plugging of the new channel cannot remove this threat, and would make the submerged part of Eastern Burdwan intensely malarious, as the plugging of the Kana Nadee did in 1863.

whatsoever would suffice to keep the waters within its course to save the city of Calcutta, its port and the mill areas. The heavy load of coarse sand brought down by the Damodar would be a constant menace to the sea-going vessels, and the Port Commissioners will have to stand heavy and recurring dredging expenses to remove the deposits.

The contemplation of a double embankment of 20 miles length near the breach region near Burdwan will not guarantee against the future breaches at other points. It is quite likely that other weak points would give way under the pressure of the flood which itself is not being eased by the embankment. The cost of erection of such heavy embankment and acquisition of the agricultural lands thereof would amount to as much as would be necessary to construct dams at the upper reaches. Whereas the dams ensure a radical cure, the wide water-tight embankment would mean piecemeal business only—and even that with all its evils on an agricultural tract.

CONCLUSION

From the critical survey, the experts concluded that dams are required to be constructed at the upper reaches of the Damodar and the Barakar in order to cope with the flood. According to the calculations of the government engineers, the dams would be able to reduce the peak discharges through the river to half. That will ensure fair amount of safety except for extremely abnormal floods. The estimate prepared by them shows that about 2 crores of rupees were to be spent for the construction of the dams. The dams should be supplemented by afforestation, canalization and desilting devices.

The schemes, however, were dropped by the Government, at that time, on the ground of cost.^{1,2} It was probably overlooked that a sum of two crores of rupees for the construction of dams, would not appear too much when the recurring expenses of the periodic repair works on the embankments were considered, or the repair jobs on the Grand Trunk Road and Railways are taken into account. Further, the periodic loss of human lives, properties and agricultural products and perpetuation of the regime of malaria should also be taken into consideration.

Objection was also raised against the dam projects by the Indian Mining Association, on the ground that these large reservoirs of water would enhance underground percolation and seriously affect the mining operations. The point is controversial, and detailed scientific investigations are necessary before any definite remark can be made over it. It appears, however, that although some closer coal pits may suffer from percolation, the distant fields would

remain unaffected. It is therefore necessary to study the problem systematically and judge what benefit would be obtained at the lower basins occupied by millions of agricultural population as against the losses due to percolation at the mining areas. It may be added that the transport of coal and other minerals from the locality would be amply facilitated down the perennial canals fed from the reservoirs, although only a slight lowering of the sale of coal at the locality may be apprehended if a hydro-electric scheme is installed along with the dams. But our total coal deposits are extremely limited and in the larger interests of the nation, any substitute which reduces annual consumption of an irreplaceable reserve like that of coal, is to be welcomed.

The opening of any perennial canal with the construction of the dams would lead to widening of the waterways along the important mining and agricultural centres. This would reduce the pressure on the railways. It is however not known how far this widening of the waterways would be liked by the railway companies, but since the railways are now mostly State owned, the question of the clash with party interests does not arise.

Considering all these factors, it will appear that the flood control projects should be taken once more, and right now, with earnestness in the interest of the Government and the public at large.

It is worthy of note, however, that much progress has been made during the course of last 20-25 years in our knowledge of the science of rivers. The German, Russian, English and the U. S. A. Governments have all established their River Research Laboratories to investigate thoroughly into their problems of irrigation, navigation, flood controls and power projects. The actual constructions follow the decisions arising out of the results obtained in the laboratory experiments and field surveys. The ideas on the constructions of reservoir dams have also much developed through systematic research work. It is therefore desirable that with the inauguration of the River Research Institute of Bengal, this year, a full fledged Hydraulic Laboratory will be established in order to cope with the Damodar flood and other allied problems arising out of the rivers of Bengal, in general. This may also lead to the alteration of the earlier schemes in the light of modern ideas and researches, and this will enable our engineers to deal with the relevant problems in a far better way.*

* The author acknowledges his thanks to Prof. M. N. Saha, D.Sc., F.R.S., for his keen interest and valuable suggestions in preparing this article. He also acknowledges his thanks to Mr K. C. Niyogi, M.Sc., for rendering valuable help in the preparation of the manuscript.

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A CENTURY-LONG TALE OF SUFFERING

THE sufferings which the inhabitants of the Burdwan and the Hooghly districts have undergone as a result of interference with the Damodar river since 1850 has been recounted by Sir William Willcocks in detail in his Readership Lectures to the Calcutta University (1928). He quotes Hamilton, an English traveller who passed through Burdwan, Hooghly and Howrah in 1815, and was so much struck with the prosperity of the country that he remarked:—

"In productive agricultural value in proportion to its size, in the whole of Hindustan, Burdwan claims first rank and Tanjore second."

The way in which the people dealt with their rivers and protected themselves against the flood has been described by Willcocks in detail.

Till 1850 when embankments for the E. I. Rly. began to be constructed these regions remained quite prosperous and healthy, and it is known that rich men from Calcutta used to go to Burdwan for recouping health.

After the work for construction of railways started the left bank was fortified by no less than three embankments—there were the ordinary embankment, the railway embankment, and the Grand Trunk Road.

These embankments had the effect of depriving people on the north from getting water for irrigation and they began to cut the embankments frequently, but it was reported that the embankments were breached. It is on record that "25 breaches took place in 1847, 14 in 1849, 56 in 1850, 45 in 1852 and 28 in 1854. The Government took over charge of the embankments in 1855, made them water tight and by special order made it a criminal act for any private party to make wholesale breaches in the embankment for getting water for their fields.

What was the result when the district was thus debarred from over-flow irrigation?—An outbreak of

malaria and a special kind of fever called 'Burdwan fever' swept the region for over a generation.

"Dr French in his special Report on the outbreak of epidemic fever estimated the total mortality at about one-third of the whole population between 1862 and 1872."

Lt-Col. Campbell states of Hooghly:—

"It would appear that, before the fever broke out, the Hooghly district must have had a population of something like 2,000,000 and that during the 20 years the fever lasted, the population fell by 50 per cent."

To make matters worse the Kana Nadee which used to carry some waters towards the other side of the embankment was closed by a bank in 1853 near Selimabad and finally sealed in 1863. Speaking of its effect Mr Adley of the Public Works Department says that "the belief current among the people is that the closing of the Kana Nadee has been the cause of all the evil, and that if the Damodar could be let down a remedy would be provided. He himself considered that the closing of the Kana Nadee had been the fundamental cause of the dire calamity that had devastated these localities."

In spite of all these opinions the Eden canal was opened in 1881 on the left bank as some sort of palliative for the people. But the medicine was worse than the disease. It provided very little water, added two more embankments on the left bank in addition to the three already existing.

These futile and mischievous measures aroused the indignation of Sir William Willcocks, and his remarks are worth quoting in detail:—

"These watertight embankments I have called 'Satanic chains', and they are 'Satanic chains' (italics are ours). The old canals were closed, and the river floods were prevented from irrigating the country with rich muddy water as they had done for centuries through these canals. New canals were, some of them running

parallel with the rivers and blocking the way of overflow irrigation. Of these new canals, some were called 'irrigation canals', some 'navigation canals', some 'drinking water canals', and there is one under construction called an 'October water canal'. (This is now known as the main Damodar canal). This perpetual change of name is a counsel of despair. It is like Balak taking Balaam from hill to hill. People were allowed to irrigate from the new canals on condition that they paid for irrigation. Land-owners who were protected from inundation and provided with irrigation at the expense of other people, accepted; but the mass of the people, who had been accustomed to infinitely better irrigation free of charge refused point-blank. The rivers bound by these Satanic chains have become congested and are a menace to every-body; while poverty and malaria are the heritage of the countryside."

Prof. Saha in his article 'Need for Hydraulic Research Laboratory in Bengal' (*Sir P. C. Ray, 70th Birthday Commemoration Volume*) wrote:—

"If there be anything like justice in the world, the people of Burdwan are entitled to compensation from the parties concerned, for all these terrible inflictions on them. It may be given to them, by imposing a terminal or thoroughfare tax on the railway passengers, and utilising the sum so collected to resuscitation of the old prosperity of the country by

undertaking new constructive works according to well-laid-out and well-studied plans. Part of the money may be spent in financing the proposed hydraulic research laboratory.

"Let nobody think that when I am proposing that the people of Burdwan are entitled to compensation for the damage done to them, I am at all joking. Such a claim is supported by many engineers; Sir John Benton (in course of the discussion on the Sarah Bridge) says about a proposal to build railway bunds in N. Bengal for the safety of the Sarah Bridge:

"Any blocking of flood waters by these proposed new railway lines would increase the damage to crops, and in the light of experience of similar works elsewhere, this would lead to demand on the part of cultivators for compensation, or for increased waterway to pass the flood waters. The best efforts of the Railway Department would be devoted to show that the flood spills were not held up, and if these efforts failed, the railway authorities would have to provide increased waterways."

History hardly affords us a similar story of such continuous, and obstinate mishandling of a problem by a civilised Government, extending now over nearly a century; and in the face of the proved fact that the problem is capable of radical solution!

Contributed.

SOME ASPECTS OF SCIENTIFIC AND INDUSTRIAL RESEARCH IN INDIA *

CYRIL S. FOX

CALCUTTA

SCIENTIFIC and Industrial Research as organised in India is a subject which is now receiving a good deal of attention under the exigencies of the War. The formation of the Board of Scientific and Industrial Research on August 1, 1940, has provided some incentive to scientific and industrial research in this country. Actually, the question of scientific and industrial research can be traced back to 1846, when a geological survey of the coal formation of India was begun about 5th February. It may be remembered, as a matter of history, that that investigation resulted in the immediate recognition of the Raniganj area as a "Great Coalfield" which largely influenced the construction of the East Indian Railway from Howrah to Raniganj in 1854.

* Adapted from the Address delivered by Sir Cyril as the chief guest at the eighth annual meeting of the Indian Science News Association held on August 18, 1943.

For many years there has been a belief that was put into words in 1919, after the last Great War, by Sir Thomas Holland:

"India, with its wealth in raw materials, has found it in the past easier to buy than to manufacture the articles required for its amenities of life. The war has shown, however, that it is desirable to be less dependent on European countries for manufactured goods, and India, like other countries, has been compelled during the last four years to improvise for the time being, while laying plans for industrial development in the future."

We seem to be in exactly the same position today, nearly 25 years after the above remarks were made. In this connection a little more from the same source may be quoted because it is even more true at the present time in regard to supplies for military requirements under conditions of active war service.

"Munitions for a modern army cover practically all the wants of a civil community, plus the special arms, or lethal munitions, employed by the soldier in actual fighting opera-

tions. The scale of operations in a modern campaign is such that the wants of the army in the field necessarily compete with the requirements of the residual community which, in India, far outnumber those on 'active service'. Thus, the duty of equipping the armies in the field brings the department of Government that is directly responsible for this duty into immediate touch with the industrial life of the country, not the manufacturing and producing section only, but the consuming section of the community also."

The Indian Munitions Board, which was established on the 1st April 1917, actually resulted from an enquiry from the Commander-in-Chief in India in 1916, General Sir Charles Munro, as to whether more could not be done to develop Indian resources for war purposes, so as to relieve the Ministry of Munitions in the United Kingdom as far as possible from the necessity of meeting extraneous demands. It may seem dreadful to think of the opportunities lost in the 20 years between 1919 and 1939. A great deal was, however, done. A High Commissioner for India was appointed in London, chiefly as an Agent to control Indian Trade Commissioners in Europe and America who were primarily engaged in improving trade with India. These efforts were not restricted to the export of Indian raw materials, and in the years 1921-1923, while I was acting as Mineral Adviser to the High Commissioner, two serious efforts were made to encourage the establishment of an aluminium industry in India, as well as an endeavour to improve the manufacture of glass in this country, and others directed to the opening up of coal and mineral occurrences. I think I may say quite definitely that the chief discouragement to the creation or expansion of industries, for the manufacture of goods in India, has been as it still is the lack of abundant and cheap electrical power. This defect had also been felt in the United Kingdom until enormous expenditure on great electricity generating stations and the power "Grid" has altered the position to an almost satisfactory one before the war—which has since probably proved a matter for congratulation.

During the intervening years, between 1919 and 1939, there have been a great many noteworthy changes introduced in various directions in the United Kingdom. A great Department of Scientific and Industrial Research was constituted, including the National Physical Laboratory, the Geological Survey of Great Britain, the Fuel Research Board, several research bodies (for buildings, roads, forest products, water pollution, chemical, metallurgical etc.) and associations (cast-iron, iron and steel, non-ferrous metals, refractories, cotton, wool, linen, leather, rubber, etc.) for technical investigations on a very comprehensive and detailed plan. The Imperial Mineral Resources Bureau was absorbed in the Imperial Institute, when this important institution, founded in 1887, was re-constituted in 1925, and now

functions as a grand centre for promoting the utilisation of Colonial raw materials. We have no similar institution in India, where the products of the provinces and Indian States can be examined and advised upon. The Imperial Institute, which is under the Department of Overseas Trade, has two chief departments—one dealing with Plant and Animal Products and the other with Mineral Resources. The nature of enquiries varies enormously—from the procurement of red squill for rat control and the testing of the oil of *Hydnocarpus woodii* in the treatment of leprosy to the search for substitutes for agar agar and the investigation of po lompon fibre (*Thespesia lampas*) as a jute substitute in the former department, to the possible development of a molybdenite property in Newfoundland and the determination of soluble alumina in bauxite from the Gold Coast in the other department.

The field of scientific and industrial research is very wide indeed, spreading across the plant and mineral kingdoms, and dealing not merely with the study of the various raw materials but also concerned with their utilisation. It is not enough to consider the production of manufactured goods when it is impossible to get them from abroad. In the case of new industries it is essential to have every factor carefully ascertained now so that cost problems and questions of tariffs may be anticipated.

In this connection it is of interest to examine the trade position in India in the period just before the war, with particular respect to the mineral industry, as this will affect considerations of research to be dealt with later. The value of the annual production of ores, metals, minerals, etc., in India then averaged about Rs. 36 crores, and the chief items which were produced—steel (Rs. 10 crores), coal (Rs. 10 crores), pig-iron (Rs. 4.2 crores), gold (Rs. 3.2 crores), manganese ore (Rs. 3 crores), petroleum (Rs. 1.6 crores) and mica (Rs. 1 crore)—represented a total of Rs. 33 crores, while salt, copper, building stone, ferro-manganese and salt-petre made up nearly Rs. 2.5 crores, leaving very little for the remaining 30 items in the list of substances. However, the statistics are not complete, the value of building stones was given as nearly Rs. 1 crore, but it did not include bricks and tiles and cement and other materials. In the case of Portland cement, say, one million tons at Rs. 40 per ton, the value is Rs. 4 crores annually, and it is not included, nor are there figures for the value of chemicals, fire-bricks, paints, petroleum products (except paraffin wax exports) so that instead of being Rs. 36 crores the total value may be nearer Rs. 50 crores.

The value of exports of Indian merchandise, excluding treasure but including the gold of the annual production, was estimated at an annual

average of Rs. 180 crores. These exports included the following chief items—building materials (Rs. 16 lakhs), coal and coke (Rs. 145 lakhs), chromite (Rs. 6.25 lakhs), iron ore (Rs. 19.5 lakhs), pig-iron (Rs. 270 lakhs), iron and steel (Rs. 85 lakhs), manganese ore (Rs. 190 lakhs), magnesite (Rs. 5.25 lakhs), mica (Rs. 100 lakhs), salt (Rs. 2.5 lakhs), paraffin wax (Rs. 30 lakhs) and gold (Rs. 320 lakhs)—say Rs. 12 crores in all, or about 1/15 the value of the total exports (excluding treasure). The 12 crores is only 1/3 the value of the recorded production (Rs. 36 crores) of minerals, ores, etc., and 1/4 that of the suspected production (Rs. 50 crores). Attention will be drawn to the value of pig-iron and steel as compared with that of the iron ore used for reduction—2 tons of ore at Rs. 2 per ton would yield 1.75 tons of pig-iron at Rs. 50 per ton and this gives 1.4 tons of steel at Rs. 134 per ton. The relative values are therefore Rs. 4, Rs. 87.8 and Rs. 187.6, or a ratio of 1:22:48 respectively. There would thus appear to be a good margin to cover capital outlay and working costs for the large-scale production of pig-iron and steel, provided the prices and the quality of the products are satisfactory to the consumers. In new projects it is fundamental that the raw materials are proved to be satisfactory before a scheme is approved or else, as already hinted, the oversight might prove very costly.

Compared with the exports (pre-war), valued at Rs. 180 crores, the annual Indian imports of foreign merchandise were roughly Rs. 160 crores in value (showing a favourable balance of Rs. 20 crores. In addition to this there was a further balance of Rs. 15 crores from exports of treasure). Among these imports the following items are of special interest—*asbestos* (Rs. 6 lakhs), *asphalt* (Rs. 25 lakhs), *building materials* (Rs. 34 lakhs), *china clay* (Rs. 13 lakhs), *earthenware* and *porcelain* (Rs. 37 lakhs), *aluminium* (Rs. 40 lakhs), *brass and bronze* (Rs. 95 lakhs), *copper* (Rs. 77 lakhs), *iron and steel* (Rs. 536 lakhs), *steel* (Rs. 94 lakhs), *lead* (Rs. 24 lakhs), *tin* (Rs. 85 lakhs), *zinc or spelter* (Rs. 50 lakhs), *mineral grease* (Rs. 13 lakhs), *paints* (Rs. 67 lakhs), *paraffin wax* (Rs. 5 lakhs), *precious stones* (Rs. 112 lakhs) and *salt* (Rs. 44 lakhs)—a total of Rs. 13 crores or a little more than the value of the Indian exports of similar goods—ores, metals and partly processed products largely. In addition to the above, however, the imports include—*chemicals* (acids, sodium carbonate, sulphur or brimstone, etc. valued at Rs. 3.25 crores), *dyes* (made from coal tar: Rs. 2.5 crores), *glassware* (excluding electric bulbs: Rs. 1 crore) and *mineral oils* (including motor spirit, kerosene, fuel oil, etc.: Rs. 15.5 crores)—valued in all at about Rs. 22.25 crores which, added to the previous total, is Rs. 35.25 crores. There are further items—*mill-work and machinery* (Rs. 17 crores), *electrical instru-*

ments and apparatus (Rs. 3 crores) and hardware and cutlery (Rs. 2.75 crores)—giving a total of Rs. 22.75 crores, and a grand total of Rs. 58 crores for materials and products made from ores, minerals, etc. This import value is nearly 5 times that of the exports of this class of merchandise.

A careful examination of the information given above will show that there must be imports of many of the items mentioned above—aluminium, lead, tin and zinc, as these metals have not yet been prepared in India from domestic ores. Similarly, the Indian consumption of mineral oils is far in excess of what this country can produce from its own resources of crude petroleum. India has a difficult problem to face in regard to patents and the necessary experience in processing before it will be possible to embark on the commercial production of coal-tar dyes. And until better facilities are available some time must elapse before the manufacture of machinery and apparatus of special types can be profitably undertaken in India. It is a very serious question to consider utilising the chromite or magnesite or manganese ore or any other raw material, at present exported. The existing industries cannot absorb the large quantities involved, while to manufacture goods for export necessitates the securing of a satisfactory market. At present there is a definite market for the ores, metals, minerals, etc. which are exported. India enjoyed Rs. 20 crores yearly from the balance of trade before the war and there was a definite advantage in the interchange of merchandise in minerals and related substances and their manufactured products. Scientific and industrial research must show that processing and manufacturing can be efficiently done before it is possible to gauge the actual commercial aspects of any industrial enterprise, the object of which is to eliminate imports or export manufactured goods.

There are good reasons for believing that the Atlantic Charter will be a blessing to India, particularly from the conditions stated in the Preamble and in Clause IV on the subject of raw materials. It will be necessary that Committees should prepare estimates to show the present position of the raw material resources in India and other countries, in order that supplies to consumers may not be overdrawn from any country. Indeed, it may come as a shock when it is realised that the chromite, magnesite, manganese ore, mica and other mineral resources of India are quite unknown, and that estimates for quantities for more than a few years supply are quite speculative. This is of course unsatisfactory and provides scope for scientific and industrial research. There are also problems relating to the copper, lead and zinc ore resources which are under consideration and which are of considerable importance. The question of sulphur has still to be

fully dealt with, both as regards the available sources of supply in India from sulphur-bearing rock, from iron pyrites and other sulphide ores and from gypsum and barytes, and to the processes by which the extraction of sulphur can be made on a commercial scale in this country. India depends entirely on imported sulphur for the sulphuric acid that is, the basic chemical of the chemical industry, which is the blood of modern industrialisation. Sulphur in India is a fundamental question and any scientific and industrial research for the production of sulphur from domestic resources is important and deserves examination by impartial experts.

The need for abundant supplies of cheap electrical power as a prime necessity for industrial development has already been mentioned. It does not matter whether the power is obtained from hydro-electric schemes or from coalfield generating stations, provided the chief condition of cheapness is secured. Hydro-electric sites are usually in difficult places and invariably require storage dams and other costly works as well as long transmission lines in India. Coal-field schemes are faced with continuous fuel expenses and difficulties in regard to adequate supplies of cool water to keep a satisfactory condenser vacuum during the hot months in India. These questions are now thoroughly well understood and any details which remain should, if of a technical character, be subject to investigation, so that this drawback to industrial progress may be removed without delay by the erection of power stations at satisfactory sites. It has already been recognised that coal is a basic factor in power generation, but the tragedy of coal conservation remains and the reserves of good quality coal are rapidly disappearing. It is well known that though the reserves of coal of metallurgical (coking) quality are exceedingly limited, this material is being used in the proportion of 3 to 1 for non-metallurgical purposes and at this rate the reserves will be exhausted within 32 years. The extraction of one ton of coal from a seam entails the loss of another ton in the same seam, but it is equally true that in mining a lower seam and permitting the superincumbent strata to subside, collapse and break up, all the upper seams are rendered unworkable and so lost from any previously estimated reserves. Both in this respect and in the better utilisation of lower grade coals it is essential that scientific and industrial research should show the way.

It may be of interest to say that estimates, made since the German occupation of France, show that the annual requirements of oil for the German armies (air, land and sea) in 1940 were computed at a minimum of 500 million gallons as compared with 1,400 million gallons for civilian needs. At that time

Germany was able to secure 750 million gallons of oil from refineries treating crude petroleum in territories under Nazi domination, including normal imports from Roumania. In addition, the plants at Leuna, Gelsenkirchen, Pollits, Brux, etc., were estimated to produce 640 gallons of synthetic petrol by the hydrogenation of coal. A further 200 million gallons of benzol (from by-product coke ovens), alcohol and related spirit (from other processes) was available. The above 1,590 million gallons, while short of Germany's requirements of 1,900 million gallons, could be made satisfactory by larger deflections from Roumania and by more synthetic petrol as new plant came into production. The bombing of the Roumanian (Ploesti) refineries and the larger synthetic oil plant will probably have altered the comfortable position Germany appears to have held for oil supplies. Italy has possibly also been a leak in the system. However, to us the most amazing fact is the enormous output of synthetic petrol by the hydrogenation of coal. This method has also provided the United Kingdom with quite considerable quantities of synthetic oil, and is of great interest to India, where there has been an excise tax of ten annas a gallon on benzol produced from by-product coke ovens.

The Indian production of petroleum from the oil-fields of Assam and the Punjab barely totals 100 million gallons a year, valued at Rs. 1.6 crores, while this country has been importing motor spirit (80 million gallons), fuel oil (150 million gallons), kerosene (180 million gallons), lubricating oils (40 million gallons), to a total of 450 million gallons, in all valued at Rs. 15.5 crores annually. Here then is a great field for thorough scientific and industrial research on the subject of oil from coal. With about 2,500,000 tons of coal used in the manufacture of metallurgical coke, there could, with some encouragement, be a recovery of 2.5 million gallons of high octane benzol, but what is this as compared with the yield by hydrogenation? If this process is able to treat low grade Indian coals, a very great step forward will have been taken, but the investigations are of so costly a nature that Government assistance is essential. One may name many other directions for profitable research and I am sure every zealous scientist in India has some plan or process under consideration. The Board of Scientific and Industrial Research have many schemes under trial as likely to yield benefits for the war effort, but the big items of a fundamental character could go forward at the same time. Had they been built up during the 20 years between 1919 and 1939, India would have been a far more important industrialised war base than is the case now, even after 4 years of energetic effort.

Notes and News

INTERNAL COMBUSTION ENGINES IN INDIA

THE Indian Chamber of Commerce, Calcutta, have recently issued a press communiqué stating the context of a communication recently addressed to the Government of India by the Committee of the Chamber on the manufacture of internal combustion engines in India. The Committee endorse the recommendations put forward by the Exploratory Committee appointed by the Board of Scientific and Industrial Research regarding the manufacture of the same and urge upon the Government to announce immediately their decision on the said recommendations. The Committee have pointed out the large demand for internal combustion engines in various industries which have been hard put to it for want of these engines. The Committee believe that there is apparently no reason for such unfortunate state of affairs when these engines can be manufactured in India without any elaborate machinery. The internal combustion engines industry, the Committee also state, apart from being an integral part of the machine tool industry, would also help in the development of other industries by providing to them a cheap and useful power generating engine. Further, it would not be difficult for the Government to obtain the necessary machinery for the purpose on lease lend basis from U. S. A. In view of these considerations the Committee have requested the Government to take early steps to start manufacture of internal combustion engines in India.

Such a communication, coming as it is from a representative body, such as the Indian Chamber of Commerce, has doubtless some significance. But we are not much impressed by the news, as the issue is almost a foregone conclusion. Competent authorities and experts, as the readers of *SCIENCE AND CULTURE* are aware, have repeatedly called the attention of the Government to this vital question of the manufacture of internal combustion engines in India and have tried to move the same in the matter since the outbreak of the present global war. But they have simply broken their heads against a stony wall. Official red tapism and vested interests have so far swept all considerations of national interest before them, and meanwhile nothing has happened to delude us to believe that wiser counsel will prevail this time.

TRAINING COURSE FOR BIOCHEMISTS AT BANGALORE

THE training course for biochemists deputed by different Provinces and States in India in the im-

proved process of preparing compost manure from town wastes, developed at Bangalore, was formally inaugurated at the Indian Institute of Science, Bangalore, on August 4. It may be recalled that the Government of India recently sanctioned a sum of nearly Rs. 2½ lakhs for a programme of large scale preparation of compost manure from town wastes, the working of the scheme being entrusted to the Imperial Council of Agricultural Research.

Sir J. C. Ghosh, Director of the Indian Institute of Science, in welcoming the biochemists to Bangalore, referred to the important role played by the present scheme in connection with the "grow more food" campaign and hoped that the biochemists would take full advantage of the opportunities offered under the scheme and put in their best efforts to carry the programme to a successful issue thus alleviating the present serious position in the matter of food production in this country. Among other speakers who addressed the biochemists were Dr Gilbert Fowler and Prof. Subrahmanyam. Dr Fowler spoke on the difficulties attending the preparation of compost manure from waste materials, which superficially appears to be a simple matter, and stressed on the need of increased application of fundamental scientific knowledge with reference to local conditions and hygienic requirements. Prof. Subrahmanyam traced the history of the work carried out at the Indian Institute of Science on compost manufacture, starting from the pioneering work of Dr Gilbert Fowler some 20 years back and culminating in the latest researches of Dr Acharya. He mentioned that, in recognition of the usual work carried out by the Institute, the Government of India have now come forward with a large grant of Rs. 2½ lakhs to introduce the process developed at the Institute throughout India.

AMERICAN INSTITUTE OF PHYSICS

Review of Scientific Instruments in one of its recent issues (13, 471, 1942) has given a survey of the first ten years of the useful work of the American Institute of Physics. The Institute was formally founded in 1931 in response to the need of preventing the different physics groups to "split up" and form a large number of separate societies. The necessity of bridging the ever widening gaps between the different groups within physics and of promoting co-operation among them on a more permanent basis

was clearly realised by a joint committee formed by the American Physical, Optical, Acoustical and Rheological Societies, who recommended the creation of the Institute. The American Institute of Physics has for its members only the five founder societies, each as an entity, the American Association of Physics Teachers being the fifth member, and does not extend its membership, unlike the Institute of Physics in Great Britain, to any individual. It is a non-profit earning, educational corporation.

One of the principal functions of the Institute is the publication of scientific journals. It was at one time proposed to combine the various physics journals into a single large journal of physics with sub-divisions devoted to special groups to be issued by the Institute. Important as the suggestion was from the view point of the cost of publication, it did not work, as it involved the inevitable loss of established tradition, pride and sense of responsibilities of the individual societies, which they were hardly prepared to undergo. It was, however, decided to entrust to the Institute the task of bringing the separate journals into a single line of publication without any change of sponsorship. According to this scheme, the Institute now issues the following eight scientific periodicals: *Physical Review*, *Reviews of Modern Physics*, *Journal of the Optical Society of America*, *Journal of the Acoustical Society of America*, *American Journal of Physics* (formerly *American Physics Teacher*), *Review of Scientific Instruments*, *Journal of Applied Physics* (formerly *Physics*) and the *Journal of Chemical Physics*.

Another important activity of the Institute consists in the constant maintenance and gradual intensification of the public interest in the achievement and progress of physics. It is rightly apprehended that if the advances and services of physics are not systematically demonstrated public interest will readily swing to other fields which are better displayed. The Institute, therefore, takes keen interest in the publication of readable books about physics and its applications and arranges from time to time symposia on physical subjects of topical interest. Such symposia serve most effectively the useful purpose of focussing the attention of the public and its industrial and educational leaders to the significant advances of science both on the pure and the applied side. The conference on biophysics held in Philadelphia in November 1937, which was attended by about eight hundred biologists, medical men, chemists and physicists is an instance in point.

The financial requirements of the Institute for publishing and other services are met by the sum collected by the societies as members' subscriptions.

Besides, the Institute has twenty-six associate members in well known industrial organisations, each paying an annual subscription of 175 dollars. The Institute also raises funds from various other sources.

NATURE

THE story of the publication of *Nature* has appeared in the editorial article of one of its recent issues (February 27, 1943) in which, we feel, our readers will find some interest. For several years this weekly journal of science has occupied the leading position and still continues to do so among semi-popular scientific periodicals devoted to the propagation of scientific thoughts and activities in various branches of science. The idea of starting the journal was first conceived by Sir Norman Lockyer, the astronomer and spectroscopist, in course of discussions with his friends, among whom was Alexander Macmillan, one of the brother founders of the famous publishing firm which bears their name. The idea was communicated to the eminent British scientists of the time, namely T. H. Huxley, Balfour Stewart, Wilkinson, Tyndall, Roscoe, Sir Joseph Hooker and others, all of whom were readily convinced of the importance and necessity of such a popular science journal and came forward with their full support for the new venture. An early materialisation of the idea was, however, largely due to the keen interest and enthusiasm of Alexander Macmillan of the House of Macmillan which undertook the publishing responsibilities. *Nature* saw the light of day in 1869. The enthusiasm with which Alexander Macmillan approached the scientists of his time to enlist their sympathy and co-operation is reflected in his letter addressed to Sir William Thomson (afterwards Lord Kelvin):

"Lockyer is going to start a weekly journal of science, which we are to publish. It is meant to be popular in part, but also sound, and part devoted specifically to scientific men and their intercourse with each other. Huxley, Balfour Stewart, Wilkinson, Tyndall, Roscoe and almost everyone who is about London have given him their names, and he very greatly wishes yours, as among those who promise support. May I tell him you consent?"

Sir Norman continued to be the editor of the journal till 1919 in which year he was succeeded by Sir Richard Gregory. These two editors were instrumental for the progress and the present position and influence of the journal in the growing scientific literature of the world. In 1938 Sir Richard Gregory left the editorial chair and was jointly succeeded by Mr A. J. V. Gale and Mr L. J. F. Brimble. The paper was run for several decades at a financial loss, and there were times when it was threatened by serious financial crisis. By steady and strenuous effort it had to create among the British reading public the long looked for interest in the news from

the laboratories. For some time past the financial problems have ceased to exist, and the journal has become financially self-sufficient. To-day, if scientific events and new developments inside the laboratory interest the British public, it is in no small measure due to the existence and service of this scientific periodical.

NEW METHOD OF BOMB SCORING

CAPT. EDWARD PETER MCKABA, Experimental Projects Officer, has recently developed, according to a report in the *Scientific American*, the new "sonic method" of instantaneously and accurately locating the position of the bombs dropped from the planes. This new method of scoring bomb accuracy offers distinct advantages over the photographic method, now in use, and is expected to introduce considerable economy in the use of scarce commodities, such as rubber, gasoline and motion picture film.

The idea of the "sonic method" was borrowed from the seismographic method of exploring the sub-soil deposits of mineral oils. In seismographic practices, the sound of explosion taking place on the surface of the ground is reflected from sub-surface layers; received on the surface by a series of geophones and finally recorded on photographic paper which throws light on the geophysical state of the sub-soil layers. In bomb scoring, four microphones are set in the four corners of a square about the target centre, each some 500 feet distant from the centre. The microphones respond to the sound waves from the explosion, and the time intervals can be recorded. Captain Mckaba has devised a unique hyperbolic plotting board to which these recorded values can be applied and the bomb's position determined with a reasonable degree of accuracy.

The existing practice of bomb scoring by photographing the explosions from the bombing plane involves huge consumption of films and the various problems associated with the developing and processing operations. The saving of the film and the photographic materials and the simplicity of the new method recommend the adoption of the sonic method for bomb scoring. Besides, the possibility of immediately wiring the results of bomb scoring back to the home base through leased telephone lines is another important advantage of the method.

ASSOCIATION FOR SCIENTIFIC PHOTOGRAPHY

THE recent creation of the Association for Scientific Photography in Great Britain, representing widely different fields of science and industry, as reported in *Nature*, is an unmistakable evidence of the importance of photography in dealing with

scientific and industrial problems. The need for such a new organisation to meet the photographic requirements and difficulties of scientific workers in general was felt for a long time, and as such its formation will be most welcome in that country. The Association appears to have a wide field of activity and will embrace photographic processes of all kinds, namely, radiography, colour photography, photo-micrography, high-speed photography and, in particular, sub-standard cinematography. The Association has, however, been formed with the following objects:

(1) To promote the advancement of photography in all branches of science, technology and medicine, and to assist its members in the application of photographic methods to the solution of particular problems.

(2) To afford its members opportunities for interchanging opinions and discussing matters connected with photographic techniques. The Association will arrange meetings from time to time at which papers and communications will be presented. The proceedings will appear in a journal to be published by the Association as soon as conditions will permit.

(3) To establish an information bureau containing, so far as is possible, full particulars of the activities of members and in suitable cases the existence and whereabouts of specialised photographic apparatus. These data will be used by the Association for the benefit of its members as a pool from which information may be drawn on the varied applications of photography to research, industry and teaching.

(4) To endeavour to obtain from members information on practically any photographic problem which may arise in their prosecution of scientific work.

(5) To foster the production of sub-standard films for research and teaching purposes and to give information on methods of production and presentation of films of scientific interest.

Photography in our country is still looked upon more as a hobby than as an essential scientific process in the investigation of scientific and industrial problems. Its great importance in the field of research and industry has been completely overlooked with the result that the outbreak of the war and the consequent dislocation of shipping have brought to a standstill all research work, pure as well as applied, where the use of photography is imperative. The neglect of this fruitful branch of research and development has adversely affected the Indian film industry which is hopelessly dependant upon foreign supply of raw films. In the pre-war period, the easy availability of best quality films

from foreign companies was one of the main reasons of scant attention and importance paid to research in photographic processes and materials in our universities and research institutes. Such being the attitude of our scientists, it is no wonder that our industrialists will be equally callous about this important line of development. The war provided some opportunities which have so far been allowed to slip by for lack of any central direction or scientific organisation prepared to consider seriously the problems arising from the shortage of photographic materials and the possibilities of organised research and eventual manufacture of photo-goods from indigenous resources. The creation of the Association for scientific photography in Britain, however, represents an advanced stage of development and an awareness of problems which do not confront us at the moment. What pains us is the absence in this country of the very first steps leading to the realisation of this important line of development which equally affects the scientific and the industrial life of the country.

THE NUFFIELD FOUNDATION

THE following announcement authorised by Lord Nuffield has appeared in the *Times*, London:

"Lord Nuffield has intimated his intention of founding forthwith a charitable trust, which will be known as 'The Nuffield Foundation'.

He desires to make this donation from resources which have been built up through private enterprise, in the essential importance of which he is a firm believer. He wishes, in so doing, to record his view that the spontaneous contributions which come from such sources to the service of the community are, and must always remain, a vital factor in the life of the nation.

Lord Nuffield will, therefore, hand over to trustees his shareholdings in the Nuffield Organisation to the value of £10,000,000 as a capital fund. The income from this fund will be administered by managing trustees, who will not exceed seven in number. He has appointed the following as managing trustees:

Sir William M. Goodenough (*Chairman*).
Sir John S. B. Stopford, F.R.S. (*Vice-Chairman*).
Professor F. L. Engledow, B.Sc.
The Hon. Geoffrey C. Gibbs.
Sir Hector Hetherington.
Sir Henry T. Tizzard, F.R.S.
Miss Janet Vaughan.

Lord Nuffield wishes to make it clear that in carrying out this arrangement he is not in any way withdrawing from his association with his business,

with which he will be personally identified in the same way as heretofore.

The objects which the trustees will endeavour to assist are as follows: 1. Medical Research and teaching. 2. The organization and development of medical and health services. 3. Scientific research and teaching in the interests of trade and industry. 4. The pursuit of social studies. 5. The care and comfort of aged persons.

The normal scope of the trust's activities will be Great Britain and Northern Ireland. Attention may, however, be given to projects particularly affecting the Empire, and in regard to items 1 and 3 above the provision of scholarships and other assistance for Empire studies is included. It is provided that Lord Nuffield's trusts which are already in being may benefit from the income of the new trust.

The managing trustees are enjoined to consult the appropriate Ministers or Departments of State in connection with any matters of major importance in which they may become interested. They are not, however, to be in any way bound by the views expressed by these ministers or departments in carrying out the work of the trust."

ANNOUNCEMENT

We acknowledge with thanks the receipt of the following:—

JOURNALS

(Foreign)

1. Scientific Monthly, March, 1943.
2. Science, Vol. 97, Nos. 2514-17.
3. Technology Review, March, 1943, Vol. 45, No. 5.
4. Journal of the American Chemical Society, Vol. 65, Nos. 3 and 5.
5. Publications of the Smithsonian Institution, Vol. 93, Nos. 3160-63.
6. Sky and Telescope, Vol. 2, Nos. 6 and 7.
7. Science News Letter, March 13, 27, April 3, 10, 17, 24.
8. Bulletin of the American Meteorological Society.
9. Chemical Education, Vol. XX, No. 4, April, 1943.
10. Agricultural Gazette of the New South Wales, Vol. LIV, Part 6.
11. Meccano Magazine, Vol. XXVII, No. 11, Nov., 1942.
12. Science and Society, Vol. 7, Nos. 1 and 2.

(Indian)

1. Aryan Path, Vol. XIV, No. 7, 8.
2. Teachers' Journal, Vol. XXII, No. 7, July, 1943.
3. Annals of Biochemistry and Experimental Medicine, Vol. 3, No. 1, 1943.
4. Journal of the Indian Chemical Society, Vol. XX, No. 7, July, 1943.
5. Journal of the Indian Medical Association, Vol. XII, No. 11, 1943.
6. Indian Medical Gazette, Vol. LXXVIII, No. 8, August, 1943.
7. Modern Review, August, 1943.
8. Indian Information.
9. Indian Listener.
10. Proceedings of the National Institute of Sciences.
11. Current Science, August, 1943.

BOOKS

1. Organic Chemistry (Revised 2nd Ed.)—P. B. Sarkar and P. C. Rakshit.
2. British Orientalists—A. J. Arbery.
3. Geology of India and Burma—M. S. Krishnan.
4. Plan for Reconstructions—W. H. Hutt.
8. Recent Advances in Galactic Dynamics—A. C.

- Banerjee.
6. Education from World Adrift—Sir Richard Stone.
7. Museum Method and the Processes of Cleaning and Preservation—Minendra Nath Basu.
8. How India Pays for the War—K. T. Shah.
9. Suggestive Studies in Education—Deb Narayan Mukerjee.

SCIENCE IN INDUSTRY

FLOATING GLASS

A NEW type of glass which floats like cork and can be used for its buoyancy in the construction of life-boats, life-belts and pontoon bridge supports has been recently prepared and is now in large scale production by the Pittsburgh Corning Corporation in U. S. A., according to a report in the *Chemical Age*. This new floating glass is technically called 'Foamglas' which weighs only 10 lb. per cubic foot and has important insulating and fireproofing properties. It has a cellular structure with countless tiny air-tight cells, but because of its closed cell structure it will not absorb water and will float indefinitely. A bullet, as it passes clean through the material of the glass, destroys only the cells in its path, but does not impair the buoyancy of the remainder. Another important property of 'Foamglas' is that it can be sawed or drilled with ordinary tools.

The process of manufacture consists in firing ordinary glass mixed with a small quantity of pure carbon. During the heating operation glass softens, and the carbon turns to gas which then acts on the molten mass in a manner analogous to the action of carbon dioxide in bread making. Successful preparation of 'Foamglas' with a uniform cellular structure calls for proper selection of the glass batch and the type of carbon and exact control over temperature and time of heating. At present it is being made in slabs 12 in. by 18 in., and 2-6 in. thick.

The new glass, it is expected, will soon be used in America and Great Britain as an alternative for scarce materials, such as cork, balsa wood, cellular rubber and kapok.

WATER-REPELLING FILM

DR WINTON I. PATNODE, research chemist of General Electric Company, has developed, according

to a report in *Science*, a new water-repelling film for treating insulator whose properties are often seriously interfered with by the deposition of moisture on them. The exact chemical composition and the process of forming such a film have been kept secret for obvious reasons.

According to the usual practice, the insulators are treated with wax, but the effect is always of a temporary character. In the new process which is claimed to be very simple, the objects to be made water-repellant are placed in a closed cabinet to which the vapours of a group of substances, known chemically as the methyl chlor silanes, are admitted. During the process corrosive acids may collect on the articles which, therefore, sometimes require to be treated with ammonia vapour to effect neutralisation. Articles treated in this way do not get wet, as moisture readily collects into round droplets, and the insulating properties remain unaffected. This new treatment is reported to be about nine times more effective than the old treatment with wax, now in use, so far as resistance to heat, chemical solvents like gasoline, naphtha and carbon tetrachloride and long exposure to ordinary weather are concerned.

Other uses of such water-repelling film have also been reported. Scientific workers are familiar with the curvature of the meniscus of water in contact with the sides of a tube or a vessel containing it, due to the phenomenon of surface tension. This makes accurate reading of gauges, glass measuring flasks and other laboratory vessels very difficult. Treatment of the inside of glass vessels in the way described prevents the formation of the meniscus and makes possible greater accuracy in such surface measurements.

It is suspected that the new treatment gives rise to a water-repelling film responsible for the behaviour mentioned. Curiously enough chemical test as

well as examination with a high power microscope, undertaken by Dr Patnode, failed to show the existence of any such tangible film. Further research work will be necessary to unfold the implication of the new process.

LABORATORY SYNTHESIS OF DIAMOND

GRAVE doubts are generally expressed as to the possibilities of synthesising diamonds in the laboratory. Yet we hear from time to time of the preparation of diamonds in the laboratory, most of which have so far appeared, according, however, to the methods of examination available at the time of testing, to be pseudo diamonds, being nothing more than mere transparent and singly-refracting minerals peculiarly resistant to chemical reagents. Prof. Moisson's name is naturally recalled among the early investigators in the synthesis of diamond. More recently significant attempts were made by J. B. Hannay, Charles Parsons and others to prepare artificial diamonds. Little importance, however, attaches to such painstaking researches unless conclusive evidences as to the purity of the synthesised specimens are available. The appearance of a short note in *Nature*, March 20, 1943 by F. A. Bannister, of the Mineral Department, British Museum, London and K. Lonsdale, of the Royal Institution, giving the results of their own X-ray analysis of the specimens of artificial diamonds prepared by Hannay and

carefully kept in the British Museum (Mineral Department) collection has roused much interest in the subject. The analysis shows that Hannay did really succeed in synthesising diamonds, although in a very small quantity, in the laboratory as early as 1879-80.

It is reported that he prepared twelve small artificial diamonds. Confirmatory X-ray tests applied to the samples have revealed that, with the exception of one, all of them are pure diamonds, some, however, containing a little amount of impurity. One of the specimens has produced only primary diffuse spots and none of the more detailed primary effects and has accordingly been recognised as a rare type II diamond. This rare type of diamond, it may be noted, exists in nature to an extent hardly exceeding one per cent. Some other specimens, though not thoroughly examined, also appear to belong to the type II variety inasmuch as they indicate a highly laminated condition.

The investigators believe that the method followed by Hannay may be successfully applied to produce the rare variety of diamond. They have, moreover, expressed their feeling that probably Moisson, Parsons and others also succeeded in producing pure diamonds which were unfortunately lost and as such could not be subjected to a searching X-ray analysis which alone is capable of providing conclusive evidences as to the purity or otherwise of the samples.

SOME LATEX BEARING PLANTS OF URTICACEAE FOUND IN INDIA

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IN any attempt to explore the possibilities of new natural sources of rubber, *Urticaceae* family is the one which comes first as many of its species are some of the most common trees of India. For example, *peepul* (*Ficus religiosa*), *bar* (*F. bengalensis*) and *gular* (*F. glomerata*) are known for their rubber-bearing milky juice from leaves and bark. Similarly the 'India-rubber tree' (*F. elastica*) latex has been known from a very long time to yield a rubber-like mass.

Roxburgh¹, in 1812, was the first to give publicity to *F. elastica* as a commercial source of rubber, which led the British people to take keen interest in this source resulting in ruthless slaughter and tapping of the *F. elastica* trees in Assam. The supply of caoutchouc from this source naturally

began to decrease very considerably and rapidly and though recommendations for starting plantations were made by Royle in 1839, no action was taken till 1869, when Mann stressed the importance once again in his progress report of the Forest Administration in Bengal for the year 1869-70. The Charduar plantations were started in 1873.

The success of *F. elastica* led investigators to look into other *Ficus* species for suitable sources of rubber. These investigations which commenced towards the end of the nineteenth century never crossed the preliminary stage, because at about the same time 'para rubber' from *Hevea brasiliensis* became so popular that it sealed the fate of *F. elastica* and all other potential sources

Species.	Place of collection.	% in original sample or latex.				% on dry basis in coagulum.			Remarks
		Caoutchouc	Resins	Residue	Water and water solubles	Caoutchouc	Resins	Residue	
<i>Artocarpus hirsuta</i> (aini)	Coorg ...	2.1	25.6	1.7	70.6	7.1	87.0	5.9	
do.	Yellapur, Kanara ...	2.7	36.9	0.8	59.6	6.6	91.4	2.0	
<i>A. integrifolia</i> (kathal)	Kolaba, Bombay ...	2.9	23.7	2.1	71.3	10.0	82.6	7.4	
do.	Yellapur, Bombay ...	1.9	26.7	2.5	68.9	6.0	85.9	8.1	
do.	Jalpaiguri, Bengal ...	2.3	20.7	0.9	76.1	9.7	86.4	3.9	
do.	Rajendrapur, Bhowal	1.3	14.1	8.5	76.0	5.3	59.1	35.6	
<i>A. lakoocha</i> (lakoocha)	Yellapur, Kanara, Bombay ...	3.7	25.0	1.5	68.8	12.2	82.9	4.9	
<i>Chlorophora excelsa</i>	Kannoth, Wynaad, Madras ...	0.3 (chloroform extract)	25.5	7.1	67.1	0.9 (chloroform extract)	77.5	21.6	
<i>Ficus altissima</i> (Malayalan name koli)	Kannoth, Wynaad, Madras ...	5.1	22.9	0.7	71.3	17.7	79.8	2.5	Hooper ^a Caoutchouc =30%
<i>F. asperima</i> (syn. <i>F. hispidissima</i>) (kharwat)	Yellapur, Kanara, Bombay ...	nil.	0.30 (mainly colouring matter)	12.8	86.9	nil.	2.3 (mainly colouring matter)	97.7	
<i>F. bengaiensis</i> (bar)	Rungkund Village, Bihar ...	3.5	18.2	0.4	77.9	15.9	82.2	1.9	
do.	Kolaba, Bombay ...	4.7	28.5	0.9	65.9	13.8	83.5	2.7	Dunstan ^a Caoutchouc = 7.3% Resins =79.1% Insolubles =13.6%
<i>F. cunia</i> (khewnau)	Saranda, Bihar ...	1.0	7.5	1.3	90.2	10.0	77.2	12.8	Caoutchouc =12.86%
<i>F. carica</i> (anjir)	Palampur, Punjab ...	2.4	18.8	12.7	66.1	7.2	55.40	37.4	
<i>F. glomerata</i> (gular)	Rungkud village, Bihar ...	7.4	0.5	20.8	71.3	25.8	72.3	1.9	
<i>F. infectoria</i> (nakar)	Yellapur, Kanara, Bombay ...	3.0	38.7	0.2	58.1	6.9	92.6	0.5	
<i>F. nervosa</i> (icha)	Yellapur, Kanara, Bombay ...	0.5	7.0	3.2	89.3	4.8	65.5	29.7	
<i>F. religiosa</i> (peepul)	Hyderabad, Deccan ...	0.7	11.2	1.7	86.4	5.3	82.1	12.6	Hooper ^a Caoutchouc =12% Resins =85%
do.	Barapahar Dn., Orissa	4.7	49.0	11.7	34.6	7.1	74.9	18.0	
do.	Multan, Punjab ...	5.1	58.0	13.4	23.5	6.7	75.9	17.4	
<i>F. retusa</i> (nandruk)	Belgaum, Bombay ...	0.2	6.6	0.8	92.4	2.2	86.8	11.0	Hooper ^a Caoutchouc =24% Resins =74%
<i>F. rumphii</i> (rumbal)	Bombay ...	6.9	28.1	1.0	64.0	19.2	77.2	3.6	
<i>F. talboti</i> (attimara)	Belgaum, Bombay ...	0.9	9.9	1.2	88.9	7.6	81.7	10.7	

Note :—Common vernacular names are given in brackets under the column species.

of rubber as commercial proposition, especially as *Hevea* begins to yield rubber very much earlier than *Ficus* and for age to age produces higher yields. It further established its superiority because of its low content of resin; *F. elastica* in comparison having 12 per cent or over. With the ever increasing popularity of the 'para rubber', investigations on other species of *Urticaceae*, which might have proved as minor sources of commercial rubber, were not considered worth pursuing. Even the existing plantations of India rubber of that time became unremunerative and soon fell into neglect.

Subsequent to the losses in the Far East, the position of rubber supply has become serious and any new source of rubber which may supplement the present supplies is welcome and therefore worthy of attention. This has naturally led to the revival of interest in *F. elastica*. It is said (a result of survey) that there are about 1,100 tappable trees in Darjeeling alone and that their tapping has already begun. With these changed conditions, thorough search for rubber in other genera and species of *Urticaceae* was considered worthwhile especially as most of the *Ficus* and *Artocarpus* species are relatively common. In case any or a few of these really contained rubber in quantity sufficient for commercial exploitation, they would be available for immediate tapping. A few of them have also been subjects of earlier investigations, but the data is so scanty that hardly any reliance can be placed on them. For example, statements such as "possessing caoutchouc of as good quality as *F. elastica*", "black, never hardens properly", "yields rather a good quality of caoutchouc" occur all through the earlier works on *Ficus altissima* (syn. *F. laccifera*),

F. obtusifolia, *F. comasa*, etc. *F. volgelii*, *F. callosa*, *F. tomentosa*, *F. cuercifolia*, etc., have also been reported to possess rubber in sufficient quantities, but as they are not indigenous to India their examination has not been included in the present paper.

The table gives the results of rubber and resin content in the latex of the common and abundant species of *Urticaceae*. In order to complete the study a few species which are not common have also been included. A standard method⁵ of analysis has been followed in all cases so that the results may be comparable.

Coagulum of the latices from these plants would in normal times be regarded as worthless on account of the high proportion of resin, but in view of the present acute shortage, these may find application as such or on suitable admixture with rubber in the manufacture of certain type of commercial goods, such as ground sheets, water-proof bonded papers, etc. where, at present, pure rubber is being used. It is in this direction that some of these coagulums or latices may find a commercial utility and thus afford relief to the supply of rubber.

References

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- ³ Hooper, 1906, *Ann. Rep. Ind. Mus. Industr. Sect.*, pp. 6, 25.
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POSSIBILITIES OF LITHIA GLASS IN INDIA

RAJENDRA SINGHA MITHAL

THE chief constituents in the manufacture of glass are silica usually in the form of quartz sand or crushed quartzite, and an alkali as sodium oxide in the form of sodium carbonate (soda ash) or sodium sulphate (salt cake). By the addition of lime or limestone, a less fusible and harder glass is prepared. For specially hard or heat resisting glassware alumina is added to the batch. Similarly if coloured glasses are desired special colouring agents are added. When the raw materials are not quite pure and final product has a tinge of colour some decoloriser is used. Among the minor raw materials borax is used only for very special glasses. However, the main ingredients are good quartz sand and alkali.

Of all the above materials required in the glass industry, except for the alkali and certain chemicals e.g., borax, cobalt nitrate, practically everything including furnace material is available in India.

The problem of obtaining alkali is quite a major one, particularly in the days of war, when the supplies are not sure. This can partly be met with if lithium salts specially the lithium carbonate be replaced for soda ash or salt cake.

Application of lithia can be done without any difficulty due to the fact that it has low equivalent weight, and it resembles the alkaline earth oxides but with strong fluxing properties, which require comparatively little lithia for the replacement of soda or potash. Dr Eric Preston of the Department of

Glass Technology, Sheffield points out in a paper, that the comparative ease of decomposition of lithium carbonate is indicated by the decomposition pressure which is about six times as high as the decomposition pressure of sodium carbonate at 1000°C. Moreover, the addition of equal percentage of lithia produce mixtures of much lower viscosity than the corresponding soda glasses. The cause of this lower viscosity seems to be due to the very low equivalent weight of lithia. This advantage has been taken in preparing special glasses by several workers. As W. C. Taylor, assignor to Corning Glass Works (U. S. A.) prepared low expansion glasses (with a linear expansion of 0.000,005 or less per degree Centigrade), Lindemann produced glasses particularly transparent to ultraviolet rays and X-rays.

The chief sources of lithia are the minerals, amblygonite, a complex lithium aluminium phosphate, spodumene, lithium aluminium silicate and lepidolite, a lithium aluminium fluo-silicate. None of these can be available commercially with a higher lithia content than about 8%. In all the three lithia is accompanied by alumina, thus the quantity which can be mixed into glass batches in the form of minerals is limited. However, it has been practical to prepare lithium carbonate, the cost of which will undoubtedly go down as larger quantities of lithia find application.

Of the above mentioned minerals, lepidolite or lithia mica with a lithia content of 2 to 6% has been found in considerable quantities in certain parts in the province of Behar. F. R. Mallet in 1874 proved its existence in the Hazaribagh region in a dyke S.W. of Pihira, occurring in irregular, scaly masses

of violet-red to greyish violet colours. On analysis the violet-red variety was found with 3.71% of lithia. In the same area at Manimundar blocks of the mineral as heavy as 8 cwt. are strewn in the sides of a hillock. Again in 1934 H. Crookshank found boulders of the mineral for over a distance of one mile, south of Mundval in the Bastar State, C.P., derived from pegmatites. According to him hundreds of tons of the mineral, containing 3.34% of lithia are available with a possibility of greater supplies. Hence further geological investigations and detailed prospecting of these lepidolite deposits of Behar and C. P. might prove of economic importance as both these areas lie quite close to the chief Indian glass industrial centres of the U. P. and Bengal.

This possible application of lithia not only minimises the alkali problem of the Indian glass manufacturers but it provides one more field for the industrialists of manufacturing lithium carbonate, besides the high quality of glass produced.

From the technical point of view the most important effects of substituting lithia for soda or potash are (a) the relatively great reduction in working and annealing temperatures; (b) the definite increase in the thermal expansion as lithia replaces soda molecularly and (c) the glasses with high lithia content have better transmission for ultraviolet rays and X-rays.

Because of the above facts, it can be deemed possible that suitable supplies of lithia may be made available after the war at such prices which will be at least justified by the better properties of glass.

MEDICINE AND PUBLIC HEALTH

STUDIES ON MEASLES

Two sets of studies on measles, as undertaken by a group of investigators working in the University of Pennsylvania (*Journal of Pediatrics*, January, 1943), have been reported in the *Scientific News Letter*. In the first, measles virus grown on the chorioallantois of the developing chick embryo from three to sixty-six serial passages was inoculated by intranasal drip, by inhalation, intradermal injection and subcutaneous injection into 255 children, most of whom were susceptible. Typical reactions of extremely mild measles occurred in the large majority of inoculated children with Koplik spots, rash,

fever, conjunctivitis and coryza but rarely with cough or malaise. In view of the nature of the reactions, the measles virus as inoculated was considered to be modified and to produce in the children an attenuated disease. The passage of the attenuated measles virus again through human beings, from evidence obtained by single human passages through several "contact control" children showed that this virus did not regain its virulence by such human passage. The reactions to the inoculations emphasized the importance of the accurate negative history of measles. Significant differences in the reactions to inoculation did not appear following the

use of (a) different routes of inoculation, (b) two different methods for preserving the virus material and (c) different dilutions of the inoculum.

In the second study, 22 children who had been previously inoculated with egg-passage measles virus were exposed by chance at various intervals up to one year from the time of their inoculations to children with active cases of measles under field conditions. Three of these children developed typical measles, 1 developed mild measles, 3 developed an extremely mild disease distinguishable with difficulty as measles, and 15 developed no disease. Twenty-four children who had been previously inoculated with egg-passage measles virus were exposed by challenging injections of blood from active cases of measles at various intervals from the time of their original inoculations. Three of these children developed typical measles, 2 developed mild measles, 5 developed an extremely mild disease distinguishable with difficulty as measles, and 13 developed no disease. One additional child showed a slight nasopharyngitis without fever, rash or Koplik spots. Suitable control children and monkeys were injected with portions of the challenge material used and developed measles typical for the species injected. The use of measles virus, attenuated by passage on the chorioallantois of the developing chick embryo, for active immunization of children against measles gave results sufficiently encouraging to warrant further trial of such immunization in larger groups of susceptible children under field conditions inasmuch as 40 of the 46 children inoculated appeared to be completely or partially protected from measles.

EXPERIMENTAL GAS GANGRENE

THERE has been much debate concerning the effectiveness of the local application of certain of the newer chemotherapeutic agents in fresh traumatic wounds to prevent gas gangrene. According to a report of the Scientific News Letter, W. R. Sandusky and F. L. Moleny designed a series of experiments to throw light on this subject, a full account of which has appeared in the December issue of the *Archives of Surgery*. The effectiveness of a number of the newer chemotherapeutic agents for the prevention of experimental gas gangrene when wounds were contaminated with various strains of gas-forming anaerobes is evaluated. When used in experimental wounds within two hours after production and contamination, sulfanilamide, sulfadiazine,

sulfathiazole and the sodium salts of the latter two were found effective in the prevention of death from gas gangrene in animals whose wounds were contaminated with either Cl. welchii or Cl. septicum. The effectiveness of zinc peroxide in such wounds was not convincingly demonstrated. Under the same conditions zinc peroxide was found effective in producing a slight but statistically significant reduction in mortality from gas gangrene in animals with Cl. novyi-contaminated wound. Sodium sulfathiazole approaches zinc peroxide in effectiveness, but the reduction in mortality is not statistically significant. Complete failure was encountered with the other sulfonamide compounds in Cl. novyi-contaminated wounds. In general, sulfadiazine, sulfathiazole and their sodium salts appear to be more effective in preventing experimental gas gangrene than is sulfanilamide. Except in the Cl. novyi-contaminated wounds, there is no significant difference between sulfathiazole and its sodium salt. Sodium sulfadiazine, however, appears to be superior to sulfadiazine. This work reflects the complexity of the problem and the multiplicity of the factors involved.

TOXICITY AND EFFICACY OF PENICILLIN

A PAPER in the January, 1943, issue of the *American Journal of Pharmacology and Experimental Therapeutics* reports that a study was made by Robinson of the toxicity and efficacy of penicillin in certain bacterial virus, and protozoan infections. Penicillin was found to be a highly effective chemotherapeutic agent in infections caused by gram-positive bacteria in mice. Crude penicillin is toxic for mice when given intravenously in single dose of 0.5, 1.0, 1.5 and 2.0 grams per kilogram of body weight. More highly purified preparations appeared to be less toxic than the crude preparation when compared on a weight basis. When given subcutaneously, penicillin is well tolerated by mice in daily doses of 1.6 grams per kilogram over a five-day period. Under the same conditions 3.2 grams per kilogram are lethal for some mice. The toxic dose of crude penicillin appears to be about 64 times the effective dose as determined by subcutaneous injection in mice. On the basis of weight, penicillin appears to be more effective than sulfanilamide and its derivatives in streptococcal, pneumococcal and staphylococcal infections in mice. Penicillin had no apparent effect in experimental infections caused by *Mycobacterium tuberculosis*, *Trypanosoma equiperdum* or the influenza virus P R 8.

MALARIA—FROM THE TREATMENT POINT OF VIEW

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OF HYGIENE AND PUBLIC HEALTH, CALCUTTA

(Continued from the last issue)

Clinical cure.—This means the administration of drugs with a view to curing all clinical manifestation of disease. It does not aim at destroying completely all the parasites in the body and effecting complete sterilisation. For this purpose, in B.T. and quartan, quinine and atebirin are equally efficacious as they can destroy both the asexual and sexual forms of these two species. The best practice is not to use more than one drug at a time and when one fails to try the other. In these infections there is no need for using plasmoquine for the clinical attack. For rapid cure of a case, atebirin is better than quinine. But for the treatment of persons living in endemic areas and getting frequently re-infected quinine is better than atebirin. In M.T. infections the case is somewhat different. With certain strains of M.T. treatment with atebirin has yielded definitely better results than quinine and is the drug of choice. As plasmoquine has no action on the asexual forms of M.T. it is not required for effecting clinical cure.

Prevention of relapses.—This means administration of drugs to persons who have malaria with the object of preventing the occurrence of relapses in them. This question arises not only when treating any individual but also in the army, in endemic areas and in large labour organisations where it is necessary to reduce the number of people getting malaria due to relapses during the malarial season. For this purpose, the considered opinion of the League of Nations malaria commission is that quinine plasmoquine combination gives better results than any other single drug or combination of drugs. Although atebirin cures an attack of malaria more rapidly than quinine, it is not better than a combination of quinine and plasmoquine in reducing the relapse rate and in preventing the onset of relapses. Some people believe that in M.T. it is better to give atebirin first and then after a short interval of a day or two to give plasmoquine, as there is certain amount of risk in giving atebirin and plasmoquine together at the same time. Of course no such risk exists when quinine and plasmoquine are given together. It should however be stressed here that whatever drug is given it should not be administered in large doses or over long periods specially when parasites and clinical symptoms are absent.

Prevention of gametocyte formation.—This is important from the public health point of view, as it

is the people who harbour gametocytes that are alone capable of infecting mosquitoes. If we can prevent formation of gametocytes we prevent the dissemination of infection through the mosquito. But unfortunately there is as yet no drug discovered which can be said to stop definitely the production of gametocytes. Plasmoquine is probably the only drug that may be said to have some such effect. It surely kills the sexual forms once they are formed and when administered during the parasitological period though it may not prevent the formation of the sexual forms it certainly renders the gametocyte carriers non-infective to mosquitoes.

Sterilisation of infection.—This means administration of drugs with a view to destroying all malaria parasites present in an infected person. This indeed is a very difficult task and requires not only a careful selection of drugs for the purpose but also judicious dosage controlled by repeated blood examinations. Even then one cannot always be certain if complete sterilisation of infection has been effected or not. For cases are known where malaria has recurred after apparent cure and after intervals of 10 and 20 years without any reinfection having occurred. The drugs that have been found most helpful for B. T., quartan and M. T. are courses of quinine or atebirin alternating with courses of plasmoquine.

Mass treatment.—This means administration of drugs to all people living in highly malarious areas during the malaria season to keep down the fever rate irrespective of the species of the parasite responsible for the malaria. For this, where medical supervision is available, a combination of quinine and plasmoquine is the best; but where medical supervision is not available daily doses of quinine (6 grains) or bi-weekly doses of atebirin (½ grains) have been found effective.

As regards the question as to how exactly the drugs are to be used for the various purposes the Malaria Institute of India has published a very comprehensive table based on the findings in the 4th Annual Report of the Malaria Commission of the League of Nations, which is reproduced in the next page. It is an authoritative statement based on enquiry and experience and it is accepted by all malarologists. Recently Covell (1942) has also given an excellent note on the use of antimalarial drugs.

ACTION OF QUININE AND THE SYNTHETIC DRUGS ON MALARIA

(From 4th General Report of League of Nations Malaria Commission)

	Action on Trophozoites.		Action on Gametocytes.		Action on Acute symptoms.		Action on frequency of relapse.	Action on spleno-megaly.	Effects on general condition of patient.
	B.T.+Q.	M.T.	B.T.+Q.	M.T.	B.T.+Q.	M.T.			
QUININE	Daily dose of 1 gm. (15 grs.) causes disappearance. 5-7 days.	Daily dose of 1-3 gm. (20 grs.) causes disappearance. 5-7 days.	Affects pre-gametocytes and gametocytes.	Affects pre-gametocytes but gametocytes only very slightly.	Marked action from 3rd day (2nd paroxysm).	Variable action from 3rd or 4th paroxysm.	Acts on all species but in B.T. & Q. relapse rate may reach 50%	Acts on all species but effect is transient where re-infection or relapses are frequent	No effect if treatment is limited to number of days essential.
ATEBRIN	Daily dose of 0.3 gm. causes disappearance after 3 days. Effects last longer than Quinine.	Daily dose of 0.3 gm. causes disappearance after 4 days in 90% of cases.	Similar to Quinine but slightly more marked.	Similar to Quinine.	Very marked action. Fever falls by 2nd paroxysm.	Marked action. Fever usually falls by 3rd paroxysm (but with some strains effect is less than with Quinine).	Action slightly more than Quinine especially in B.T. & in certain strains of M.T.	Effect somewhat slower than Quinine but seems to last longer.	Sometimes yellow colour of skin.
PLASMO-QUINE	Slight action only.	Practically no action.	Definite action in both species.	Marked action in minimum doses of 0.02 gm.	No indication for using Plasmoquine for treatment of acute attack.		Definite action on B.T. & Q. In Association with Quinine & Atebrin it has a marked effect in reducing relapses in all three species.	Insufficient data.	In doses now used e.g., 0.02 gm. it seems to have no depressing effect.

NOTES

A. Action of combination of drugs.

1. There is no advantage in combining Quinine and Atebrin in treatment.
2. Quinine+Plasmoquine simultaneously produce less frequent and less intense toxic symptoms than Atebrin+Plasmoquine, but are best given consecutively where possible. Quinine (15-20 grains daily for 7 days)+Plasmoquine (0.02 gm. daily for 5 days)* are probably the best treatment.
3. Simultaneous administration of Atebrin and Plasmoquine aggravates the toxicity of each and is not recommended. Consecutive treatment with Atebrin (0.3 gm. daily for 5-7 days) and Plasmoquine (0.02 gm. daily for 5 days*) has no advantage in the primary attack but acts on the gametocytes and relapses in the same manner as Quinine and Plasmoquine treatment.

B. Practical suggestions for treatment

1. Individual treatment: (i) Quinine (15-20 grs.) or Atebrin (0.3 gm.) 5-7 days, followed by Plasmoquine (0.02 gm.) 5 days; or
(ii) Quinine+Plasmoquine simultaneously.
2. Treatment in field: Quinine (15-20 grs.) or Atebrin (0.3 gm.) 5-7 days followed by Plasmoquine (0.02 gm.) 5 days if funds and medical supervision are available.
3. Mass drug prophylaxis: Daily doses of quinine (0.40 gm. or 6 grains) or bi-weekly doses of Atebrin (0.02 gm.).

* For gametocidal purposes alone, however, one dose of 0.02 gm. Plasmoquine followed by a second dose, if necessary, on the 5th day is equally effective. It may be noted also that in one mass treatment experiment (in Sardinia) the daily administration of 0.02 gm. Plasmoquine had to be stopped after 3 days on account of toxic symptoms.

The last two questions namely, the availability of antimalarial drugs in India to-day and the policy to be adopted in the future will be dealt now. From the foregoing account of the antimalarial drugs it would have been clear that for a vast country like India with her slender finances, the only drug that the country can afford or attempt to supply to its millions of sufferers is the Cinchona alkaloids. Although it is true that India began the cultivation of cinchona in 1860 and has been extending cultivation of cinchona by growing it in the Nilgiris, Ceylon, Burma, Sikkim and other places, she has only been able up till now to produce a tenth of her needs. She has all along been depending on Java for the major part of her supplies. Within the last few years attempts are being made to make India self-sufficient with regard to her quinine requirements and to make the drug available to all sufferers at a reasonable cost. However with the rapid developments of the new synthetic drugs it is being felt by some that there would ultimately be no necessity for quinine in malaria. Since the outbreak of the war with Germany in 1939 the supply of the synthetic drugs has practically come to a stop. Since the fall of Java into enemy hands the source of our main supply of quinine has also been shattered. Thus India to-day is threatened with a shortage of quinine and anti-malarial drugs. Fortunately she has enough supplies to last 2 or more years and she can make her own quinine and cinchona. The Government enquiry (Wilson, 1939) on the prospects of cinchona cultivation in India brought forward evidence to show that there are nearly 38,000 acres in India suitable for cinchona cultivation and that each acre can produce about 100 to 200 lbs. of quinine per annum. That means that India can produce 10 times more cinchona alkaloids than what is required for her own consumption. Action is being taken on this report and it is hoped that the problem will be tackled in a such way that India will soon be independent as regards her quinine requirements. It may be argued that even if cinchona cultivation is

started now it would take 8 to 10 years before the plants begin to yield, and that the future is for synthetic drugs and not for cinchona alkaloids, yet it can be said that for a poor country like India with millions of sufferers and with absolutely no prospect of her getting anything better than quinine for the treatment of the masses in the next 25 years to come increased cultivation of cinchona is her only salvation.

Synthetic drugs are being manufactured in India. Synthetic drugs are not only expensive but are also very toxic. Their administration in rural areas would need medical supervision and this would increase the cost of distribution. India can ill-afford to use these for mass treatment for a long time to come. Also India has been and almost solely dependent on other countries for her supply of these and there is no prospect of her getting her requirements till long after the war is over. Looked at from this point of view also the salvation lies in increased cinchona cultivation at the earliest possible moment (Chopra 1938).*

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* Since this article was written early in January, 1943, papers have appeared regarding the value of mepacrine hydrochloride which has been placed in the market by certain pharmaceutical concerns of Calcutta. Tests conducted at the School of Tropical Medicine, Calcutta, show its effectiveness in the treatment of malaria like atebrian. This shows that if the necessary raw materials are available in adequate quantities, Indian firms can supply all the needs of atebrian in this country. Ed.—*Science and Culture*.

BOOK REVIEWS

Science and Education—By S. R. HUMBY and E. J. F. JAMES. Published by the Cambridge University Press, 1942. Price 3s. 6d. net.

This is another important addition to the new series of books on current problems for general reading, published by the Cambridge University Press. Today there is clearly a great need for books of this type, which seek to popularise the social significance of science and propose to discuss suggested reforms in our educational system calculated to create a truly scientific attitude towards problems affecting the life of the individuals and of the community. Unmistakably science has become today a vital social force and a dominant factor in the shaping of our civilisation. Scientific progress during the last three hundred years has worked profound changes in the condition of life and in human relationship. Unfortunately this is yet very imperfectly understood by a vast majority of people who, in their utter ignorance of science and scientific methods, still continue to view civilisation in the old and traditional perspective and have therefore the most confused notion about the shape of things to come. The inadequacy of the present educational system with its somewhat alien attitude towards the teaching of science, particularly with reference to its social significance, has been largely and rightly held responsible for this unfortunate state of affairs. The authors have therefore correctly remarked, "In our view one of the principal causes of the maladjustment between education and the needs of the world lies in the fact that the new scientific knowledge, from which the recent profound changes in society so largely spring, is itself only very imperfectly incorporated in our education. . . . If what is perhaps the greatest moulding force of contemporary civilisation is only half understood by the majority of citizens, then here is an obvious direction of reform of education to be brought into closer relationship with the needs of life."

In the present monograph under review, the authors have accordingly emphasised two points, namely (1) the need for a fuller and wiser application of scientific knowledge and of the scientific attitude to social questions, and (2) the need for the reorganisation of the present educational system. The first point has been discussed in Chapter I under the heading "Science and Society" where they have presented a strong case for the creation of a right scientific attitude towards social problems through an increased cultivation of scientific knowledge in

our education. In Chapter II the history of gradual incorporation of science subjects in the schools of England has been traced to indicate the conservatism of the authorities in the matter of science teaching in the schools. This is adequately reflected in the fact that the subjects and methods of education remained the same from the days of Quintilian to the days of Arnold, from the first century to the mid-nineteenth century of the Christian era. In the three subsequent chapters the directions of reorganisation and reorientation have been laid down in a general way with special reference to the contents of science courses, the problems of presentation and the teaching of scientific method. The suggestions do not, however, incorporate any new idea, but the systematic and logical presentation of the existing shortcomings and the directions of reform with an easy and lucid style, characteristic of the authors, constitutes the special feature of this little monograph which deserves to be widely read by all students of science and sociology as well by the teaching profession.

S. N. S.

Museum Method and the Processes of Cleaning and Preservation—By MINENDRA NATH BASU, M.Sc., P.R.S., Asutosh Museum Series No. 2, University of Calcutta, 1943.

This small brochure is welcome evidence of the increasing interest in India in the methods of preservation, cleaning, etc., of museum exhibits and of records. The book really deals only with the subject indicated in the latter part of its title and mentions methods of cleaning and preservation which the author and his colleagues have found suitable. At the end there is a list of references to literatures consulted in writing the brochure and most of the processes described are based on those previously used. The author's efforts justify commendation. The presentation however lacks somewhat in critical assessment of the different methods and often very minor changes or adaptations have been given undue prominence. It is evident that objects in a museum have to be guarded against deterioration caused by sun light and other atmospheric conditions. The present tendency is undoubtedly to take recourse to air-conditioning and artificial lighting especially as scientific control of these is becoming easier and the cost is very likely to be within reach of most central organisations. The author might have devoted some

space to this aspect especially as preservation of museum objects is most likely to receive increasing financial support from the State in the future. However many institutions whose finances may not be adequate for such amenities would have to depend on the methods described in the book.

A number of statements require comments. On page 21 the reference to wind borne salt spray from the sea may create the impression that the salt (or salt efflorescences) in old household bricks *generally* results from this cause. The short account of chemical composition and formulae of glass is not only somewhat out of date but also wrong in some places. There are also some other evidence of the want of a really critical approach in describing the various methods mentioned in the book.

Records are being kept of observations on the effect of various treatments. They would be useful in assessing the values of different treatments. The use of the letters "P.R.S." in the publication of the Calcutta University should at least be avoided. Abbreviations and scholarships should not be used in this fashion.

J. N. M.

The Life of Sir J. J. Thompson—By LORD RAYLEIGH, Cambridge University Press, 1942. Pp. 300, with 9 illustrations. Price 10 shillings.

Sir J. J. Thompson, known to his intimates and students as J. J. is one of the stalwarts of modern physics. He is well-known for his discoveries on the electron, and famous as the man who made the Cavendish Laboratory, a great institution.

Dealing admirably with J. J.'s early life in a few short pages the author goes on to J. J.'s appointment to the Cavendish professorship at the age of 27 and his marriage to Miss Rose Paget at the beginning of second chapter of the book. J. J. started his long and fruitful career at Cambridge under great difficulties. The Laboratory was being starved for the usual 'Cambridge-reason of lack of funds'. The author gives us a wealth of incidental information regarding the early struggles of J. J. to obtain funds for Cavendish. For instance, the contribution he made regularly from his not too meagre salary. There are interesting glimpses of life at Cavendish, the scarcity of apparatus that 'led to predatory habits, so that it was necessary to carry a drawn sword in one's right hand while assembling one's apparatus with one's left.' One catches intimate moments with J. J. in the Laboratory visiting each student every morning, smoothing the friction between workers, doing his own experiments or telling an anecdote in his inimitable style. There is an admirable description of the institution of tea at Cavendish, initiated by J. J. and presided over by Lady

Thompson. The table talk, at first general, would turn to anything interesting that might be going on in the physical world. It is an interesting picture of the beginning of a habit that has now become an universal practice in almost all physical laboratories.

J. J.'s contribution to physics in the fields of the mobility of ions, the corpuscular nature of Cathode rays, the electronic charge, the properties of X-rays and the discovery of positive rays are well known, and it is interesting to hear an account of the story behind these discoveries. The history of his famous investigations on Cathode rays have been dealt in detail in Chapters IV, V and VI. A historical account is given in Chapter IV of the controversy regarding the nature of the Cathode rays and of the results obtained by Thompson in 1892 from which he concluded that the velocity of these rays and the ratio of their mass to charge observed, "seem to favour the hypothesis that the carriers of the charges are smaller than hydrogen atoms".

The significance of Townsend's experiment on the determination of the number of drops falling with terminal velocity in the cloud produced in a Wilson's chamber and the use of this method by Thompson for the determination of e , the charge on a gaseous ion produced by X-rays have been discussed in detail in Chapter V. In Chapter VII an account of Thompson's conception of the structure of the atom and the determination of the number of electrons in an atom from the results of scattering investigations on scattering of X-rays by Barkla is given. Chapter VIII deals with the award of Nobel Prize in Physics to J. J. in 1906 which won him an unprecedented ovation from his friends and students, and with his trip to Winnipeg, U. S. A. in connection with the meeting of the British Association in 1909 of which he was elected the President. Chapter IX is devoted to Thompson's researches on positive rays during the years 1910-13. The initial difficulties encountered in these experiments and the facts which led to final success have been discussed in detail. It is interesting to note that although Thompson obtained parabolas for neon corresponding to mass numbers 20 and 22 and suggested that these might be two isotopes of neon, he was always haunted by the suspicion about hydrogen compounds and "for this reason he hesitated for time to accept Aston's later results about isotopes of other elements. He took a rather curiously hostile attitude about it at a discussion on the subject at the Royal Society in 1921". The account of his researches show a fertile imagination and a lucid mind fond of concrete pictures and analogies.

Perhaps J. J.'s greatest contribution to physics is the legion of his students, among whom are such great names as Rutherford, Aston, his son G. P.

Thompson and others. His views on education were very practical. He realised perhaps, his own deficiencies and favoured a strong technical background in physics experiments. The story is told of Thompson that he used to say, he would rather go up in an aeroplane with a pilot who knew how to use a spanner rather than with an expert in aerodynamics.

The war of 1914 came as a rude shock to the well ordered world of Cambridge. J. J. was not untouched. His son was at the front in France and J. J.'s letters to him were full of human interest. J. J. was active in several war researches mostly in an advisory capacity, as a member of the newly founded Board of Invention and Research. J. J. lent his support to industrial research and pointed out on various occasions to the Government the importance of fundamental research to industrial progress. His dual function as President of the Royal Society and a member of the newly founded Advisory Board helped him to emphasize the rela-

tion between science and industry. He helped to create the Department of Scientific and Industrial Research and to transfer the National Physical Laboratory from the aegis of the Royal Society to this newly created department. The end of the war saw a gradual diminution of J. J.'s scientific activities. He had become by now one of the great public figures of his time and was offered the mastership of Trinity College at Cambridge. He accepted it and retained it till the end of his life in August, 1940. J. J. was a good administrator and was very successful in his relations with undergraduate students of Trinity College. He was always a popular figure at the festivities of the boat race night.

The author deserves utmost praise for a very readable biography of the grand old man of Physics. He has taken great pains to elucidate Thompson's views on education and the value of scientific method.

S. C. C. and B. D. N. C.

LETTERS TO THE EDITOR

[The editors are not responsible for the views expressed in the letters.]

ATMOSPHERICS AND METEOROLOGICAL CONDITIONS AT MADRAS

The frequency of occurrence of atmospherics at Madras at various hours of the day and during the various months of the year was studied in detail. Thus the diurnal and seasonal variations of the number of atmospherics per minute were found. An ordinary straight radio receiver of high sensitivity, connected to a long inverted "L" aerial and tuned to 2,000 metres, was used for this purpose. Atmospherics were counted for 15 minutes at a stretch, every time measurement was made and the mean per minute was found. This was repeated for different hours of the day and for different months. From the large amount of data collected average values were taken and used to find the diurnal and seasonal variation of the number of atmospherics per minute. It must be mentioned here that feeble atmospherics were not taken into consideration.

Diurnal Variation.—The diurnal variation of the frequency of atmospherics at Madras for October is represented in Fig. 1. The minimum at 1100 hours is well marked and appears almost throughout the year. Atmospherics are most frequent at about

1,500 hours occurring about once every second. This maximum also is characteristic and is shown by

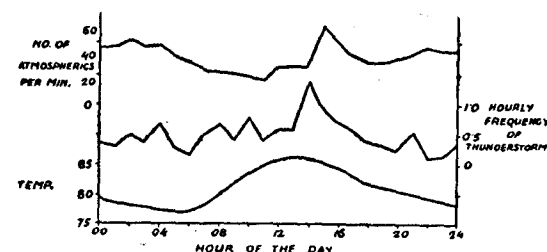


FIG. 1. Diurnal Variation for October at Madras.

the curves for other months as well. The second curve in the same figure represents the hourly frequency of thunderstorms at Madras for October, mean for 1916-30 (S. P. Venkateswaran, 1931). The general nature of the two curves is similar. The afternoon maximum is prominent in both cases but the thunderstorm minimum seems to occur early in the night. The third curve shows the diurnal variation of local temperature for October.

Seasonal Variation.—The annual variation in the frequency of atmospherics is shown in Fig. 2. A

clearly defined maximum is noticeable during September and October and a similar maximum might be expected during midsummer. Atmospherics are

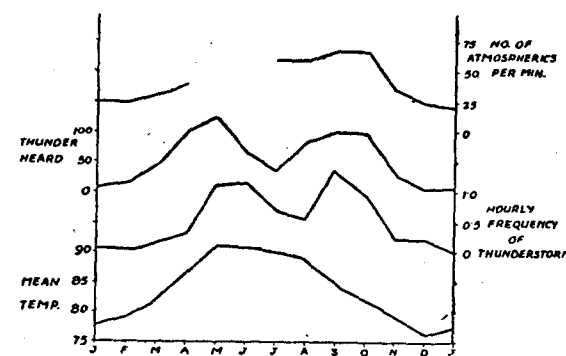


FIG. 2. Seasonal Variation at Madras.

definitely fewest at Madras during December and January. The thunderstorm frequency also shows two corresponding maxima, the winter minimum and the subsidiary minimum in August. 1,500 hours values have been taken in plotting these two curves.

The third curve in the same figure represents "thunder heard" during the various months of the year—mean for 1935-39—at Madras and twenty nearby places surrounding it. (Data obtained from India Meteorological Department). This curve is seen to resemble the atmospherics curve very closely. Lastly the local mean temperature is shown for the year 1941. The gradual rise in the first quarter and the gradual fall in the last quarter of the year and the winter minimum are points of resemblance between this and the atmospherics curve. The two distinct peaks of the latter are replaced by a flat maximum in the temperature curve.

It would appear from the above that thunderstorms provide a great majority, if not all, of atmospheric disturbances and that local and nearby thunderstorms play the greatest part in their production. The high rate of production of atmospherics seems to suggest that lightning phenomena alone may not be sufficient to cause so many atmospheric disturbances. All tropical thunderstorms are heat thunderstorms and they occur with the greatest frequency in summer and during the afternoon on moist land areas. Thunderstorms, therefore, follow temperature variation roughly and hence the correlation between the occurrence of atmospherics and local temperature becomes clear.

Physics Department,
C. D. College,
Anantapur, 15-5-1943.

T. K. LAKSHMANAN

ON SAMPLING IN UNKNOWN FIELDS

In an earlier note¹ it has been pointed out that in the absence of any previous knowledge regarding the field to be sampled, the conditions of homogeneity and isotropy are to be observed while choosing a model for the representative population set (R.S.) of points. There will be other criteria as well, by which we can choose among the different models. In the model generally used for such cases, the ultimate cells are all equal squares (S-model). An alternative model having as its cells equal regular hexagons in a bee-hive pattern (H-model) is proposed in this note. The points of the R.S. are situated at the centres of the cells, and the cells may ideally be of infinitesimal size. Condition of homogeneity is obviously satisfied by both the models. Condition of isotropy—unavoidably of a restricted nature—is satisfied in a more developed manner by the H-model than by S. For any direction in S there are three other directions (four in all) having the same properties. Taking a line of closest packing as the initial line ($\theta=0$), these directions may be represented by $\theta=\alpha, \frac{\pi}{2}+\alpha, \pi+\alpha$ and $\frac{3\pi}{2}+\alpha$. Associated

with these, there are four other directions, $-\alpha, \frac{\pi}{2}-\alpha, \pi-\alpha$ and $\frac{3\pi}{2}-\alpha$ also having the same directional properties but in the opposite sense (mirror-image). Whereas in the H-model, for any α there are six directions in all, represented by $\frac{n\pi}{3}+\alpha$ ($n=0, 1, 2, 3, 4, 5$), with the same properties, and six more directions, $\frac{n\pi}{3}-\alpha$ with 'mirror-image' properties. Then, the hexagon has less perimeter than the square area and is thus a closer approach to the circle. Moreover, the H-model is better suited than the S-model, as a consequence of its more developed isotropy, for randomisation in terms of the polar co-ordinates (r, θ). The cells bordering any particular cell (the 'central' cell) are defined to constitute the first ring; the cells bordering the first ring form the second ring; and so on. The central cell will be the zero-eth ring. Then the number of cells in the n -th ring is $8n$ in the S-model and $6n$ in H ($n>0$). The integer n will represent the co-ordinate r , and θ will have any of the $8n_0$ or $6n_0$ discrete values, when $r=n_0$. It is obvious that the rings of H-model will be a better approximation than those of S for the family of concentric circles $r=n$.

The R.S. for the H-model can be easily generated by the points of inter-section of any two families (out of three possible) of equi-spaced parallel lines, inclined to each other at an angle of 120° . The sampling technique will likewise be simple consisting merely of independent randomisation of

x and y co-ordinates, where these are inclined to each other at 120° (or 60°) with $\Delta x = \Delta y$.

A simple modification of these two models may also be noted. If the regular pattern is elongated in any principal direction so that the square cell becomes a rectangle or a rhombus, and the regular hexagon gets similarly deformed, the successive rings will represent a family of similar and similarly situated ellipses. Here also the H -model will provide a better representation.

It is no use taking a polygon with more than six sides as the ultimate cell. The principle restricting our choice is that 2π must be an integral multiple of (say y times) the angle of a regular polygon with x sides. Then it is easily seen that

$$\frac{1}{x} + \frac{1}{y} = \frac{1}{2}, \text{ whose only possible solutions with}$$

finite positive integral values of x and y are $x=3, 4$ and 6 . Thus the cell must be either a triangle, or a quadrilateral, or a hexagon. Of these, the triangular model is the least satisfactory. There is, however, a reciprocal relation between the triangular and the hexagonal models: the vertices of the cells of the triangular model form the points of the R.S. of the H -model; and *vice versa*. The S -model is self-reciprocal in this respect. Further studies in the technique of sampling are proceeding. My thanks are due to S. N. Roy for his kind interest.

Statistical Laboratory,
Calcutta, 1-7-1943.

BIRENDRANATH GHOSH

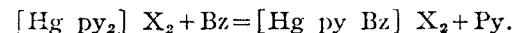
¹ SCIENCE AND CULTURE, 7, 117, 1941.

3-CO-ORDINATION COMPOUNDS OF MERCURY

Mercury is rarely known to form 3-co-ordination compounds. In mercuric triammino chloride, the co-ordination number of mercury is 3. But this compound is decomposed in air and hydrolysed by water. Here, a series of stable 3-co-ordination compounds have been prepared. These are obtained by the addition of pyridine, piperidine and aniline to benzidine mercuric salts of the general formula $[\text{Hg Bz}] \text{X}_2$ (Bz=benzidine, X=univalent acid radical). The additive compounds with pyridine and piperidine are very stable and are not decomposed by boiling with water; those with aniline, on the other hand, are hydrolysed by water.

Pyridine addition compounds of the general formula $[\text{Hg Bz py}] \text{X}_2$ are bright yellow in colour and are readily obtained by (i) adding water to benzidine mercuric salts dissolved in hot pyridine, (ii) boiling with water equimolecular proportions of

a mercury salt, pyridine and benzidine or (iii) acting on mercury dipyridine salts with benzidine. In the last reaction a molecule of pyridine is liberated



The formation of the above type of additive compounds is so very general in character that it appears possible to detect mercury in aqueous solution by a reagent containing equimolecular proportion of benzidine and pyridine. Piperidine behaves like pyridine but the additive compounds are not of characteristic colour. The unstable additive compounds with aniline are obtained from only a limited number of mercury benzidine salts.

In complete absence of water, pyridine and piperidine unite with mercury benzidine salts to form 4-co-ordination compounds, two molecules of the bases being added to a molecule of the complex salts. These unusual types of 4-co-ordination compounds are, however, quickly converted in presence of water to the more stable 3-co-ordination salts. The newly prepared *o*-tolidine mercuric salts resemble to a large extent benzidine mercury compounds in forming additive compounds with pyridine, piperidine as well as aniline.

Chemical Laboratory,
Presidency College,
Calcutta, 27-7-1943.

KANAI LAL MANDAL

A SUPPLEMENTARY NOTE ON THE CONSTITUTION OF THE TANNIN FROM INDIAN TERIPODS

In a recent publication¹ the tannin has been described as identical with the tannin isolated from Indian gallnuts procured from the Punjab side and it has been provisionally termed as penta-digalloyl glucose. Subsequent experiments have confirmed the teripod tannin to be a *mono*-digalloyl glucose and it appears probable that the constitution of the Indian gallnut tannin is also different from the Chinese gallnut tannin to which E. Fischer has assigned a penta-digalloyl glucose structure.²

A detailed paper on the constitution of this tannin is being published in the journal of the Indian Chemical Society.

H. G. BISWAS.

Sir Prafulla Research Laboratory,
Bengal Chemical & Ph. Works Ltd.,
Calcutta, 4-8-43.

¹ Biswas, H. G.—SCIENCE AND CULTURE, 9, 89, 1943.

² Fischer, E.—*Ber.*, 46, 3253-89.

MORE PLANETARY SYSTEMS IN THE UNIVERSE

It had for long been an open question, whether our Solar System was unique in this vast Universe. Observation had not so far disclosed any, and, according to Russell¹, it should never be able to, even through the most powerful telescope that we could construct. It had been left to theory to guess the plurality or otherwise of planetary systems. According to the tidal theories of Jeans², Jeffreys³ and Lyttleton⁴, planetary systems should be 'freak formations' in Nature. We shall quote Jeans⁵ on the frequency of planetary systems in space on the tidal theory. He says, "We may conclude that in the whole of the galactic system planetary systems only come into being at the rate of about one per 5000 million years, so that our own system, with an age of the order of 2000 million years, is probably the youngest system in the whole galactic system of stars." We shall not enter into the vexed question of the age of the Universe. The majority of the astronomers are in favour of a short time-scale—between 10^9 and 10^{10} years. This allows at the most two planetary systems in the whole of the galactic system, on Jeans' theory. On Littleton's binary star collision theory, the frequency of collisions would be still less, and the number of planetary systems practically nil.

Spencer Jones⁶ has, on the other hand, observed that amongst the myriads of stars in our galaxy and the extra-galactic nebulae, not only a few but many might be endowed with planetary systems like our own. It will be interesting to quote in this connection Prof. A. C. Banerji's⁷ concluding remarks in a recently published paper on his new Cepheid theory of the origin of the Solar System. Banerji⁸ says, "One conclusion seems to be irresistible. If the theory be correct in its essentials, there may be more planetary systems than at present supposed, and, if life on this earth be the result of an orderly natural process, some of these other planets may be inhabited by beings like us." Banerji's prediction has indeed come true. Non-solar planetary systems have this very year been detected by simple though quite unexpected means.

From the study of parallax observations Dr K. Aa. Strand⁹ has detected the presence of a planetary companion to the 61 Cygni system. Dr Strand finds the visual pair to show periodic deviations from a Keplerian orbit. This can only be explained on the assumption that a third invisible body of small mass revolves round one of the binary stars. The mass of this third body (61 Cygni C) is found to be about sixteen times that of Jupiter and its luminosity very low. Both these facts enable us to classify it as a planet. 61 Cygni C is however not the only one of

its kind. A similar non-solar planetary body of even smaller mass has been detected by Reuyl and Holmberg¹⁰ in the system 70 Ophiuchi.

Observation has thus brilliantly confirmed Banerji's suggestion of the plurality of planetary systems. A short account of Banerji's Cepheid theory of the origin of the Solar System has been given by the author in an article, entitled "Variable Stars"¹¹. In this connection the author¹² has said, "Thus Banerji's theory solves in a most natural way the two outstanding difficulties of the previous theories, *viz.*, of energy and angular momentum. A specially remarkable feature of the theory is that it makes a lesser number of assumptions than any other existing theory. The parent Cepheid, in this theory, will also have a planetary system of its own; and the probability of there being other planetary systems than our own is definitely increased." This may be contrasted with what Spencer Jones¹³ has said regarding most of the existing theories—"So many special assumptions are involved that it has been remarked that the Solar System had a very narrow escape from never coming into existence."

It is interesting to observe that the star 61 Cygni is within 5 parsecs and 70 Ophiuchi within 10 parsecs of the Sun¹⁴. Thus we have evidence of the existence of other planetary systems quite near our own system. This definitely favours Banerji's prediction of there being numerous planetary systems and very much weakens the case for the grazing encounter theories, according to which, as we have just said, there can be at most two planetary systems in the whole of the galactic system.

The author also wishes to refer in this connection to the theory of the origin of binary stars which he advanced in the same article¹⁵. An originally homogeneous Cepheid was supposed to break up into a double star system on account of increase of angular velocity due to radiation of energy. Planets would be likely to be formed by condensation of the filament connecting the two stars. The recent observational fact of binary stars being endowed with planetary systems is very plausible on the Cepheid theory of the origin of binary stars.

It may be remarked that both the Cygnus and Ophiuchus constellations abound in Cepheids.

H. K. SEN

Mathematics Department,
University of Allahabad,
Allahabad, 5-8-1943.

¹ Russell, H. N.—"The Solar System and Its Origin", p. 113, 1935.

² Jeans, J. H.—"The Problems of Cosmogony and Stellar Dynamics", p. 275, 1919.

- ³ Jeffreys, H.—"The Earth", p. 16, 1929.
⁴ Lyttleton, R. A.—*M. N.*, 98, 536, 1938.
⁵ Jeans, J. H.—"Astronomy and Cosmogony", p. 409, 1929.
⁶ Jones, H. S.—"Life on Other Worlds", p. 247, 1940.
⁷ Banerji, A. C.—"The Instability of Radial Oscillations of a Variable Star and the Origin of the Solar System", *Proc. Nat. Inst. Sci. Ind.*, 8, 173, 1942.
⁸ Banerji, A. C.—*loc. cit.*, p. 196, 1942.
⁹ Strand, K. Aa.—*Publ. Astro. Soc. Pac.*, 55, 29, 1943.
¹⁰ Reuyl and Holmberg—*Ap. J.*, 97, 41, 1943.
¹¹ Sen, H. K.—"Variable Stars", *SCIENCE AND CULTURE*, 7, 579, 1941-42.
¹² Sen, H. K.—*SCIENCE AND CULTURE*, 7, 582, 1941-42.
¹³ Jones, H. S.—*loc. cit.*, p. 234.
¹⁴ Jeans, J. H.—"Astronomy and Cosmogony", pp. 7, 22, 1929.
¹⁵ Sen, H. K.—*SCIENCE AND CULTURE*, 7, 582, 1941-42.

My best thanks are due to Prof. P. C. Mitter for the keen interest he has taken during the progress of the work.

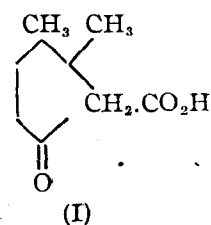
D. K. BANERJEE.

Palit Laboratory of Chemistry,
 University College of Science and Technology,
 92, Upper Circular Road,
 Calcutta, 7-8-1943.

* Taken from the thesis submitted for the Degree of Doctor of Science of the University of Calcutta in 1940.
¹ Banerjee—*SCIENCE AND CULTURE*, 5, 715, 1940.
² Simonsen *et al.*—*J. C. S.*, 767, 1938.

SYNTHESIS OF 3:4-DIMETHYLCYCLOHEXANONE-3-ACETIC ACID*

In continuation of our investigations¹ on the synthesis of the degradation products² of hydroxyeremophilone, namely 1 : 2-dimethylcyclohexylacetic acid and 3 : 4-dimethylcyclohexanone-3-acetic acid (I), we like to place on record the results of our further experiments for the synthesis of the acid (I) in the d, l-form.

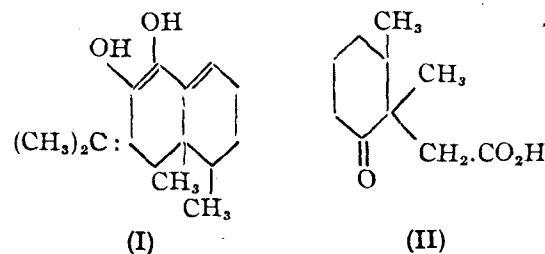


Ethyl-γ-acetyl-n-valerate was condensed with ethyl cyanoacetate in saturated ammoniacal alcoholic solution at low temperature. On working up, a thick oil was obtained which consisted of the desired imide along with the unchanged keto-ester. The crude product was hydrolysed with sulphuric acid and the mixture of acids obtained therefrom was esterified, when ethyl-2 : 3-dimethyl-1 : 5-dicarboxypentane-2-acetate (b.p. 170°/4.5 mm., 150°/2.5 mm.) along with the low boiling ethyl-γ-acetyl-n-valerate were obtained. The above tricarboxylic ester underwent cyclisation by sodium in benzene solution to yield ethyl 3 : 4-dimethyl-2-carboxycyclohexanone-3-acetate or ethyl 3 : 4-dimethyl-6-carboxycyclohexanone-3-acetate (b.p. 163-165°/5.5 mm., 147°/3.5 mm.). On hydrolysis of the β-ketonic ester, the required keto-acid was obtained in a rather impure condition and it was purified through its ethyl ester (b.p. 109°/2.5 mm.), which on hydrolysis with alcoholic caustic potash yielded the keto-acid (I) as a colourless oil (b.p. 143-147°/2 mm.).

SYNTHESIS OF 2:3-DIMETHYLCYCLOHEXANONE-2-ACETIC ACID

As a result of further study on the constitution of hydroxyeremophilone Simonsen *et al.*¹ have revised the older formula and suggested (I) as the probable structure representing the same. On the basis of this new configuration, the keto-acid C₁₀H₁₆O₃, obtained by the oxidation of hydroxyeremophilone benzoate, also received new interpretation for its structure, namely (II).

In an attempt for the synthesis² of the reduced liquid acid C₁₀H₁₈O₂, Simonsen prepared the above keto-acid, the poor yield of which, however, prevented him from making further progress along this line. We describe below a new synthesis of the keto-acid (II), in an excellent overall yield. The resolution of the d, l-acid thus obtained is in progress.



1-cyano-4-carboxy-4-acetylpentane (b. p. 160-165°/9 mm.), obtained by the methylation of ethyl α-acetyl-δ-cyanovalerate, was hydrolysed with concentrated hydrochloric acid, when δ-acetylpentonic acid (b.p. 150-160°/8 mm.) was obtained in an exceptionally good yield. Ethyl δ-acetylpentanoate (b.p. 112-115°/8 mm.) was condensed with ethyl cyanoacetate according to the modified method of Cope *et al.*³ to give ethyl 1-cyano-2 : 3-dimethyl-Δ⁴hexene-1 : 6-dicarboxylate (b.p. 190°/8 mm.) in tolerably good yield. The above unsaturated cyanoester smoothly

added on a molecule of hydrocyanic acid and the resulting crude dicyanoester was hydrolysed with concentrated hydrochloric acid, when crystals of 2 : 3-dimethylhexane-1 : 2 : 6-tricarboxylic acid separated out from the cold acid solution, which on recrystallisation from dilute hydrochloric acid with the aid of charcoal melted at 174°. Triethyl ester of the above tricarboxylic acid (b.p. 180-185°/6 mm.) underwent cyclisation by refluxing with sodium in dry benzene solution with the addition of a few drops of alcohol to yield ethyl 1 : 2-dimethyl-5-carboxy-6-keto-cyclohexylacetate (b.p. 164-165°/6 mm.). d, 1-2 : 3-dimethylcyclohexanone-2-acetic acid (b.p. 156°/5 mm.) was obtained by the hydrolysis of the

above β-ketonic ester with an excess of 20% sulphuric acid, the semicarbazone of which melted at 184°.

SUNIL KUMAR RAY.
 D. K. BANERJEE.

Sir P. C. Ray Research Fellow's Laboratory,
 University College of Science and Technology,
 92, Upper Circular Road,
 Calcutta, 7-8-1943.

- ¹ Simonsen *et al.*, *J. C. S.*, 61, 1941.
² Simonsen—*J. C. S.*, 415, 1940.
³ Cope *et al.*, *J. Am. Chem. Soc.*, 63, 3452, 1941.

SUPPLEMENT

Indian Science News Association

PROCEEDINGS OF THE EIGHTH ANNUAL MEETING

THE Eighth Annual General Meeting of the Indian Science News Association was held on August 18, 1943 at 5 P.M. in the hall of the Applied Chemistry Department at the University College of Science, Calcutta.

In the absence of Dr S. C. Law, President of the Association, Prof. M. N. Saha, Vice-President was in the Chair and Sir Cyril S. Fox, Late Director of Geological Survey of India, Calcutta was the Guest of Honour.

The proceedings of the last annual meeting were read and confirmed.

On behalf of the Secretaries Prof. S. K. Mitra submitted the following report of the working of the Association and the audited accounts for the year 1st July, 1942, to 30th June, 1943.

ANNUAL REPORT

The Council of the Indian Science News Association have much pleasure in submitting this, the Eighth Annual Report and the Statement of Accounts for the period July 1, 1942 to June 30, 1943.

MEMBERSHIP

During the year under review 14 members joined us as Members of the Indian Science News Association as compared with 15 in the previous year. Of these, 8 were already subscribers to the journal.

The number of life members at the close of the year under review was 103 compared to 97 on the corresponding date last year showing an increase of 6.

SCIENCE AND CULTURE

The total number of copies of SCIENCE AND CULTURE despatched in June 1943 i.e., the last month of the period under review was 1041 as compared with 965 in the same month in 1942. The number of subscribers in June 1943 (including members of the Association) was 853, which represents an increase of 94 since June 1942. The actual number of new subscribers enrolled was however 164.

We had difficulties owing to scarcity of paper. We were, however, able to obtain a regular supply

of paper for the journal and our thanks are due to Mr Raghunath Dutt of Bholanath Dutt & Sons Ltd.

We venture to assert that we have been able to maintain the high standard of the articles published in the journal. They are always from the pens of the specialists and as such, are authoritative. To show that the high quality of our journal is being appreciated abroad we may mention that very recently we received in a private communication an offer of an article from Sir Edward Appleton, F.R.S., Secretary of the Department of Scientific and Industrial Research, Great Britain. The offer is a result of a casual request made about six years ago by one of the members of the Editorial Board. The fact that Sir Edward has remembered the request and has volunteered to send an article shows that he reads the journal and appreciates its quality.

We would take this opportunity of thanking our contributors who by their articles, notes and letters have helped to make SCIENCE AND CULTURE what it is to-day.

EXCHANGE JOURNALS

The total number of copies sent out every month in exchange and for review was 65. We received in exchange only 4 English, 13 American, 17 Indian and 1 Australian journal as compared to 4 English, 10 American, 10 Indian and 1 Australian journal in the previous year. We also received journals of 13 learned societies and publications of 4 Government Scientific Departments. Four Calcutta news papers, viz., the *Statesman*, the *Hindusthan Standard*, the *Amrita Bazar Patrika* and the *Jugantar* supply their daily issues in exchange. We send the journal regularly to 20 Societies and Institutions on request.

ADAIR DUTT RESEARCH FUND

You are probably aware that last year the well-known firm of Messrs Adair Dutt & Co., Ltd. placed at the disposal of the Association a sum of Rs. 4,000/- to award research scholarships. The Fund is managed by a Committee consisting of the members of the Editorial Board of the journal and the General Manager of the firm. Three scholarships tenable for two years were awarded last year for carrying on

researches on (1) "Artificial Culture of Natural Foods for Fresh water fishes of Bengal" under Prof. H. K. Mookerjee, D.Sc., (2) "Study of long Chain Dienic Acids with Conjugated Double Bonds under Prof. P. C. Mitter, Ph.D., and (3) "Ionosphere and Upper Atmosphere Problems" under Prof. S. K. Mitra, D.Sc., M.B.E. The firm has donated a further sum of Rs. 2,500/- to the Association to award two more scholarships, of which one is to be given to a lady student for research on Biology, Domestic Science, Nutrition or Dietetics and another for industrial Research.

(For statement of account see next page).

GRANTS

We express our gratitude to the University of Calcutta, the Bengal Chemical and Pharmaceutical Works, Ltd., and the Indian Association for the Cultivation of Science for renewing their annual grants. The amounts of these grants are as follows:

Calcutta University	...	Rs. 500/-
Bengal Chemical & Pharmaceutical Works Ltd.	...	Rs. 250/-
Indian Association for the Cultivation of Science	...	Rs. 100/-

We had been fortunate enough to receive donations almost every year in the past from our patrons and sympathisers. We regret to announce that we have received no such donation this year. There is, however, one satisfactory feature of our finances which we may note in this connection. It was only by drawing on these donations which were really intended for creating a reserve fund that we had been able to balance our budget all these years. In the year under review, we have been able to meet the expenses from our own income. If the improvement of our financial position continues, we may be able to take up new lines of work such as publication of books etc., which is also one of the objects of the Association.

To the authorities of Calcutta University we are further indebted for allowing us accommodation in the buildings of the University College of Science and Technology.

CONCLUSION

The development of science in all its branches is proceeding so fast and has been so extensive that it is not possible for an ordinary scientific worker to keep himself informed of the latest progress and their applications. One of the desires of the promoters of the Indian Science News Association when they started the journal eight years ago was therefore to help the scientific workers by providing them with a sort of ready reference of the latest developments of science. They also had in view the education of the general public in taking an intelligent interest in

science and to impress upon them that the salvation of this unfortunate country of ours lay in wider and still wider application of science and its method in every aspect of her social and economic life. How far we have succeeded in achieving our objects, it is for you to judge. But the fact that we have been able to publish the journal regularly all these years, in a country of 10 per cent. literacy—only a microscopic proportion of which is able to appreciate the value of science—is some proof that we have not totally failed in our attempt.

To the scientific workers of the country we would say that the Indian Science News Association through its journal SCIENCE AND CULTURE tries to reach their voices to a large and influential section of the community. We therefore appeal to them to rally round the Association and to help it in attaining the objects with which it was started.

(For statement of account see next page).

OFFICERS AND MEMBERS OF THE COUNCIL

The following persons were unanimously elected officers and members of the Council for the year 1st July, 1943 to 30th June, 1944.

President—Dr S. C. Law. *Vice-Presidents*—Sir U. N. Brahmachari, Dr Baini Prasad, Prof. M. N. Saha, Dr B. C. Law, Sir S. S. Bhatnagar, Prof. P. N. Ghosh. *Treasurer*—Prof. P. C. Mitter. *Secretaries*—Prof. S. K. Mitra, Prof. B. C. Guha. *Members*—Prof. S. P. Agharkar, Dr B. Ahmad, Mr H. P. Bhaumik, Prof. D. M. Bose, Mr Rajsekhar Bose, Dr K. Biswas, Dr M. Qudrati Khuda, Col. Sir R. N. Chopra, Mr A. T. Ganguly, Sir J. C. Ghosh, Kt., Dr D. S. Kothari, Mr B. N. Maitra, Dr S. C. Mitra, Prof. H. K. Mookerjee, Prof. J. N. Mukherjee, Prof. B. B. Ray, Mr M. K. Sur, Prof. P. Ray, Dr S. L. Hora and Dr A. C. Ukil.

The Editorial Board of "Science and Culture" for the next year was constituted with:—

Sir J. C. Ghosh, Prof. M. N. Saha, Dr A. C. Ukil and two Secretaries as ex-officio members.

Prof. M. N. Saha then delivered his welcome address at the meeting which was attended by distinguished scientific men of the city. Prof. Saha humorously described Sir Cyril S. Fox as the "Bolshevik Geologist" and referred to the important work he carried on as the director of the Geological Survey of India and the valuable services he rendered to the cause of geological progress in this country. He then traced the history of the gradual development of SCIENCE AND CULTURE in the face of financial difficulties which have been solved only narrowly in recent years. He referred to the recent grants of Rs. 2,000/- from Sir P. C. Ray Fund and that of Rs. 1,000/- from Messrs. Sur Enamel & Co. It has been proposed that the grant from Sir P. C. Ray Fund will be spent in the compilation and publica-

tion of an authorised biography of Sir P. C. Ray who dedicated his whole life to the cause of scientific and industrial progress in this country. He finally sent an appeal to leading industrialists and business concerns of the country to lend their financial patronage to the journal so that it can extend its activities to various important directions so far untouched owing to limited financial resources and can more effectively serve the cause of the dissemina-

nation of scientific knowledge and information among scientific workers and general reading public of this country.

Sir Cyril S. Fox in course of his address traced the history of the development of geological resources in India since 1846 and described the present mineral position of India with particular reference to important statistics. His address is published on p. 109 of this issue.

Receipts and Payments Account for the year ended 30th June, 1943.									
RECEIPTS		Rs. As. P.		PAYMENTS				Rs. As. P.	
To Opening Balance on 1-7-42 :—				By Stipend				1,006 10 8	
At Bengal Central Bank Ltd. S. B. A/C. ...				" Advertisement				43 2 0	
Grant (Adair Dutt & Co. Ltd.) ...				" Bank Charges				2 5 0	
" Bank Interest				" Postage & Receipt Stamp				0 12 3	
				" Stationery				2 10 0	
				" Conveyance				0 9 3	
				" Closing Balance on 30-6-43 :—					
				(a) At Bengal Central Bank					
				Ltd. in Savings Bank A/C.				7,940 2 1	
				(b) With Treasurer				27 14 6	
								7,968 0 7	
								</	

AUDITOR'S REPORT TO THE MEMBERS

I have audited the above Receipts and Payments account of ADAIR DUTT RESEARCH FUND for the year ended 30th June, 1943, with the books and vouchers and have obtained all the information and explanations I have required. I certify that the said Account is correctly stated in accordance with the books of accounts of the fund.

10, Old Post Office Street, Calcutta, the 14th August, 1943.

Sd. S. K. MITRA,
Honorary Secretary,
Adair Dutt Research Fund.

Sd. A. K. GHOSH,
Government Diplomat
Accountant,
Registered Accountant,
Auditor.

Sd. G. BHATTACHARYA,
Treasurer,
Adair Dutt Research Fund.

II

Receipts and Payments Account for the year ended 30th June, 1943.

RECEIPTS		Rs.	As.	P.	PAYMENTS		Rs.	As.	P.
To Opening Balance on 1-7-42 :—					By Establishment	...			2,667 2 6
(a) At Bengal Central Bank Ltd. in Current A/C. ...	678	1	9		„ Journal Printing	...			3,124 1 0
(b) At Bengal Central Bank Ltd. in Savings Bank A/C. re: Science and Culture A/C. ...	715	12	3		„ Paper	...			2,712 15 6
(c) With Treasurer	107	13	6		„ Postage & Receipt Stamp	...			566 9 0
					„ Conveyance	...			34 7 3
					„ Telephone	...			184 14 6
					„ Miscellaneous	...			113 6 0
					„ Audit Fee (1941-42)	...			40 0 0
					„ Bank Charges	...			42 12 0
					„ Stationery & Printing	...			206 14 0
„ Grant					„ Binding Charges	...			7 6 0
„ Life Membership Fee					„ Closing Balances on 30-6-43 :—				
„ Ordinary Membership Fee					(a) At Bengal Central Bank Ltd. in Current A/C. ...	1,481	13	9	
„ Subscription					(b) At Bengal Central Bank Ltd. in Savings Bank A/C. re: Science and Culture A/C. ...	796	13	3	
„ Advertisement					(c) With Treasurer	118	3	6	
„ Reprint									2,396 14 6
„ Miscellaneous									
„ Bank Interest									
			</						

AUDITOR'S REPORT TO THE MEMBERS

I have audited the above Receipts and Payments Account of INDIAN SCIENCE NEWS ASSOCIATION (registered under Act XXI of 1860) for the year ended 30th June, 1943, with the books and vouchers and have obtained all the information and explanations I have required. I certify that the said Account is correctly stated in accordance with the books of accounts of the Association.

10, Old Post Office Street, Calcutta, the 14th August, 1943.

Sd. S. K. MITRA,
Honorary Secretary.

Sd. A. K. GHOSH,
Government Diplomat
Accountant,
Registered Accountant,
Auditor.

Sd. P. C. MITTER,
Treasurer.

SCIENCE AND CULTURE

A Monthly Journal of Natural and Cultural Sciences

Vol. IX

OCTOBER, 1943

No. 4

POST-WAR ORGANISATION OF SCIENTIFIC RESEARCH IN INDIA*

IN a broadcast at the beginning of the war, H. E. Sir Robert Cassels lamented that India's industrial backwardness stood in the way of adequate military preparation. "India's greatest asset is a large supply of the finest type of fighting men. Her great weaknesses are a low national income and a limited industrial development incapable as yet of supplying the technical equipment of a modern army. History has amply shown that victory is not the prerogative of a large organisation swollen with ill-armed soldiery but rather of small well-equipped armies modern for their period. This is even more true to-day than at any time before, and now-a-days ill-equipped armies are nothing more than sheep for slaughter." If this war has proved any thing beyond doubt, it is this—that human valour cannot compensate for technical and scientific efficiency.

The aim of every post-war reconstruction in India should be the removal of these two weaknesses—"A low national income and limited industrial development." And we are met together to-day to discuss how science should be organised in India so that this object may be achieved.

It will be a mistake to ignore the fact that there are powerful leaders and a well-organised party in India who have been so impressed by the evils of the modern world, that they do not hesitate to declare that the introduction of Western methods for increasing our national income should be resisted, that it is no business of the State to help scientific and technical development which have led to two

such world catastrophies in the course of 25 years. They would prefer non-violent non-co-operation to armed resistance against aggression. They would prefer the culture of cottage industries, peasant farming, and living on subsistence level with its inevitable doses of famine and pestilence, to the immense wealth but maladjustment and inhuman greed of modern societies. Men of science in India have to shoulder the additional burden of educating their masters out of this conservative view. We cannot preach too often that the powerful tools of science, which have been used for evil purposes by evil men, are capable of doing immense good if handled for the benefit of humanity; that the blame for our present trouble does not lie with science, but with the evil men and their duped followers who have made this world an insanity fair; that in these days of rapid communications we cannot live in isolation from the rest of the world even if we wish to do so; that life in India will be stagnant if we run counter to the characteristics of the present age, which consists in applying the principles, properties and products revealed by scientific research to industries and agriculture; that stagnation is the half-way house to death, and to ignore science, which has changed the national economy and cultural levels of the rest of the civilized world by invading every industry, craft and art, will be to invite effacement. One would wish to remind them of the famous saying of Pasteur, than whom there has been no greater benefactor of humanity, that "Science is the soul of all progress and the source of all prosperity."

There is another school of thought in the country whose advocates do not believe that scientific and technical research is necessary for the industrial development of the country. They consider that all

* Opening address of Sir Jnan Chandra Ghosh, President, National Institute of Sciences of India, on the occasion of the Symposium on Post-War Organisation of Scientific Research in India, held at Calcutta on September 27 and 28, 1943.

that is needed is to decide on general grounds if the country has the potential resources in power, raw material and transport, which will justify the establishment of any particular industry, and then import into the country the necessary machinery and experts for the purpose. They are in favour of providing such technical education in the country which will enable the industry to be run by indigenous talent after a period of probation under foreign experts. They would strongly support technical and vocational education, but stop at research as being more in the nature of a luxury. I have often met this attitude in our powerful industrial magnates and *entrepreneurs* in business. To them the history of the dyestuffs industry should be an object lesson. The first synthetic dye was made in England by Perkin, but the industry soon found a congenial home in German soil. In Germany the practical outlook of businessmen is, more often than anywhere else, enthused by that faith in scientific research which comes from first hand knowledge. Thus, twenty long years of painstaking research were necessary at a cost of more than a crore of rupees before Bayer's process for the synthesis of indigo could be commercialised. But once it was done, the fate of the natural indigo of Bihar was sealed and it disappeared from the world's market in another twenty years. Of great topical interest is that exciting venture of the late Prof. Haber when in 1909 he demonstrated before the Badische Chemical Engineers that it is possible to obtain small quantities of ammonia by synthesis from nitrogen and hydrogen. Millions of pounds had to be spent before this discovery could be exploited commercially; and to-day synthetic ammonia, apart from its value in war, constitutes the biggest single item in the fertiliser industry with an annual production of more than 100 crores of rupees. The attitude in Great Britain, on the other hand, was one of complacent 'wait and see'; and the result was that in 1914 she had no dyestuffs industry of any importance. As the war progressed it was realised that the British dependence on Germany for dyes was tantamount to a much wider and more fundamental weakness of British Chemical Industry. Modern war depends for its successful prosecution on an abundant supply of a large variety of chemicals; and a dyestuffs and fine chemicals industry must be considered an integral part of every defence programme. The British Government took immediate and far-reaching steps. Beginning with a direct and large subsidy for the formation of a company, which ultimately was absorbed in the Imperial Chemical Industries, millions of pounds were spent on developmental research in every branch of the industry. Later on, the importation of dyes and even intermediates were prohibited. As a result Sir Gilbert Morgan in 1939

claimed with justifiable pride that of the 5 most fundamental discoveries in dyestuffs chemistry since 1921, the world owed three to British talent. The British dyestuffs factories are not only producing now their home requirements but have also in addition a considerable export trade. This altered attitude in Great Britain is reflected in the Ormsby Gore report of 1928 which observes that "no nation can advantageously depend only on the efforts of other nations for the purpose of promotion of knowledge. This is not only because such dependence is an ignoble parasitism, but also because in the field of international relations no less than in national life, the power that comes from knowledge comes from its early and rapid use and from close contact with men who have created this knowledge." The conviction has now become universal that the nation, which will enjoy the benefits of science in the day-to-day progress of its industries and agriculture; is the nation which habitually applied to them scientific method and scientific knowledge; and it is that nation which will be able to seize the advantages of the more spectacular achievements of science in its economic life.

We are reminded often in our country of the distinction that exists between pure and applied research. It is unfortunate that any great stress should be laid upon such difference even before we have made much progress in the field of scientific research. There are explorers to whom discoveries are ends in themselves, there are others who create new knowledge or utilise existing knowledge for practical purposes. They belong to the same family; their efforts are not antagonistic but supplementary. To a chemist the examples of Bayer and Haber, which I have already quoted, make such distinctions meaningless. The physicist and mathematician may be regaled with an anecdote about Heaveside. When this British mathematician was told that an American had made a million dollars by the practical use of his theory of distortionless telephone circuit, he replied that the American deserved a million dollars more for having understood his mathematics properly. -It often happens that the application of a discovery may not be obvious to the discoverer himself or the progress in cognate branches of science and technology has not been such that the discovery can be taken advantage of at the time it is made. Great and perhaps equal credit is due to Marconi for the development of radio communication as to Hertz, the discoverer of electromagnetic waves. To us in India both aspects of research should receive equal attention. We may differentiate between a long range programme and a short range programme. Both forms of research are generally good financial investments; while the short range may bring some immediate return for the capital, the long range

programme is often an insurance against dark days, and its indirect return by fostering research-mindedness in the country and by training personnel with a flair for discovery is of inestimable value. It also often happens that the direct return of one fruitful piece of long range research pays back many times over the cost of ninety-nine which may not find useful application. Synthetic ammonia is a case in point.

No informed person in Europe or America would disagree with the observations that I have made; but in our country the opinion of men that count, the custodians of the public purse, is not generally helpful. I remember the Hon'ble Sir Ramaswamy Mudaliar saying sometime ago that as soon as the war broke out, a note was put up to the Hon'ble the Commerce Member by the Departmental Officials that as a measure of retrenchment the old Bureau of Scientific Research should be abolished; he had the foresight to note back that the old Bureau should be abolished not as a measure of economy but to make room for a Board of Scientific and Industrial Research with vaster resources and wider objectives; that in war time, no economy can be too disastrous which starves industrial research and no expenditure can be too high which mobilises the scientific and industrial talent of the country for research and production of war materials. Thus was brought into being the Board of Scientific and Industrial Research in India in April 1940. The Board now receives an annual grant of ten lakhs of rupees from the Government.

Now that the victory of the United Nations is in sight, we feel that time is ripe for a critical examination of the facilities for scientific research and training that are available in India and drawing up plans for improving and co-ordinating such facilities. The agencies that are responsible for this work are the Universities, the Central Institutes under the Government of India, the Imperial Council of Agricultural Research, the Indian Research Fund Association, the Board of Scientific and Industrial Research, the endowed Research Institutes like the Indian Institute of Science, the Indian Association for the Cultivation of Science, the Bose Research Institute etc. and the Research Laboratories of Industrial concerns like the Tata's. It is difficult to estimate the total funds that are available to these bodies for the discharge of their onerous duties. At a very optimistic estimate, the total expenditure from all sources will not exceed seventy-five lakhs of rupees per year. In the more progressive countries scientific research is being planned with a crusading zeal, as it has been realised that modern developments in science and technology, if utilised to their fullest extent, can give to every individual a fuller and more satisfying life. In the new world of four freedoms, the able scientific researcher will be a key

man and it is a matter of primary importance to enquire what economic and educational structure "will produce this type in maximum abundance and satisfactory activity." In Russia, they spent one per cent of the national income on scientific, technical and agricultural research, i.e. 1.2 billion roubles; and in 1938, the Soviet Union had 902 scientific research institutes with a staff of 29,000 research workers. We are full of admiration for the heroic Russian resistance, which has now fortunately become a mighty offensive. Determination and valour have no doubt played their part in the ordeal through which the Russians have passed, but no less important for success have been the high degree of scientific backing, the abundance of equipment and war materials which are the fruits of long planning and forced marches in industry. Yet science in Russia of 1915 was hardly in a better condition than science in India at the same time! The United States of America employed 70,000 research workers and spent seventy million pounds in scientific and technical research in 1940 which is 0.3% of the national income.

In India the national income has been estimated at Rs. 65/- per head. Even an expenditure of 0.1% of national income for research will amount to 2.6 crores of rupees. An annual grant of Rs. 2.6 crores from the public exchequer for research and an equal grant for training of research workers will, I hope, be not considered unreasonable in the first three years after the war. There is no end of new devices by which funds can be raised. I may commend to the attention of the Central Government the example of France, where an employer has to pay to the public exchequer two francs for every 10,000 francs paid in wages. This gave annually a sum of three crores of rupees which was devoted to technical and vocational education in France. At a recent Rotary lunch in Bombay, the Rotarian President Sir Vithal Chandavarkar said that he felt ashamed when he saw any scientific worker begging for funds which would give him facilities for research. His time and energy could far better be utilised for creative work for which he is best fitted. I wish every thinking person in India would re-echo the sentiments of Sir Vithal.

If, as we expect, funds become available in a generous measure for scientific research in post-war India, it is necessary that every care should be taken that they are utilised to the maximum advantage of the nation. In Soviet Russia, the Academy of Sciences is charged with this responsibility. I may quote from a recent speech of Prof. Crowther the following: "The Academy of Sciences is directly responsible for the planning of scientific development to the Supreme Soviet. Its executive power is equal to its social prestige. The Academy deter-

mines the general lines of scientific work in accordance with the needs of the State and possibilities, in subjects and personalities. It sees that balanced attention is given to all sides of science, that no important branch is neglected, and overlapping is reduced" (not altogether avoided?)...... "The planning proceeds as much from the top as from the bottom. In every institute, the research staff first prepares a programme for each year's work. It is then reduced and incorporated into the plan of the Institute and then given final shape by the Academy who calls a meeting of the Directors of all these Institutes for the purpose." "In the planning of the development of scientific research, the Soviet began with the finding and training of men and then built the Institute later. They did not start with paper-plans of Institutes into which men were subsequently made to fit." ".....In the early twenties, Prof. Joffe started the Physico-technical Institute at Leningrad, collected promising students from all parts of the Soviet Union. By 1929, the Institute had grown to immense size with 700 students in various laboratories and about 1300 assistants and workers." It is the men from such laboratories that have been chiefly the brains and executives of the successive five year plans. The Board of Scientific and Industrial Research in India are now preparing plans for the establishment of the National Physical Laboratory, the National Chemical Laboratory, the National Metallurgical Laboratory, Glass Research Institute, Radio Research Institute, etc. I would remind the Board, of the Russian emphasis on the training and finding of researchers who would be called upon to man these All-India National Laboratories.

It is doubtful if in post-war India, Russian methods will find much favour. Reference to any Academy of Science in India also brings back unpleasant memories of the past. We may, however, study with care the work of the National Research Council of Canada where a young nation with a bold and vigorous outlook is rapidly securing a high place in the world's counsels and esteem. The National Research Council have their own Research Laboratories, whose annual budget in 1939, exceeded one million dollars. These Laboratories supplemented the work of a thousand laboratories for research on process and plant control which are maintained by the industries themselves. In 1938, capital grants were available for building and equipping up-to-date research laboratories in Aeronautical Engineering, Hydraulics and High Voltage Electrical Engineering. By virtue of having under their control laboratories representing all branches of science, the Council are in a favoured position for the study of any important problem. It is not always easy to know in advance which branch of

science can offer the solution; but the Council can easily gather together experts in all related branches of science and set up a team to find such solution. It is a pity that our Imperial Council of Agricultural Research, which has been in existence for more than ten years, has not yet got any research laboratory of its own. Perhaps it is too unwieldy a body to be entrusted with the administration of a laboratory. While we should guard with zealous care the autonomous administration of a University laboratory, where a free lance researcher is exploring the borderland between knowledge and ignorance with no other guide but his own intuition, the laboratories which are mainly concerned with short range programmes of research should be administered on a different footing. Such laboratories should at least have Governing Bodies, with interlocked personnel, and lay the greatest emphasis on team work. Better still if they are administered by an All-India National Research Council through properly constituted Research Committees functioning on their Governing Bodies. Such committees of the National Research Council in Canada "settle the objectives of research, indicate the individuals or organisations which should undertake the several component parts of the enquiry, receive and co-ordinate the resulting information, make it available to those who will turn it to advantage and form a national plan into which all who are in a position to contribute information can fit their particular lines of research." These Research Laboratories, however, do not monopolise scientific research in Canada. Assisted research through Universities is an accepted policy of the Council. The advantages of bringing fresh minds in an academic atmosphere to bear on the solution of a problem are well understood. No worthwhile project of research is delayed for lack of funds with the result that there are some times more problems demanding solution than post graduate students wishing to take up a research career.

The National Research Council, Canada, also manages another unique institution—The Research Enterprises Ltd. In war time every invention of value is immediately seized upon and exploited by eager businessmen for the production of war materials. In peace time, however, this does not generally happen. There is a long gap between the birth of knowledge and its availability for use. The Research Enterprises Ltd. is intended to bridge this gap and shorten the time lag. We should have in India a similar Development Corporation, which will be encouraged to take risks by a guaranteed annual subvention from the State, and introduce into industry and agriculture the inventions and processes which have been satisfactorily worked out under the auspices of the National Research Council. We have already the nucleus of such an organisation

in the Utilisation Branch of the Geological Survey of India and the Utilisation Committee of the Board of Scientific and Industrial Research. It is definitely to be understood that such a corporation can not be self-supporting. We remember with sorrow how the progress of scientific research in India for a decade after the last great war was blocked by the recommendations of the Inchcape Committee. I am told that they recommended that the Imperial Veterinary Research Institute at Muktesar should become self-supporting by the sale of their biological products and that this recommendation was given effect to. I consider that this is a wrong policy to adopt. In normal peace times the research workers should not be saddled with the duties of commercial production of any material. If it is considered desirable that such production be carried out under the auspices

of Government, and in many cases the consuming public will welcome such an arrangement,—it should best be done by a corporation of the type of Research Enterprises Ltd.

War is an ill wind that sometimes blows good things. It makes the public conscious of ulterior objectives. It takes them out of the hurly-burly of routine existence and creates an yearning for a new order of things. It stimulates enterprise in many fields and lifts vital problems clear of the arena of dispute. We hope that the post-war organisation of scientific research in India is one such vital problem and that every citizen of India will pull his weight in implementing the recommendations that may ultimately be evolved by representative gatherings of the type that have assembled here this morning.

ISAAC NEWTON (1643—1727)

A. K. DAS,
METEOROLOGIST

THREE hundred years ago on the 4th of January 1643 a puny, premature child was born in a family of simple yeoman farmers who lived in the little Lincolnshire village of Woolsthorpe. This was Isaac Newton, whose intellectual development was so precocious that he made three of the most fundamental discoveries in astronomy (law of gravitation), mathematics (fluxions or differential calculus) and physics (theory of the rainbow) before he was twenty-four years old. Newton had his schooling at Grantham and at the age of sixteen returned to his native village to take charge of his mother's farm; but he proved to be so incompetent as a farmer that he was sent back to school and from there he went to Cambridge. Soon after his graduation Newton was forced to leave Cambridge because of the plague and returned to Woolsthorpe in the autumn of 1665; the following eighteen months of seclusion proved to be the most fruitful period of his long life, for it was during these months that his extraordinarily powerful mind conceived the ideas of universal gravitation, the theory of colours, the differential calculus as well as the binomial theorem and the method of the infinite series.

Newton was born in an age in which great things were already in the making; he benefitted from the great achievements of his immediate predecessors and those of his contemporaries. Medieval scholasticism had already been seriously challenged

and the foundation of the exact sciences had already been laid by Copernicus, Tycho Brahe, Kepler, Galileo, Descartes and others; Newton's great contemporaries, Hooke, Halley, Huyghens and Grimaldi were practising the observational method as the better way of tackling the mysteries of Nature rather than the method of purely speculative and argumentative philosophy advocated by Plato as the best way of arriving at the truth. But experimental science had not yet been quite firmly established when Newton began his scientific career. The most important reason for the unparalleled influence which Newton's work has exerted on the development of science from his own time right up to the present day is his rare talent for combining observation with theory. His was a supremely penetrating mind that could unerringly pick out the essential out of a mass of isolated and confused facts.

It is a common saying that circumstances make the man. In this sense Newton was a true product of his age. The stage was set for the appearance of just such a man when Newton appeared on the scene. Kepler had already discovered the true laws of planetary motion; Galileo had established his epoch-making laws of falling bodies and had given the world what is known to-day as rational mechanics; this was probably the greatest work of Galileo, for the ancients had only discovered the laws of statics and were greatly puzzled by the phenomenon of motion;

Gilbert had conjectured that there might be an attractive force between the earth and the moon like the attraction between two magnets and Kepler had gone so far as to surmise that the planets might be kept in their orbits by some power inherent in the sun and even that this power might vary as the inverse square of the distance. But there is a great deal of difference between surmising the truth and demonstrating it by unimpeachable quantitative proofs. Without knowing anything about Newton's prior discoveries at least four of his contemporaries,—Hooke, Halley, Huyghens and Wren, had independently noticed that the law of attraction between the sun and the planets ought to be the inverse square law; but though convinced of the correctness of their conjecture they could not prove it mathematically. A Newton was required to probe into the root of the problem, enunciate in simple language the laws of motion and to discover the simple, yet all-engrossing law of universal gravitation. His discovery of the method of fluxions* or differential calculus as we call it to-day happened in much the same way. At least seven mathematicians,—Napier, Kepler, Cavalieri, Pascal, Fermat, Wallis and Barrow,—had foreshadowed the method before Newton; but it was Newton, the supremely practical mathematician who realised it as the most potent and invaluable mathematical tool for the quantitative treatment of physical problems and thus laid the foundation of mathematical physics. The greatness of Newton lay in the fact that he could not only distinguish the true from the false, but his extraordinary mathematical talent could quickly demonstrate the truth, so that with full confidence in his fundamental ideas he could stride forward to unravel further mysteries of Nature. When Newton appeared in the field various fundamental problems were crying out for solution and it was just a mind like his that was needed to synthesise and systematise all known facts and ideas and bring out the elemental truth from which all natural phenomena could be derived as necessary logical deductions. As Macaulay has said "In no other mind have the demonstrative faculty and the inductive faculty co-existed in such supreme excellence and perfect harmony."

Newton's discoveries in optic followed rather a different course. In this field he was scarcely indebted to his predecessors or his contemporaries; here he 'voyaged alone' (as Sir James Jeans has said) 'because everyone else had lost the way'.† By his

* Newton's contemporary, Leibnitz, laid prior claim to this discovery, but it is now generally agreed that the discovery was almost simultaneously and independently made by the two savants.

† It does not appear that Sir James Jeans is quite correct in his claims for Newton. The Jesuits had shown that sunlight is decomposed into seven colours on

simple, yet most convincing experiments with the prism Newton demonstrated that white light was a composite of many colours and that the differences of colour must result from different degrees of refrangibility. This discovery laid the foundation of spectroscopy which to-day is one of the most powerful methods of analysing matter on the earth and is practically the only method of studying the constitution of the inaccessible astronomical bodies. Newton also realised that the disturbing chromatic aberration of lenses was due to the different degrees of refrangibility of the component colours of white light. He therefore designed and constructed, all with his own hands, the first reflecting telescope to replace the refracting telescope of his great predecessor Galileo. The greatness of this invention made some two and a half centuries ago can best be realised from the fact that the largest astronomical telescopes of the modern world are of the reflecting type.

Newton's work in optics did not stop with his study of the spectrum produced by prisms. He carried out the most original experiments in order to investigate the properties of light and evolved a theory of the nature of light which was based upon the results of his varied experiments on the colours of thin plates, on the partial reflection and partial transmission of light at the surface of a transparent body and on the polarisation of light. Although his theory of light does not specifically mention 'corpuscles of light' yet his explanations of the results of his experiments are understandable only on the basis of a corpuscular nature of light. This was regarded by his contemporaries and the later exponents of the wave theory of light as a proof of Newton's failure to appreciate the true nature of light. But strangely enough Newton seems to have visualised something of the dual nature of light, for, in order to understand his own experimental results, he did assume subsidiary waves accompanying the particles of light in their interaction with matter (fits of light); this appears to-day as an anticipation of the modern view of the nature of light as advocated by the wave-mechanics of de Broglie and Schrödinger.

Although he grasped the essential principles of his major discoveries during the two plague years of 1665 and 1666, Newton was in no hurry to publish his thoughts. He worked on his ideas and developed them on quantitative lines during the many years he was Lucasian Professor of Mathematics at

passing through the prism; but they gave no explanation of the observation. Newton placed a prism in the inverse position in the path of the spectrum, and showed that the colours combined into white light. He gave the correct explanation of the spectra, i.e., it is due to the varying refractive index of light of different colours in glass.—*Ed. Sci. & Cul.*

Cambridge. When he had proved his ideas to be quantitatively correct he put down his results often in ciphers and it is doubtful if they would have ever been published but for the persuasion and insistence of his friends. It has been truly said of him that "when Newton made a discovery somebody else had to make the discovery that he had made it." But for the pressure applied by Halley and Hooke the *Principia* and the *Opticks*, two of the greatest monuments of scientific thought, would probably have never been written. This secretiveness in Newton's make-up was partly a characteristic of the age in which he lived, but was largely due to his extreme sensitiveness to criticism and his distaste for controversy. More than once this distaste for controversy resulted in his disinclination to further scientific work. Some people think that it was perhaps this attitude that made him finally give up his chair at Cambridge and accept the post of Warden of the Mint which could never provide the necessary scope for his mathematical and inventive mind. Though his creative work in science virtually came to a close after 50, he retained his intellectual vigour and skill almost to the last years of his life. A very interesting anecdote is on record about this point; in 1698, Johann Bernoulli one of Europe's foremost mathematicians published a challenge problem addressed to the most acute mathematicians of Europe. Newton solved the problem the day he received it and got the solution published anonymously, as was the custom in those days. But as soon it came to the hands of the challenger, he immediately recognised the authorship, declaring with interjection "Ex ungue leonem"! (out of the claws of the lion is this work!)

Newton's intellectual achievements have tremendously impressed his contemporaries and posterity. He was elected President of the Royal Society in 1703, and occupied the presidential chair till his death in 1727. Voltaire, in his youth, witnessed his funeral, and was subsequently present in an assembly where the trite question was being discussed "Who has been the greatest Englishman." Some mentioned Cromwell, some Shakespeare, but Voltaire* thought it was undoubtedly Newton. Laplace, the French savant who did more than any one else in extending Newton's work, wrote that there was but one 'Cosmos' hence one law governing it. It was reserved for Newton to make known to us the general principle of celestial motion. And Laplace was notorious for his refusal to praise the work of others, whether contemporaries or predecessors.

* Voltaire had no good feelings for Shakespeare, for the latter's highly abusive picture of the character of Joan of Arc, in his drama of Henry VI, and characterised him as an inspired barbarian.

Some body once asked Newton as to what led him to astronomy. He replied "I wanted to find out whether there is any truth in judicial astronomy." The reader may be puzzled by this word, now so unfamiliar. It is none else than "Astrology", the "fifth column" of astronomy. But in those days, calculating the fates of persons from positions of planets during the time of nativity, in other words casting horoscopes, predicting fates of countries, predicting auspicious and inauspicious days were supposed to be the essence of astronomical studies and people whose intellectual works demolished the foundations of this superstition, viz., Tycho Brahe, Kepler, had to practise it for their living. It is not known whether they believed in it. Tycho certainly had profound contempt for it which he was not at pains to disimulate. But Newton's work, more than that of any one else, demolished the foundations on which astrology was reared. It showed that the positions and motions of planets which according to astrological notions, are a kind of cipher writing in which God is supposed to reveal the fate of individuals and groups, are merely the result of the Universal Law of Gravitation which all material bodies must obey. There was therefore no mystery about such things as retrograde motion of planets, or conjunctions of planets with some star groups which are used by astrologers. Newton showed us how to calculate the mass, motion, and distance of planets, so that no room for doubt could be left in the minds of those who were intellectually honest that pretensions of astrology were based on premises which had no foundation in fact.

But Newton was unconscious of the greatness of his own intellect, he never realised the unique influence which his creative thought was to have on human progress for centuries to come. The man, who nearly three centuries ago founded celestial mechanics, differential and integral calculus, theoretical physics and a theory of the universe embodied in his universal laws of motion and gravitation not really superseded even by the revolutionary theory of relativity of the present day, thought that he was like a boy playing on the sea-shore 'and diverting himself in now and then finding a smoother pebble or a prettier shell than ordinary, while the great ocean of truth lay all undiscovered before him'. The scientific world however has had an ever-increasing appreciation of Newton's contribution to human thought;—this year on the occasion of the tercentenary of his birth astronomers, mathematicians, physicists and philosophers all alike are paying homage to the memory of the supreme genius whose breadth and depth of vision and record of achievement remain yet unmatched in the whole history of experimental as well as theoretical science.

The Story of the Falling Apple

There is a popular story that Newton was led to the discovery of the law of gravitation from reflections arising out of the fall of an apple in his garden. A piece of apple wood is preserved in the show room of the Royal Astronomical Society of London, as being part of the original apple tree. This story was long disbelieved, but recently an unpublished biography of Newton by the Rev. William Stukeley, a friend of Newton has come to light which appears to support this story. The apple story is due to Voltaire who got it from Newton's niece. Stukeley's story is as follows (*Sky and Telescope*, Vol. 2, No. 3, 1943):

"After dinner, the weather being warm we went into the garden and drank thea (!), under the shade of some apple trees, only he and myself. Amidst other discourse, he told me, he was just in the same situation, as when formerly, the notion of gravitation came into his mind. It was occasioned by the fall of an apple, as he sat in a con-

templative mood. Why should that apple always descend perpendicularly to the ground, thought he to himself. Why should it not go sideways or upwards, but constantly to the earth's centre? Assuredly, the reason is, that the earth draws it. There must be a drawing power in matter: and the sum of the drawing power in the matter of the earth must be in the earth's centre, not in any side of the earth. Therefore does this apple fall perpendicularly, or towards the centre. If matter thus draws matter, it must be in proportion of its quantity. Therefore the apple draws the earth, as well as the earth draws the apple. That there is a power, like that we here call gravity, which extends itself through the universe.

And thus by degrees he began to apply this property of gravitation to the motion of the earth and of the heavenly bodies, to consider their distances; their magnitudes and their periodical revolutions; to find out, that this property conjointly with a progressive motion impressed on them at the beginning, perfectly solved their circular courses; kept the planets from falling upon one another, or dropping all together into one centre; and thus he unfolded the Universe. This was the birth of those amazing discoveries, whereby he built philosophy on a solid foundation, to the astonishment of all Europe."

Shakespeare on Astrology

"This is the excellent foppery of the world, that when we are sick in fortune—often the surfeit of our own behaviour—we make guilty of our own disasters the sun, the moon, and the star: as if we were villains by necessity; fools by heavenly compulsion; knaves, thieves and treachers by spherical predominance; drunkards, liars and adulterers, by an enforced obedience of planetary influence; and all that we are evil in, by a divine thrusting on; an

admirable evasion of whoremaster man, to lay his goatish disposition to the charge of a star: My father compounded with my mother under the dragon's tail, and my nativity was under Ursa Major; so that it follows I am rough and lecherous. Tut, that I should have been that I am, had the maidenliest star in the firmament twinkled on my bastardisation."

EDMUND IN "KING LEAR"

BALANCED VEGETATION AND PISCICULTURE

KALIPADA BISWAS

THE paper entitled "Role of Vegetation in Fishery Tanks" by Dr Sunder Lal Hora¹ is a contribution on an important subject which needs further elucidation in the light of the writer's results of investigation on Limnology.

The aquarium methods followed within closed doors and under artificial conditions in overseas temperate countries, if adopted, would be of very little help towards the solution of this and other allied, rather difficult, problems especially the question of maintaining a balanced vegetation in our tanks and jheels. There is no dearth of different types of water plants required for oxygenating pur-

¹ Hora, S. L.—Role of Vegetation in Fishery Tanks. SCIENCE AND CULTURE, Vol. VIII, No. 8, 1943.

poses and for preservation of purificatory action in our water area. In tropical countries such a beneficial action of Nature is however interfered with more by density of vegetation than by scarcity of water plants. It is, therefore, obvious that cleaning of excess vegetation of our static fresh waters from time to time is imperative with a view to reducing the congested growth of aquatic plants and keeping the requisite quantity of vegetation. The congested vegetation as described in my limnological works is inimical to all submerged animal and plant organisms in tanks, jheels, ponds etc. The question concerning our province involves in controlling the vegetation of different types of aquatic associations in our water areas. In tropical countries such a

physico-chemical and biological conditions will prove to be favourable not only to the development of fishes but also necessary from the standpoint of public health.²

Experience however tells us that the thick screen of surface vegetation produced by the network of such long and partly floating trailers as *Jussiaea repens*, *Ipomoea reptans*, *Enhydra fluctuens* and other species including aquatic grasses growing in association with *Utricularia* sp., *Salvinia* sp., *Eichhornia speciosa* (water hyacinth) and other allied floating and amphibious plants have a deleterious effect on the sanitation of tanks, jheels, etc.

The members of floating vegetation grow rapidly by means of vegetative methods of reproduction. A dense covering of these plants over the surface of water inhibits growth of the submerged and rooted aquatics both along the sides and over the muddy bottoms of tanks, jheels etc. forming what may be called limnae formation of Benthos of loose soil. The limnae formation of our tanks, jheels and ponds etc. consists chiefly of *Vallisneria spiralis*, *Ottelia alismoides*, *Chara* sp., *Nymphaea* sp., *Nelumbium* Sp., *Limnanthemum* Sp., *Eleocharis* Sp., *Cyperus* Sp., *Limonphila* Sp., and others. The Brazilian waterfern *Salvinia auriculata* which was introduced by the writer to this country is utilised for this purpose when a tank is crowded with excess submerged vegetation causing insanitation as a result of decomposition of dead and decaying plant and animal bodies. The surface cover of vegetation may be used as a biological means with a view to reducing the over abundance of submerged and rooted aquatic plants. A complete surface cover of *Salvinia* and other larger floating plants prevents light from penetrating into the water and thus interferes with the absorption and diffusion of atmospheric oxygen and also the normal flow of water and thereby suppresses and finally kills the submerged plants which are responsible for imparting oxygen to the water in the presence of sunlight as a result of their photosynthetic action.³

In the extract quoted by Hora (SCIENCE AND CULTURE, 8, 324, 1943) from Innes⁴ paper, Innes simply lays emphasis on balanced submerged and rooted vegetation as advocated by me and other workers. The ecological conditions of the vegetation in tropical waters are quite different from those of

the United States of America and European countries. Reference to Sewell's long list of water plants (*loc. cit.* p. 324, para 4) by Hora in his contribution has no bearing on the question at issue. The list incorporated in Sewell's paper⁵ of the common water plants occurring in tanks and jheels was furnished by the writer.⁶ The question is the quantitative and qualitative effects of the different communities of water plants in our permanent and temporary water areas. The problem of water plants producing oxygen to the water is altogether a different problem from the control of vegetation of choked up surface, submerged and rooted vegetation in our tanks commonly seen in our urban and rural areas. Reference to the bibliography cited in the papers which are noted in the list of literature to this article will show the amount of work done on this and allied subjects.^{7, 8, 9, 10}

The aquatic plants including algal flora of the Museum Tank and the gut contents of the fish were worked out by me during the investigation of fish mortality first by Sewell and subsequently by Pruthi. There was sufficient quantity of rooted and submerged aquatic plants when fish mortality in the Museum Tank actually occurred. A list of the plants examined by me is added to Pruthi's paper.¹¹ The real cause of mortality of fishes in the Museum Tank is still a debatable question. Fish mortality is by no means a rare phenomenon in this country particularly during Norwesters and at the advent of the rains, in the tanks harbouring over abundance of vegetation. The writer has investigated such a phenomenon in many a tank of the Royal Botanic Garden, Eden Gardens, Dalhousie Sq. Tank, Maidan Tanks in Calcutta and elsewhere.¹²

It is a matter of simple observation that in a tank, jheel, or a pond overloaded with vegetation, the dying and decaying masses of plant and animal organisms give out, particularly during the hot months, stinking smell due to production of acetic

⁵ Sewell, R. B. S.—Investigations regarding an epidemic of fish mortality in the tank in the Indian Museum compound. *Jour. Proc. As. Soc. Bengal* (N. S.) 22, 177, 1926.

⁶ Biswas, K.—Aquatic vegetation of Bengal in relation to supply of oxygen to water. *Jour. Dept. Sc. Cal. Univ.*, Vol. VIII, 1927.

⁷ Pearsall, W. H.—Factor influencing distribution of free-floating vegetation. *Jour. of Ecology*, 9, 24, 1922.

⁸ Storm, K. M.—Recent advances in Limnology. *Pr. Linn. Soc. London*, p. 180, 1927-1928.

⁹ Welch, P. S.—Limnology, 1935.

¹⁰ Whipple, G. C.—The Microscopy of Drinking Water, 1937.

¹¹ Pruthi, H. S.—Investigations regarding a recent epidemic of fish mortality in the tank in the Indian Museum compound with remarks on the causation of such epidemics in general. *Internat. Rev. Hydrobiol. Hydrograph*, 26, 242, 1932, 5 Tables.

¹² Biswas, K.—The algal flora of Maidan Tanks. *Cal. Univ. Rev.*, 1925.

acid, ammonia, peptone, carbon dioxide, sometimes even sulphuretted hydrogen and other poisonous gases of complicated structure. These gases are discharged from the decomposed organic matters deposited at the bottom which is constantly exposed to the action of such organisms as putrefaction bacteria, Sulphur bacteria, Iron bacteria, Schizomycetes, Myxophyceae, Mesosaprob and Saprob—Unicellular and Colonial Chlorophyceae and Diatoms. Respiration and excretion of the aquatic animals including fishes also enrich the stock of carbon dioxide in a water reservoir, if not replenished during day time by the plants giving out oxygen after utilising sufficient sunlight reaching them through a sufficiently open and clean space in the surface of the tanks. Such a state aggravated by the unfavourable climatic and physico-chemical conditions in and outside the tank often upsets the balance of the biological self-purificatory action of our tanks and jheels and cause insanitation and mortality of fishes. I therefore submit again, with all the emphasis I can command, that the water of tanks, jheels, ponds etc. thus devoid of light and oxygen, becomes surcharged with the excess of humic acid, carbonic acid and other injurious productions of putrefaction bacteria such as ammonia, sulphuretted hydrogen, acetic acid, peptone and other various compounds of complicated structures.

With regard to the food of fishes it may be recorded that the writer's examination of the gut contents of several hundreds of different edible fishes from various tanks, jheels, rivers, bheris in the salt lakes of Calcutta and the Chilka Lake in Orissa reveals that different types of algae along with tender most or less decayed vegetable matters form substantial food of fishes. It has therefore been rightly stated by Bukht that "the food of *Cirrhina mirgala* consists of 80% of other indigenous decayed refuse matters and mud." Careful examination of these refuse matters reveals that the materials are mainly composed of algal flora and decomposed parts of common submerged plants along with the muddy matrix. It appears that Bukht did not have occasion to examine microscopically what he terms "indigenous decayed refuse matters and mud." Fishes and animal organisms in water cannot possibly subsist on inorganic matters alone.

My examination of the samples of gut contents of the fishes show that as much as 32% are algae. The nature of the other 68% of the materials forming the matrix also indicates, as found from the remnant of the fragments of the vessels, cell walls and sheathes, consumption of sufficient amount of larger algae and tender parts of submerged plants which, delicate as they are, must have been digested beyond recognition after they were swallowed by the fishes. Abundant

remains of Crustacea and worms, which, as far as my observation goes, live mainly on algae, have also been found in the stomach contents particularly of *Katla* fish. It can thus be said that algae form quite a major item of the original food materials of fishes. It is also interesting to note that some of the algae that have been discovered in the tank of the Indian Museum have also been traced in the stomach contents of the fishes received from Dr H. K. Mukherjee, Professor of Zoology, Calcutta University—in charge of the investigation on the culture of fresh water fishes under the auspices of the Imperial Council of Agricultural Research. Polunin¹³ writes, "After Prof. Hardy's article came a useful one by Dr F. Gross (*Nature*, July 19, p. 71, 1941) suggesting methods of fish culture to extend our food supply." Dr Gross pointed out the remarkably high yields obtained by continental carp pond "farmers" with proper manuring and feeding, and suggested that we apply similar principles to salt water in harbours or lochs of narrow or controlled outlet. Thus by careful feeding small flat-fish could be reared, without the usual enormous loss, to stages well past that of yolk-absorption, and could then be transferred to water prepared "for a rich and prolonged production of phytoplankton". Here molluscs and polychaetes will thrive, having plenty of food, and so will the fish whose increase in weight in a single summer is often of the order of 400% under suitable conditions. If ideal conditions of food supply could be maintained in winter the increase would continue throughout the year. To this, phytoplankton may well afford the key in being the original food supply on which animal life in the sea depends. During the spring outburst as many as 25,000,000 cells per litre may be present for a short period in nature, in culture, "500,000 cells per litre may be reared at all seasons, provided the culture medium is properly enriched with nutrients required for their growth, namely nitrate, phosphate and soil extract, containing substances the action of which, though not yet fully understood, is highly beneficial for the growth of marine organisms." All these data lead to the conclusion that the plankton algae are the chief source of vegetable food to fishes. Of these fresh-water phytoplankton algae composed of blue-green and green algae diatoms are dominant. The blue-green algae, which form the most common phytoplankton associations either pure or mixed in the fresh and brackish waters of this country, play an important role in this respect.

It has been also observed that at a certain period of their growth fishes prefer smaller members of macrophyto and zooplankton such as *Wolffia*, *Azolla*

¹³ Polunin, N.—Plant Science Forum, *Chronica Botanica*, 7, 134, 1942.

and *Lemna* sp. and smaller crustacea and other lower animal organisms living on algal food. It is therefore of utmost importance that these smaller floating plants should be kept on growing up to a certain limit along with the microscopic plankton flora composed chiefly of unicellular, colonial and delicate filamentous algae as indicated in my papers on this subject. If however the larger free-floating plants such as *Pistia*, *Utricularia*, *Salvinia*, *Ceratopteris*, *Tholistoidea* and *Water hyacinth*, not to speak of such amphibious plants such as *Jussieuia*, *Ipomoea*, *Polygonum* sp., *Enhydra fluctuans*, *Panicum fluitans*, *Hygrophysa arista*, *Leersia hexandra* and other species of grasses and other similar plants are allowed to have their full play and encroach upon the surface of the tanks, they will replace the smaller *Wolffia*, *Lemna*, *Azolla* and other floating plankton algae in no time. Thus the main items of food of the fishes namely, *Wolffia*, and *Lemna* are eliminated. As regards the cover of vegetation produced by water hyacinth and similar amphibious plants, experiments were done on tanks which were choked up with surface vegetation for years. In such a tank and the lake like Loktak Lake, Manipur there was hardly sufficient edible fishes in the area congested with vegetation but a large number of mud fishes were found. The water of such a tank and the lake after clearing of the vegetation was found to be brown and rich in humic and other acids and CO₂ and other poisonous gases which are injurious both to fishes and animals.¹⁴ I, therefore, stress once again that such a condition of the tank is unfavourable to pisciculture. The fishermen all over Bengal, if not in India, are fully aware of these facts. Hence there is the common practice with the fishermen of yearly, if not half-yearly cleaning and netting of tanks for oxygenating the water in Autumn and Spring. It has been found that tanks, khals, jheels etc. which are not too deep but fairly long and spacious having sufficient clear areas in the middle and sparse submerged and rooted aquatics proportional to the area of the tank fulfil, to a large extent, all the conditions necessary for the healthy growth of fishes. The fishes in such a tank can have sufficient oxygen, shade, shelter and free locomotion in the water containing good food in the form of microphyto and zooplankton. The food of the fishes in the bheris of the Salt Lakes and Bidyadhari and other riparian areas is composed of floating intestine like *Enteromorpha intestinalis*, *E. prolifera*, *Chaetomorpha Linum*, *Synedra affinis*, *Oscillatoria* sp., *Phormidium* sp., *Microcystis aeruginosa* and other blue-green algae and diatoms.¹⁵ The water hyacinth,

as noticed by Sen, evidently got access to some of the bheris through the khals and channels. It is during very hot season that sometimes some plants are allowed to remain floating along the sides of bheries for the purpose of shade but they must be removed afterwards. Smaller fishes cannot possibly eat fleshy stem leaves or root-stock of water hyacinth which float on the surface of water. Even larger ones, unless starved, cannot possibly like water hyacinth for their food because the cells of water hyacinth contain bunches of needle-shaped crystals of calcium oxalate which are likely to get stuck and injure the internal organs of fishes. Reference to scientific papers regarding the assumption of water hyacinth serving as food to fishes will be welcome, as tackling of the water hyacinth problem in this province will then be easier. Nevertheless the algae attached to the roots of water hyacinth are greedily eaten by fishes, but there exists the danger of this pest choking up the bheris and tanks. In fact, several square miles of Bidyadhari spill area have already been overrun by this plant, much to the damage of fisheries here as elsewhere (*loc. cit.* p. 326). The importance of luxuriant vegetation to fish culture as imagined by Hora is however not supported by the fact that there is hardly any floating vegetation and very little of submerged and rooted aquatics in the bheris (large expanse of enclosed water areas where fishes are regularly cultivated on a commercial scale). The Chilka Lake and the creeks in the Sundarbans which are also the important centres for the supply of fishes to Calcutta and other towns harbour very little, floating submerged, and rooted vegetation. Such lakes have only a sparse benthos vegetation and the food for fishes are chiefly found to be the algal flora. During the writer's survey of the aquatic vegetation of the Chilka Lake¹⁶ and the Loktak Lake it has been found that in contrast to the Chilka Lake, the Loktak Lake in Manipur which is covered with floating islands of vegetation and packed with submerged vegetation in more or less open areas contains very few sufficiently large good edible fishes¹⁷ whereas the former is the store house of various kinds of delicious fishes.

Preliminary experiments carried out so far by the writer with regard to the balanced vegetation considered to be beneficial to the water areas and pisciculture led him to support Pond's formula¹⁸ as modified from Kofoid. It runs as follows "The amount of plankton produced by bodies of fresh-water is, other things being equal, in some inverse ratio proportional to the amount of its gross non-rooted vegetation and

¹⁶ Biswas, K.—Algal flora of the Chilka Lake. *Mem. As. Soc. Bengal*, Vol. XI, No. 5, 1932.

¹⁷ Bruhl, P. and Biswas, K.—Algae of the Loktak Lake. *Mem. As. Soc. Bengal*, No. 5, 1926.

¹⁸ Pond, R. H.—The biological relation of aquatic plants to the sub-stratum, Univ. Michigan Sc. Arts, 1905.

¹⁴ Bruhl, P. and Biswas, K.—Algae of the Loktak Lake. *Mem. As. Soc. Bengal*, No. 5, 1926.

¹⁵ Biswas, K.—Flora of the salt-lakes, Calcutta, *Jour. Dept. Sc. Cal. Univ.*, Vol. VII, 1926.

in some direct ratio proportional to the amount of its gross rooted vegetation."

The study of vegetation in relation to culture of various fishes and also maintenance of sanitation in our tanks, jheels, ponds, puddles, etc. is undoubtedly of utmost importance. The problem demands investigation in the light of up-to-date limnological researches at present carried on in the leading overseas countries of the world. The new methods of investigation will have to be employed, with necessary modifications in solving the problems concerning our country and the remedies to be discovered by prolonged researches and actual experiments both in the field and the laboratory.

APPENDIX

The following inaccuracies contained in the paper entitled "Role of Vegetation in Fishery Tanks" are corrected below:

- Ceratophyllum demersum* Linn. should be *Ceratophyllum demersum* Linn. (Beng. Jhanji), p. 325 and 326.
Ipomoea reptans Poir. should be *Ipomoea reptans* Poir. (Syn. 1. *Aquatica* Forsk.—Beng. Kalmi shak), p. 327.
Utricularia stellaris Linn. should be *Utricularia stellaris* Linn. f., p. 327.
Salvinia cucullata Roxb. should be *S. cucullata* Roxb. (Beng. Indur or Musakani Pana), p. 327.
Salvinia verticillata Roxb. is a synonym of *Salvinia natans* Hoffm. which is the correct name.
Lemna triscula Linn. which should be *L. trisulca* Linn. (Beng. Tilak Pana) is very rarely met with in Bengal; it

is very likely that the *Lemna* mentioned in p. 327 is some other species, possibly *L. minor* Linn. or *L. polyrrhiza* Linn., or *L. paucicostata* Hegel.—the three authentic species occurring in India (Beng. Khudi Pana).

Wolffia sp. is very likely *Wolffia arrhiza* (Linn.) Wimm. (Guri Pana) the only recognised species in India. The other species *W. microscopica* Kurz—seems to be a variety only.

Lemnaceae has two recognised genera—*Lemna* and *Wolffia* and four authentic species found in India—*Lemna minor*, *L. polyrrhiza*, *L. paucicostata* and *Wolffia arrhiza*. It is therefore inaccurate to state that the family Lemnaceae constitutes many representatives of the macrophytoplankton of India (Observations on Indian Duckweeds, Lemnaceae by Charles McCann, *Jour. Bom. Nat. Hist. Soc.*, Vol. XLIII, No. 2, p. 148, 1942 may be consulted).

There is no *Panicum* sp. called "Samna" grass. *Echinochloa crus-galli* Beauv. (Syn. *Panicum crus-galli* Linn.) is known as "Shyama ghash" in Bengal. This species like other grasses of similar habits cannot therefore be called "the only microscopic plant." The two floating grasses commonly met with in our tanks, etc., are *Hygroryza arista* Nees and *Leersia hexandra* Sw. *Panicum fluitans* Retz. and a few others (Cf. "Hand Book of Common Water and Marsh Plants of India and Burma" by K. Biswas and C. C. Calder, 1936) are also marsh grasses. *Pithophora oedogonia* (Mont.) Witttr and *P. polymorpha* Witttr. are two of the many large filamentous algae found in our water areas. Bhotka is a common name for floating masses of algae particularly the slimy species. The genus *Pithophora* belongs to the family of Cladophoraceae under the Class Chlorophyceae.*

* These include corrections of all the mistakes pointed out by Prof. G. P. Majumdar, Ph.D., and other botanists to the Editor, *Science and Culture*.

VEGETATION IN FISHERY TANKS*

BESIDES certain typographical mistakes, to which the attention of the editors had already been directed, and inaccuracies in the names of plants in Mr Bukht's article, there is hardly any point in the above note which repudiates what is stated in my article "Role of Vegetation in Fishery Tanks". Dr Biswas and I are agreed that *too much vegetation* in fishery tanks is inimical to fish life and that *selected and controlled vegetation* in tanks used for pisciculture is necessary. We also seem to be agreed that though experiments in aquaria are helpful in elucidating natural phenomena, no one should advocate a blind application of the results achieved therefrom to larger pieces of water without further investigation.

In view of Dr Biswas's note, it seems worthwhile to reiterate that *suitable* aquatic vegetation is

* Dr S. L. Hora whose article has been referred to in Dr K. Biswas's article has sent this note in reply to the criticisms made by Dr Biswas.—Ed. *Sci. & Cul.*

required in fishery tanks to ensure (i) the proper aeration of water and its self-purification; (ii) necessary shade for fishes and other aquatic organisms during the hot summer months; (iii) shelter from enemies and (iv) supply of food to fishes or to organisms on which fishes feed. From the standpoint of pisciculture it was remarked that "no investigations have been carried out on the influence of the quantity and quality of vegetation on the fishery of a tank in India" and it was earnestly hoped that some botanist would enlighten fishery students about the desired plant associations in fishery tanks to serve the above objects. A tentative list of 10 plants was given at the end of my article to elicit further information.

Attention may be directed to the following points referred to in Dr Biswas's article:

1. *Vegetation and Epidemics of Fish Mortality*.—Both Col. Sewell and Dr Pruthi agree in ascribing mortality to asphyxiation by a reduction of the oxygen content of the water. According to Sewell,

this was due to the almost complete absence of chlorophyll-bearing weeds in the tank at the time, whereas Pruthi ascribes it to cloudy days interfering with the photosynthetic activity of the chlorophyll-bearing organisms living in the tank.

It is well-known that epidemics of mortality among tank fishes in India are fairly frequent, but the writer is not aware of any serious attempts having been made, excepting those by Sewell and Pruthi, to investigate their causation. Dr Biswas states that he has investigated several such cases, but unfortunately the results of his studies are not published. In his article, "The Algal Flora of Maidan Tanks" (*Calcutta Univ. Rev.*, pp. 449-455, 1925), to which he invites the attention of the readers, no reference is made to the epidemics of fish mortality. However, a quotation in it from Dr Bruhl's essay "About Algae" shows that "A flourishing water flora is an absolute necessity for successful pisciculture."

Just as absence of any vegetation from fishery tanks is inimical to the growth of fishes, it is known to fishery students that its excess has a deleterious effect on the ecological balance of the tank. For these very reasons only selected and controlled vegetation was advocated in my article.

2. *Vegetation and Food of Fishes*.—So far as I am aware, results of Dr Biswas's examination of the stomach contents of fishes studied by him have

not yet been published, so no reference could be made to them. There is no doubt, however, that lower plants, *directly or indirectly*, form the source of food of all animals, and on this point there can be no difference of opinion.

3. *Vegetation and Fisheries of the Chilka and Loktak Lakes*.—The statements made by Dr Biswas about the vegetation and fisheries of the Chilka Lake and the Loktak Lake do not agree with the published accounts. For a brief description of the vegetation of the former, reference may be made to Annandale and Kemp (*Mem. Ind. Mus.*, V. pp. 12-14, 1915). As regards the fish and fisheries of the Loktak Lake, Manipur, reference is invited to my article on 'Fish and Fisheries of Manipur' (*Rec. Ind. Mus.*, XXII, pp. 165-214, 1921). A dozen kinds of fish, including carps, catfishes, etc., were obtained from this lake. The vegetation of the lake is described by Annandale (*Rec. Ind. Mus.*, XXII, pp. 535-536, 1921). The fish were abundant in the lake, though of a smaller size than usual and the general facies of the specimens was that of swamp-fishes. However, several species of economic importance, such as *Labeo*, *Barbus*, *Callichrous*, etc., are found in the lake, and there are several prosperous villages of fishermen around it.

S. L. Hora.

ERRATA

Dr K. Biswas has directed our attention to some typographical and other mistakes occurring in Dr Hora's paper (Vol. VIII, pp. 324-327). The fact is that Dr Hora wanted to see the final proof of his article but this could not be done as Dr Hora was away, and we could not wait for his return. As soon as Dr Hora returned to Calcutta, he drew our attention to these errors. We are, therefore, adding the following errata:—

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|---|--|
| 1. Page 325, 2nd column, line 23 from top ... | Read <i>macroscopic</i> for <i>microscopic</i> . |
| 2. " 327, 1st " " 35 " " ... | Read <i>weed</i> for <i>reed</i> . |
| 3. " " 2nd " " 5 " " ... | Read <i>repens</i> for <i>reptens</i> . |
| 4. " " " " 6 " " ... | Read <i>reptans</i> for <i>reptens</i> . |
| 5. " " " " 14 " " ... | Read <i>cucullata</i> for <i>cuculata</i> . |

Some of the other mistakes pointed out by Dr Biswas occur in Bukht's article which has been quoted by Dr Hora.—Editors.

[Further correspondence on the subject will not be entertained.—Ed. *Sci. & Cul.*]

THE ACTION OF LIGHT ON SILVER SALTS AND THE MECHANISM OF PHOTOGRAPHIC PROCESSES

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THAT silver chloride and other silver salts blacken on exposure to light was observed as early as the middle of the 17th century by Robert Boyle. The Swedish chemist Scheele supplied for the first time a chemical explanation of this phenomenon in the later period of the 18th century. The foundation of the important art of photography is based upon this fundamental observation. White papers moistened with a solution of silver nitrate were employed in those early days to obtain pictures of prints or paintings on glass by allowing light to pass through the glass and then to fall on the prepared papers. These pictures were not permanent and could not subsequently be exposed to day light as there were portions of unacted silver salts still present on the paper. The process for the removal of these latter with a view to render the photographic image permanent was developed by Niepce and Daguerre in 1826 and the process known as Daguerreotype was discovered by the latter investigator in 1839. It consists in subjecting a polished surface of silver to the action of iodine vapour which produces a thin film of silver iodide coating the surface. The iodised surface is then exposed to light in a camera. Though no perceptible change is produced by the light, a picture appeared on the exposed surface when subsequently acted upon by mercury vapour, due to the deposition of metallic mercury in an extremely fine state of division on the spots where the light has fallen. The portions unaffected by light contain the unaltered silver iodide. This latter was removed by treatment with a hot solution of sodium chloride, replaced later on by the more effective sodium thiosulphate. This method underwent rapid improvement and in 1839 Talbot introduced the process of photography on paper. In this, a paper coated with moist silver chloride, which was prepared by soaking in a weak solution of sodium chloride followed by washing with a solution of silver nitrate, was exposed in a camera. The negative image, thus obtained, was fixed by treatment with a solution of sodium chloride. The chloride in later years was replaced by iodide. After exposure there was no visible image, which was developed only after treatment with a solution containing silver nitrate, gallic acid and citric acid. A negative image was obtained in this manner. The paper was

then coated with transparent white wax. Positive prints were prepared from this waxed negative by placing it over moistened silver chloride paper and then exposing the system to sunlight. The process was named Talbotype after its author.

Further improvement consisted in the use of transparent iodised collodion spread upon a glass plate. The plate was sensitised by dipping into a bath of silver nitrate and was then exposed moist in a camera. The latent invisible image produced by exposure was developed by treating the plate with reducing agents like ferrous sulphate, pyrogallie acid, etc., metallic silver being deposited by reduction at the portions affected by light. The image was finally fixed by removing the unacted silver iodide by means of a solution of potassium cyanide or sodium thiosulphate. From the negative thus prepared, positive prints can be obtained and afterwards fixed in sodium thiosulphate. By the employment of collodion plates, the period of exposure was reduced to a few seconds and the details of the object were reproduced with greater precision.

This wet-plate photography was, in course of time, superseded by the dry-plate process, which constituted a marked improvement of the art.

The modern dry plates of great sensitiveness are prepared by coating glass plates with an emulsion of silver bromide in gelatin containing traces of iodide. The latent image produced by light is developed by a suitable reducing agent, of which there is a large variety now in use. To prevent too rapid development or fogging of the plate a restrainer or retarder, such as an alkaline bromide, is also added to the developer. The plates are afterwards fixed in sodium thiosulphate solution.

The developer effects the deposition of finely divided metallic silver at the spots acted upon by light leaving the silver bromide unchanged in those parts of the film where the light had no previous access.

Various theories have, at one time or other, been advanced in order to explain the action of light upon silver halides and the mechanism of development of the photographic image.

Formerly it was believed that light splits up the silver halide molecule with liberation of free halogen and formation of a subhalide: $2\text{AgBr} \rightarrow \text{Ag}_2\text{Br} + \text{Br}$. The bromide atom is then taken up by the gelatin which thus accelerates the action. This view was supported by the belief that certain subhalides of silver of definite composition could be isolated in crystalline condition. Later experiments, however, have failed to confirm this idea, proving, on the contrary, that silver chloride or bromide and colloidal metallic silver are miscible in all proportions. The blackening of silver halide, on exposure to light, is, therefore, due to the separation of colloidal particles of metallic silver which remains dispersed in the silver halide emulsion.

In view of the fact that cathode rays, X-rays and rays from radioactive bodies affect the silver halides in the same way as light, it has been suggested that light brings about a photo-electronisation of the silver halide molecule. As a result of which in the case of silver bromide, for instance, the bromine ion loses its electron to the positive silver ion giving rise to the formation of metallic silver and free bromine which combines with gelatin. The particles of metallic silver formed after a very short exposure are colloidal in character, form solid solution with silver bromide and are too small to be visible. They are, therefore, developed, *i.e.*, artificially enlarged, and rendered visible by treatment with reducing agents. The invisible colloidal particles of silver, initially separated by the action of light, serve, therefore, as nuclei or centres of crystallization on which silver is preferentially deposited from emulsion of silver halide in gelatin by the action of the developer. Hence, this reduction occurs mainly on those spots on which light has previously fallen and as gelatin fixed on to the glass plate retards diffusion to a great extent, the change produced is more or less confined in and around these spots. A visible image is thus obtained.

The work of Svedberg and his collaborators in Sweden, of the British Photographic Association in England and of the laboratories of Eastman Kodak Company in Rochester (U. S.) have contributed largely to our knowledge regarding the origin of the sensitivity of the silver bromide crystals. As a result of their work a comprehensive theory regarding the nature of the action of light on silver salts and the mechanism of photographic process has only become available in the last 3 or 4 years. This has brought about a radical change in our views about the entire process.

It was found that larger the size of the grains of silver bromide, greater was their sensitivity. The sensitivity was also found to depend upon the nature

or kind of gelatin used in making the emulsion. Sheppard succeeded in tracing it to the presence of a sensitizer in gelatin, which is derived during the process of its extraction from the animal skins. This was proved to be an impurity associated with the fatty substance cholesterol of the skin. Since sterols occur in plant seeds, an examination of the extracts of various plant seeds was undertaken. Some of these proved to be powerful sensitizer, the most effective being that from the mustard seeds. The sensitizing substance in gelatin was finally identified as mustard oil, which contains sulphur. Into the animal skin this mustard oil found its way from the pasturage.

Mustard oil gives allyl thiocarbamide which can act upon silver bromide crystals in alkaline solution giving black spots of silver sulphide. Sheppard found that these specks of silver sulphide in gelatin, far too small to be observed under the microscope, served as the sensitizing spots. He and his colleague advanced a theory of the action of light upon the photographic film on the basis of this idea. It was called the "concentration speck theory." The silver sulphide specks, according to them, are formed on the surface of the silver bromide crystals and then penetrate into its lattice structure. This causes a strain in the latter, which stretches as an area of weakness on to the surface of the crystal. Light energy falling upon such a crystal travels unhindered through the crystal till it reaches the boundary of the speck, where owing to the sudden change of structure, metallic silver is set free from the silver bromide. The sensitizing speck, therefore, acts as a nucleus for collecting or concentrating the energy and liberating metallic silver at or around it.

A mechanism of this energy concentration and separation of metallic silver has been supplied by the work of Prof. Gurney and Mott, and of Dr J. H. Webb. From a consideration of the energy diagram of silver bromide crystals it may be stated that there are generally two energy levels characterised by S and P bands. The S-band is normally empty and is termed "conduction band", while the P-band is normally completely filled with electrons. On exposure to light the electrons are promoted from the lower P- to higher S-band and the crystal becomes conducting. This property is known as photo-conductance. We may imagine the silver bromide crystal under this condition to be filled with a sort of conducting electron gas. This is the primary photographic process that happens instantly when light falls on the crystal (Fig. 1). When the electrons set free in this way reach a sensitive speck, either consisting of an impurity or of the silver sulphide derived from the gelatin, they are trapped and absorbed by

the sensitivity speck, which becomes thereby negatively charged.

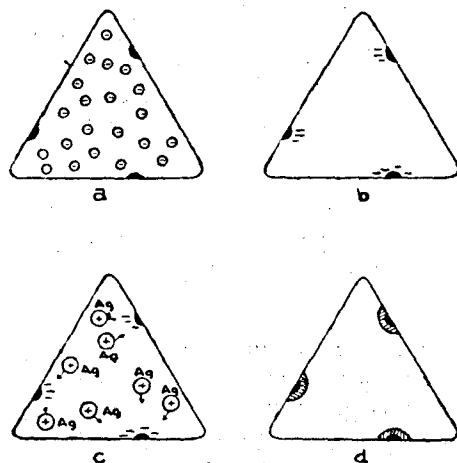


FIG. 1. Action of Light upon a Silver Bromide Crystal. (a) Liberation of Electrons into the conducting level. (b) Charging of the sensitivity specks by the liberated electrons. (c) Migration of silver ions to the charged specks. (d) Deposition of silver on the specks to form the latent image.

Silver ions of the silver bromide crystal moving about in the lattice reach a sensitivity speck, containing absorbed electrons, and are discharged and deposited there as metallic silver. The theory thus postulates that the production of the image by the action of light occurs in two stages: first, the instantaneous release of free electrons and then the transfer of free electrons to silver ions to form silver atoms at the sensitivity specks. The formation of the latent image after a short exposure arises in this way. On longer exposure visible discoloration takes place and this undoubtedly consists of metallic silver as can be shown by means of X-rays and electron microscope.

The theory, as it is claimed by the authors, supplies a mechanism for the phenomenon known as the "failure of the reciprocity law" in photography. In the case of photography it is well known that there is an optimum rate at which the light energy should be supplied for the formation of the maximum amount of photographic image, unlike in other photo chemical reactions where the action is dependent only on the total amount of energy. A much longer exposure with low intensities of light or a much shorter exposure with light intensity greater than the optimum rate requires a considerably more energy to produce the same density of deposit. In the former it is assumed that the silver atoms, newly liberated at the sensitivity specks, can easily be lost in the early stages of the formation of the image by acquiring a positive charge owing to thermal action. With high intensities of light, on the other hand,

the electrons are supplied too rapidly for the silver ions to reach the sensitivity specks by diffusion through the crystal and some of the electrons are repelled from the highly charged sensitivity specks before they can be neutralised.

Moreover, a study of the form of silver produced in development by means of electron microscope has led to a very satisfactory explanation of the mechanism of photographic development.

When the developed silver grains were examined with the electron microscope, since they are too small to reveal any detail of their structure under ordinary microscope, it was observed that the silver grain is a tangled mass of ribbon-like filaments looking like a mass of sea-weed (Fig. 2.). The earlier supersaturation theory of development based on the idea of deposition from supersaturation of metallic silver upon a nucleus, cannot account for it. The examination further showed that these filaments are much longer than the diameter of the crystals from which they were formed. This led to the conclusion that the silver filament is formed by ejection from the silver bromide crystal. It is squirted out during the process of development from the solid crystal, the development reaction being represented as follows. The reducing ions of the developer attack the silver bromide crystal, and in some way the initiation of the formation of metallic silver is facilitated by the presence of the latent image speck.

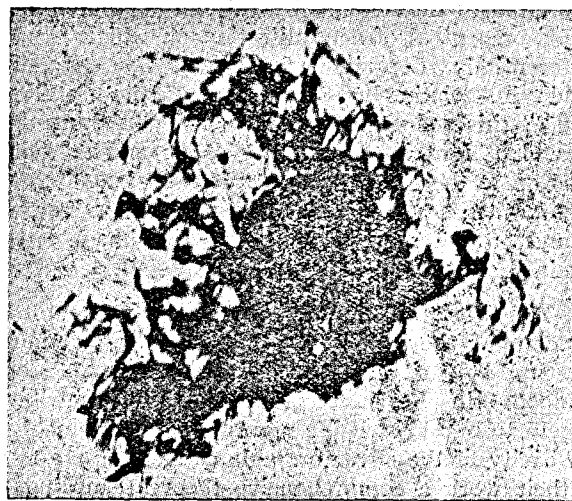


FIG. 2. Electron Micrograph of a grain of developed silver. $\times 50,000$.

The mechanism of this deposition is supplied by the following considerations. The surface of the silver bromide grain itself has an excess of bromide ions from the method of its preparation. This gives a negatively charged surface. Outside this negative

charge there must be held a positive layer of potassium ions for electrical neutrality. A double charge layer, consisting of negative bromine ions on the grain and positive potassium ions in the gelatin just outside, may be considered to exist around the surface of each silver bromide grain. (Fig. 3).

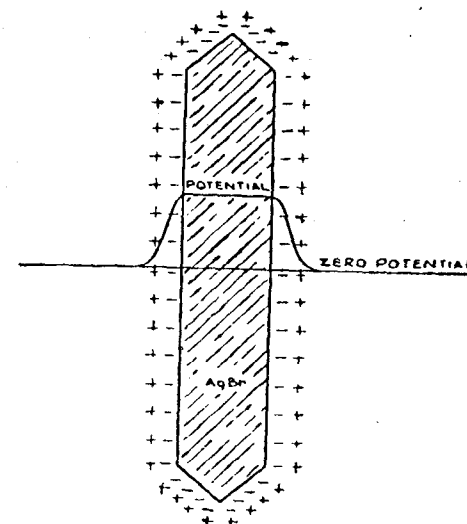


FIG. 3. Distribution Diagram of the potential and charge of a silver bromide crystal.

An electron placed inside the grain away from the double layer would experience no force, nor, in the same way, would an electron placed outside such a double layer. There is, however, a marked difference in potential between the inside and outside grain and the total jump in this potential occurs in the region between the two charge layers. Hence an electron placed between these charge layers would experience a force towards the outside positive layer. It is considered that the double charge layer acts in this way as an effective potential barrier to the entrance of an electron into the silver bromide grain of the emulsion and prevents the developer from attacking the grain.

The conditions existing in the exposed grain containing a latent image silver speck are shown in Fig. 4, which gives a greatly enlarged scale model of a charged grain surface with a clump of silver atoms on it, supposed to represent the latent image resulting from exposure to light.

J. H. Webb assumes that the development of a grain is initiated by a break in the double charge layer caused by silver speck, permitting the negative developer ions to reach the latter. The latent image speck may be viewed as an electrode penetrating into the grain. The electrode is charged negatively by the electrons released from the developer ions which have a tendency to give them up. According to Gurney and Mott this occurs if the electrons of the developer ions occupy levels above the highest

occupied energy levels of the silver metal. The penetration of the negative electrode into the silver bromide grain upsets the electrical neutrality previously existing inside the grain and an attractive force is

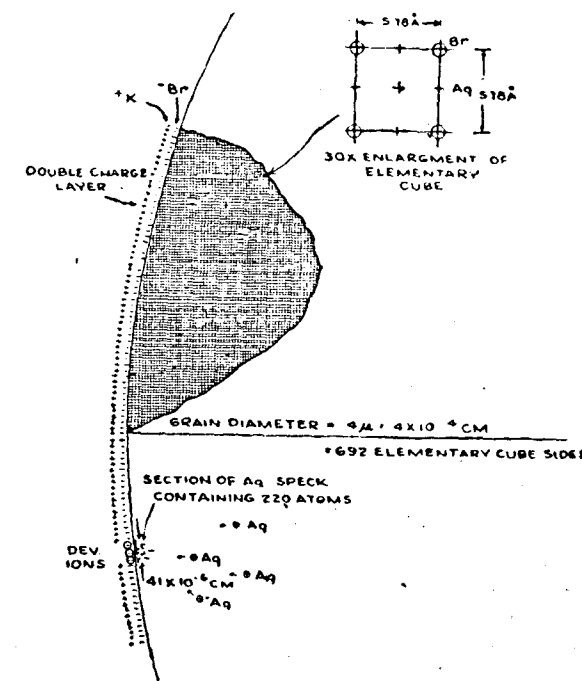


FIG. 4. Diagram showing a latent image speck in a silver bromide crystal attacked by a developer.

exerted upon the positive silver ions in the neighbourhood of the latent image speck. Some of the positive silver ions of the crystal lattice of the silver bromide grain become comparatively free due to thermal motion, and these diffuse to the speck under the attraction of its negative charge and are discharged there. The originally minute silver speck of the latent image thus continues to grow by this mechanism. As this proceeds the protective double layer is more and more ruptured, and a rapidly increasing layer of the silver halide grain is exposed to the attack of the developer. Since the reduction of silver bromide by developer is exothermic, a large amount of energy is liberated at the boundary between silver and silver bromide, while the local rise of temperature facilitates the migration of silver ions, so that the metallic silver is extracted as a filament.

A much clearer picture of the mechanism of photographic process than was hitherto possible is presented by the new theory.*

* More than half of this paper is rather an abridged account of the article "Recent Advances in our Knowledge of the Photographic Process" by Dr C. E. Kenneth Mees, published in "The Scientific Monthly, October 1942." The figures are all reproduced from the same article.

Notes and News

NICHOLAUS COPERNICUS (1473—1543)

ON May 24, 1943, the world of science and culture celebrated the four hundredth anniversary of the death of Nicholas Copernicus, the great astronomer who is claimed as a Pole by Poland, and a German by Germany. As he lived before the growth of Nationalism, the claims may not be irreconcilable, but it is quite certain now that he was a Pole by birth, who made the earth move round the sun. History of science is divided into few significant periods of great constructive work and progress introduced by equally few revolutionary thinkers who always broke away with the traditional concepts in their zealous search for truth. Copernicus was one such thinker and great figure in the history of science, who, by dethroning the earth from its majestic central position in the Ptolemaic Scheme of cosmology in favour of the sun, revolutionised astronomical thought and ushered in an era of scientific progress which culminated in the pioneering work of Kepler, Galileo and Newton.

Born in 1473 at Thorn, on the Vistula, then under Poland, Copernicus appears to have been a Slav by ancestry. He was educated at the University of Cracow, and later on (1496) at those of Padua and Bologna in Italy, at that time great centres of learning and progressive thought in Europe. Originally he intended to study medicine, after the fashion of the day, but was subsequently attracted to philosophy, mathematics and astronomy which occupied his interest and attention till the last day of his life. At Bologna, Copernicus came in contact with Dominico Maria da Novara, an advocate of Pythagorean doctrines and stern critic of the Ptolemaic astronomy, who appears to have considerably influenced his analysis and investigation of the astronomical problems he grappled with.

In 1505 Copernicus was appointed a canon of the Cathedral Frauenburg and resided at the episcopal palace of Heilsberg as physician to his uncle who was the bishop of Heilsberg. It was during his quiet years at Heilsberg that he conceived his ideas about a new system of astronomy and set himself to the preparation of the draft of his monumental work, "De Revolutionibus Orbium Coelestium" which was destined to be the corner stone of modern astronomy. He spent nearly thirty years for the preparation of this great work, revising the manuscript from time to time and incorporating every

piece of new observation. It would appear that the manuscript was almost complete by 1529, as the book does not record observations of a later date. But the publication of "De Revolutionibus Orbium Coelestium" was not undertaken till 1541, and the first printed copy of his work was actually placed at his hands when the great astronomer lay semi-conscious on his death-bed.

The delay in the publication of his great work is sometimes quoted as an evidence of his fear for persecution from the Church. This view is strengthened by the apologetic nature of the preface inserted by his friend Osiander, a Lutheran preacher interested in astronomy. He was obviously unwilling to face the consequences and accordingly tried to reduce the weight of the implications of his view by pointing out that the sun was placed at the centre for the simplicity of mathematical calculation. Copernicus, however, did know nothing of such intentional distortion, and when the printed copy of the book was handed to him, his judgment was already impaired by the approaching death. But there seems hardly any justification for ascribing any temporising view to him, as he made no secret of his thoughts and allowed a short summary account of his astronomical system in manuscript form to be circulated among his friends many years before the book actually appeared in print. His ideas, however revolutionary, were not at first adversely looked upon by the Church, and both the Medici Popes, Clement VII, and his successor Paul III (Farnese) showed interest in his work. But he was not spared the bitter criticism and satire of his contemporaries, such as Martin Luther, who declared his theory to be incompatible with the Scriptures. As the new knowledge developed and attracted an ever wider circle of adherents, the Church saw in it a direct challenge to its supremacy, and the book was declared heretical sixty-three years after the death of Copernicus and placed in the Papal Index, from which it was not removed until 1835.

Like many scientific pioneers, Copernicus was inaccurate as to detail, and there are portions of his work which are of a controversial nature. The importance and greatness of his work should, however, be judged against the background of the Ptolemaic scheme of cosmology. He introduced simplicity to the accepted scheme by postulating the rotation of the earth once in 24 hours and an annual motion round the sun. The astronomical consequences were worked out, on the basis of these postulates, by the

old devices of eccentricities and epicycles. The motion of the earth is not, however, a new conception in older philosophical speculations. Aristarchus of Samos had postulated it thousands of years earlier. But the credit of formulating a constructive heliocentric theory uniquely belongs to Copernicus. Copernicus lived and asserted his views in an age full of religious dogmas, prejudices and superstitions, when scientific free thinking was looked upon with suspicion and opposition to ideas expressed by accepted ancient philosophers, such as Aristotle, as heresy. He takes his place among the original thinkers of history, because he could boldly undertake a complete reform of astronomy for the sake of truth in which his belief was unshakeable.

SCIENCE AND THE CITIZEN

It is with great interest that we watched the conference on Science and the Citizen, recently arranged by the Division for the Social and International Relations of Science of the British Association, to consider ways and means for the promotion of the public understanding and appreciation of science. The conference was the first of its kind, ever sponsored in Great Britain, and many significant facts emerged from the discussions introduced by leading British men of science, which doubtless have important bearing on any scheme of post-war reconstruction. The discussions in the conference mainly centered round the following subjects, namely the Exposition of Science, Radio and Cinema, Science as a Humanity and Science and the Press. Sir Lawrence Bragg referred to the charge usually levelled against the scientific workers for their lack of clear exposition and the technical nature of presentation of their subjects. But the central trouble, as he pointed out, consists in the neglect of science as an essential part of a balanced education. He deplored the attitude of the industrial leaders towards scientific workers who are looked upon as experts to deal with technical difficulties and not as colleagues with a share in the making of plans. Mr J. A. Lauwerys emphasised the importance of museums in the public understanding of science. The museum method of exposition produces silent but sure appeal, and Mr Lauwerys advocated the creation of science museums, after the example of the United States, in the cities after the war.

The final session devoted to the subject of "Science and the Press", however, commanded much interest and attention owing to the importance of the subject itself. Sir Richard Gregory was in the chair, and among those who took part in the discussions were Mr J. G. Crowther, Prof. J. B. S. Haldane, Mr H. G. Wells and Mr Ritchie Calder. Mr Crowther dwelt on the various aspects of the

problem and recognised that the improvement of science reporting in the Press depends on the simultaneous advance of several interests; the increasing interest and demand from the public; the effects of a higher standard of science teaching; the raising of the school leaving age; the recognition by owners and editors of newspapers of the growing importance of science; recognition by the State and philanthropic bodies of the necessity for better public understanding of science; the efforts of scientific men themselves to make their activities better known and understood, and the promotion of scientific interest which arises from the increasing mechanisation of daily life. Furthermore, he suggested the creation of a science news service providing reliable science news to all newspapers and of a full-time science editor for every newspaper. Similar suggestions were also put forward by Prof. J. B. S. Haldane who criticised the Press for devoting more space to anti-science than to science. He also advocated a science news service, scientific features in every newspaper, a science reporter for every newspaper, and scientific and technical advisers attached to the staff of every newspaper to direct policy. Mr H. G. Wells, in his characteristic vein of prophecy, sounded the death knell of newspaper and assured those attending the session that in near future news will be available on tap, like the time of day, by way of the telephone dial. In the new shape of things to come, old, stale and out-of-date text books will cease to exist, and books and pamphlets containing the solid facts of investigations will be the best sellers.

LARGE-SCALE INDUSTRIES IN INDIA

THE All-India Manufacturers' Organisation (A. I. M. O.) has recently issued a monograph on 'large-scale industries in India' with a useful statistical table relating to large-scale factories in India. This is the first of two monographs so far issued by the A. I. M. O. with a view to enlighten the Indian public about the present position of Indian industries and the extent of recent industrial development. "Iron and Steel Industry in India" forms the subject of the second monograph which will be reviewed in the following note. This new move on the part of a non-official commercial association like the A. I. M. O., which ought to have been initiated long ago by the Government, will be most welcome at this stage, and the Organisation accordingly deserves to be widely congratulated by all interested in the dissemination of useful knowledge among the people of this country.

The monograph under review has made possible a bird's eye view of the present position of large-scale industries in this country. The A. I. M. O. has classified industries into large-scale, medium-

scale and small-scale industries, on the basis of investment of capital alone, and has not complicated the classification by taking into account debentures and short term loans. A large-scale establishment has been defined as an industrial concern with a paid-up capital of Rs. 30 lakhs and over. Concerns with a capital between Re. 1 lakh and 30 lakhs and below Re. 1 lakh have been classified as medium-scale and small scale establishments respectively. Since statistics relating to medium and small-scale industries can be profitably collected on a regional basis, A.I.M.O. has in the first instance concentrated on the collection of available statistics about large-scale industries on which, however, the industrial status, if any, of India largely depends.

According to the classification indicated, the monograph has included the following in the list of large-scale establishments: Textiles, Jute Mills, Electricity, Paper, Sugar, Chemicals and Oils, Building construction, Cement, Rubber, Iron and Steel, Engineering (Electrical and General) and Matches. Textiles, Jute, Iron and Steel and Hydro-electric concerns are, however, by far the most leading of these large-scale industries. The total number of cotton textile mills in India is at present estimated at 388, of which only 30 can claim to be regarded as large-scale factories. Recent tendency of the textile industry is towards the establishment of more medium-scale factories distributed in different parts of India. There are 26 large-scale jute mills, mostly in the hands of non-Indians, employing largest number of workers. India still exports large quantities of raw jute to United Kingdom, U. S. A. and other industrially advanced countries to be manufactured into hessian and sack bags and cloth. Obviously her jute manufacturing industry which is as yet little developed has ample scope for expansion. The textile and jute industries are jointly responsible for affording employment to more than 80 per cent of workers in large-scale factories, though the paid-up capital employed in these industries amounts to only 34.63 per cent of the total paid-up capital invested in all the large-scale factories in India. The statistical table indicates a flourishing state for the Iron and Steel industry of which there are at present three large-scale concerns. The industry has to its credit the largest amount of profits amongst the large-scale industries in India. The electricity industry represents 25.23 per cent of the total; but in other respects it falls far below other major industries. The total number of electricity works is at present ten. The position of the sugar, matches and paper industries in this country is far from satisfactory compared to the amount of consumption of these commodities, the number of large-scale factories in these categories being hopelessly few (Sugar: 3; Matches: 1;

Paper: 5). The position of other industries has also been briefly discussed.

IRON AND STEEL INDUSTRY

THE second pamphlet issued by the A.I.M.O. deals with the present position of the Iron and Steel Industry in this country with particular reference to the repercussion of war on this industry and the factors impeding its expected expansion during the war. The discussion is presented in the form of three notes devoted to (1) the review of the present situation, (2) certain handicaps impeding progress and (3) world future of steel, particularly alloy steels. The addition of a foreward by Sir M. Visvesvaraya, President of the Organisation has lent further importance to the monograph.

The Indian Iron and Steel Industry recorded steady development since 1927-28, in which year total imports of iron and steel of all kinds into India, including Burma, reached their peak of 1,450,000 tons. By 1936-37 the imports had fallen to only 400,000 tons. The imports of protected steel to India alone dwindled from 915,000 tons in 1927-28 to 58,000 tons in 1941. The Indian production of steel, on the other hand, rose from 429,000 tons in 1927-28 to 935,000 tons in 1938-39, a total which has since been considerably increased. During the recent years, India has been one of the world's chief exporters of pig iron which enjoys a very high reputation in the world market for its quality.

The outbreak of the war made the expansion of the industry inevitable. The difficulties of converting peace time production to war production in the event of a global war were clearly foreseen by the Tatas who had accordingly constructed and equipped their new research and control laboratories a few years before the war broke out. This foresight enabled the Tatas to manufacture and supply a large variety of new types of steel for which war immediately created a large demand. The following are the more important of the various special steels being manufactured in India to-day: special bar for the manufacture of shells; a bullet-proof armour plate for the fabrication of armoured vehicle bodies; bullet-proof plate howitzer shields and gun turrets; various kinds of alloy steels for the manufacture of steel helmets; armour-piercing bullets and shots, and shear blades for shearing armour plates; a chrome-molybdenum alloy steel for air-craft; spring steels for machine-guns; special deep drawing steels for rifles and machine-gun magazine; nickel steel plates for gun-carriage mountings; high carbon steels for high-explosive shells and mint dice; a high speed steel for machine tools and a stainless steel for surgical instruments. A process for the manufacture of acid open hearth steel, required for gun forgings, gun-

carriage axles and railway wheels, tyres etc. has also been developed.

The total production of steel in India from all sources at present amounts to 1.5 million tons per annum. Though the figure is apparently encouraging, the production of steel in India really pales into insignificance compared to the production in other countries. This is clearly borne out in the statistical chart provided in the monograph. The production of steel per capita in U. S. A., United Kingdom and Japan is $\frac{1}{2}$, $\frac{1}{3}$ and $\frac{1}{5}$ ton respectively. If India is to strike as low a level of production as $\frac{1}{50}$ ton per capita annually, she requires to produce about 8 million tons of steel each year. This would not have been a very difficult task, had it not been for the retrograde policy of the Government always discouraging with determination the development of heavy industries in this country. India has none of the heavy industries, such as automobile, aeroplane, shipping, armaments and industrial machinery, which alone can place heavy demands on the steel industry. Sir Visvesvaraya has observed in the foreward: "There have been statements made in the Press—statements which have not been contradicted—that as a result of the meetings of the Eastern Group Conference and the visit of the Roger Mission from England, the Government of this country decided that the expansion of steel and the establishment of heavy industries required for war material should be kept out of India". In the face of such a policy it is futile to expect any reasonable expansion of the industry which alone can give India some industrial status. That spectacular development of the iron and steel industry under the stimulus of war would have been possible in India backed by a Government with a national outlook is adequately reflected from the fact that Australia which produced no steel before the war has equalled or even surpassed India in the production of steel.

INDUSTRIAL X-RAY LABORATORY OF THE UNIVERSITY OF ROCHESTER

THE recent establishment of an industrial X-ray laboratory equipped with a million-volt unit, one of the most powerful in the world, at the University of

Rochester, is a fitting instance of what co-operation between industry and an educational institution should mean. The new industrial research laboratory, according to a report in *Science*, is the result of the collaboration of eight leading Rochester industries with the University. The big firms, of which may be mentioned Eastman Kodak Company, Rochester Products and Delco Appliance divisions of General Motors, the Pfandler Company, the Rochester Gas and Electric Corporation, Consolidated Machine Tool Corporation, Symington-Gould Company and the Rochester Brewing Company, financed the enterprise. The University has come forward with its supplies of scientific staff and research personnel to carry on tests, initiate investigations in the important fields of metallurgy, medicine and engineering with the new equipment for research. The apparatus was designed by Dr E. E. Charlton, of the General Electric Research Laboratory, who expressed optimism about the future prospect of this million-volt X-ray unit in the investigation of industrial problems. The installation of this new powerful machine has immediately made possible the minute inspection of heavy steel parts within a few seconds or minutes, as compared with the hours or days required under the old units with much less output voltage, and bids fair to be an important factor in the war effort of the United States.

This is not the first instance of the application of X-rays to industries. There are about 30 of these powerful X-ray machines in use in various places in America; but all are in industrial plants. It is, however, for the first time that a powerful X-ray machine has been installed in a university to have the fullest advantage of congenial university research atmosphere in the investigation of industrial problems amenable to X-ray methods. The enterprise, as Dr Charlton said, represents 'a novel and most useful co-operation in the joining of hands of university and industry in the development of the full use of X-ray in the industrial field.' We hope the example of the American industrialists will not be completely lost upon the industrialists of this country, who do not see any point in the co-operation between industry and university for the promotion of useful industrial research.

SCIENCE IN INDUSTRY

MUSHROOMS AS FOOD

MUSHROOMS are generally eaten for their innate flavour and taste appeal. But that they possess definite food values and are not a purely luxury food was demonstrated by Dr E. E. Anderson and Dr C. R. Fellers, of the Massachusetts Agricultural Experiment Station at Amherst, Mass., according to a note in the *Science News Letter*. The nutritive value of mushrooms is generally underestimated. One of the principal reasons is the failure to take into account the differences between the various types of mushrooms available. The investigators selected the particular type of mushroom, *Agaricus campestris*, which is commercially cultivated, and studied the composition and nutritive properties of this variety. Their findings indicate that, properly supplemented, mushrooms can be satisfactorily used as a source of protein. Rats supplied with protein from mushrooms were found to thrive well and recorded growth. Like the gliadin of wheat or the hordein of barley, mushroom protein is partially incomplete. In addition to their protein value, the type of mushrooms examined was found to contain vitamins and important minerals, such as iron and copper. As a matter of fact, they constitute one of the best plant sources of the vitamin B complex and also contain vitamins B₁, C and K in appreciable quantities. It is further reported that about three and one-half ounces of fresh mushrooms would provide about one-fifth of a grown-up man's daily requirement of riboflavin and about one quarter of his requirement of pellagra-preventing nicotinic acid.

AIR-PLANE TESTING TUNNEL

ACCORDING to a report in *Science*, a new air-craft testing tunnel, now under construction at Wright Field, U. S. A., is expected to generate synthetic winds at a velocity of 600 miles per hour and at controlled temperatures down to 67 degrees below 0°F. The giant air conditioning plant, when complete, will produce four million cubic feet of refrigerated air in a minute. The tunnel will be shaped like the letter "o" and will be 600 feet long. A 40,000 H.P. motor will be employed to produce the gale which will pass through cooling coils in which will be circulated calcium chloride solution. Two giant refrigeration machines will previously cool the solution to -40°F. In this way air is cooled to only -7°F. Further cooling has been secured in a very interesting way. The tunnel

is so constructed that it gradually narrows down from its widest part in the centre to the smallest opening at the throat. This narrowing has the effect of transforming static into velocity pressure. The temperature of the air stream in its passage through the tunnel automatically drops down from -7°F to -67°F in accordance with the well-known physical laws. The increase in the speed of the gale brings about a fall in the pressure and a consequent drop in the temperature without the need of additional refrigeration equipment.

The new air-craft testing tunnel will provide further arrangement for performing stratosphere tests. Models will be placed in a steel compartment in the throat of the tunnel fitted with an air-tight door and a pumping equipment. Conditions of the atmosphere at various altitudes, so far as pressure is concerned, will be artificially created. It is calculated that in the proposed tunnel there will be no difficulty in simulating pressures found at altitudes of above 40,000 feet.

NEW AGENTS OF CHEMICAL WAR-FARE

THE use of mustard gas as an agent for chemical war-fare is quite well known. It was employed in the World War I with conspicuous success. Researches stimulated by the present War have produced a class of new war gases, known as nitrogen mustards, according to a report in the *Science News Letter*. The new class of war gases is reported to cause blindness and blisters on the skin. In their vesicant action (blister-causing), the gases are, however, less active than the old mustard gas, but resemble them in their delayed action. Several hours generally elapse before the blisters actually make their appearance. Heavy concentration of nitrogen mustard in the lungs may prove fatal.

The nitrogen mustards have none of the strong garlic scent of the usual mustard gas. They are practically odourless, having at best a faintly fishy smell. This has rendered an easy detection of the gases extremely difficult, which can only be identified by applying several colour tests with sensitised papers, crayons etc., developed for this purpose.

Nitrogen mustards, like the older mustard gases and lewisite, are not gases in the truest sense of the term, but are liquids or even easily melted solids thrown into the air in the form of fine spray or mist.

They can be dropped in bombs, thrown in artillery shell, or sprayed from special containers on airplanes.

Ordinary gas masks and protective clothing devised for use against the older mustards can be used to keep out the nitrogen mustards from the skin, eyes and lungs. Soap and water are good decontaminating agents for clothing. For buildings, furniture etc., bleaching powder solutions and light petroleum extracts can be used with advantage.

WOOD CHEMISTRY RESEARCH IN GERMANY

GERMANY has always been one of the leading countries in the field of research in wood chemistry. With the outbreak of the War, fibre research in the country received renewed interest, and two new synthetic fibre research centres were opened at the Institutes of Technology of Breslau and Munich to cope with the diverse problems presented by the War. A summary account of the recent German progress in the field of wood chemistry has appeared in the *Chemical Age*, May 8, 1943. For a fuller information the readers are referred to *Chemical and Metallurgical Engineering*: 50, 2, p. 196, 1943.

Hitherto slow growing timber formed the bulk of the raw material for cellulose. At present the German synthetic fibre industry utilises about one million tons of wood to produce some 400,000 tons of cellulose. This figure, however, represents a small fraction of the total cellulose requirement of the country. Accordingly the attention was directed to the possibility of utilising annual and biennial plants for the extraction of cellulose. The plants now being investigated for the purpose are esparto grass, flax and hemp waste, broom, hop vines, potato tops, corn stalks, grape, rye and wheat straw, sun-flowers, and reeds. The possibility of reeds as source of cellulose has been carefully investigated by the Ager Cellulose G. m. b. H. in Vienna and the Sueddeutsche Zellwolle at Kelheim with promising results. Reeds of the type of the Danubian *Arundo donax* are capable of producing on an average 9 tons of synthetic fibres per hectare. It is estimated that if one quarter of the reeds in the Danube delta were harvested and processed, about 475,000 tons of cellulose could be

obtained theoretically as against the present yearly production of about 50,000 tons of cellulose from the Rumanian delta area. Investigations with potato tops indicate that about 300,000 tons of cellulose could be available per year. At present this source cannot, however, be tapped economically owing to the absence of a satisfactory solution of problems relating to collection, cleaning, and cellulose extraction.

Important work has been carried on in the direction of obtaining types of cellulose best suited for making cell wool. A better grade of cellulose was already obtained by treating the raw material with weak acid, chiefly hydrochloric, with or without pressure. Experiments carried out by the Thuringische Zellwolle A. G., Schwarzburg, with "chlorsulphate" pre-hydrolysis have succeeded in raising the α -cellulose content from 90 to 95-97 per cent and in facilitating removal of pentosans. Experiments are being made to find new uses for the hemicelluloses which are removed in the preparatory hydrolysis in order to prevent the fibre from deteriorating. These hemicelluloses contain 3-4 per cent sugars which, by fermentation with the yeast *Torula utilis* (in the presence of phosphate and ammonium salts), can be transformed into a yeast rich in vitamin B₁ and B₂. This food yeast is claimed to be fit for animal as well as human consumption. With the present production of chemical fibres in Germany, it is estimated that 100,000 tons of pure protein could be made from the source which was hitherto neglected.

The problem of reducing inflammability of cell-wool and rayons so that they can be used for electrical insulation, etc., is claimed to have been solved by a new process using tungstates. Sodium tungstate solution is applied first, and then a dilute tin chloride solution to give it tin tungstate impregnation. Aluminium and zinc tungstates have also been tried, as well as mixtures of tungstates and phosphates. Direct production of non-inflammable rayon by the acetate process has been carried out by adding to the spinning solution small amounts of ortho-tungstates and nickel borate, together with Mg-NH₄-orthophosphate, Ca-NH₄-dimetaphosphate, and Zn-NH₄-orthophosphate.

IMPROVED METHODS OF POTATO STORAGE

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THE question of storage of the perishable food-stuffs of this tropical country is a question of prime importance. In this article the problem of storage of potato in Bengal, which has got a generally hot and moist climate, is discussed.

How awfully Bengal is dependent on the outside supply of potato, would be evident from the fact that she has, to meet her own requirements, to import some 60 lakh maunds of potato at a cost of about 2 crores of rupees. The United Provinces, Bihar, Assam and Burma used to be the chief sources of this supply in normal times. Due to war situation the entire supply from Burma is now completely cut off, while due to heavy strain on the country's existing railways and other transport systems for war needs, outside supply cannot regularly come to the Bengal markets. The seriousness of the situation is further aggravated by the fact that a part of this restricted supply is used up in feeding the growing number of evacuees and military personnel now stationed in Bengal. There is thus seen an actual dearth of potato in the market, and the potato position is further deteriorating with time.

For this threatened situation, release of more acreage is constantly advocated by the "Grow-More-Food Campaign". That more land must be released for this crop is unquestioned but it should at the same time be remembered that acreage under this crop cannot be unlimitedly increased without encroaching upon the quotas for other crops, which are equally important for a balanced supply of other economic as well as food crops. Even if this unlimited release of acreage was possible, which is however not, it could not in itself solve the problem of potato shortage and its even supply throughout the year unless and until we can conserve from losses through rots, which is unfortunately often very considerable, what we produce. Therefore the limiting factor for augmenting the potato supply is the problem of storage, i.e., to conserve or in other words, to make available to the last one what we produce from the time they are harvested till they are in demand some months later. And it is during these months between harvest and consumption that a considerable proportion goes waste every year due to the lack of knowledge on the part of the cultivators about the proper methods of storage during the above period. Once the losses due to rots and diseases could be controlled the potato situation

in the province would be appreciably improved. Furthermore, the storage problem, once solved, would help to bring down the high level of prices of potatoes during "off-season" by maintaining an even and proportionate release all the year round as demand rises or falls. It may be mentioned here that in normal years the "season" price of potato hangs around Rs. 2-8 to Rs. 3-8 per maund while during the "off-season" months the price soars up to as high as Rs. 10 or more a maund.

Below are outlined the methods of potato storage some of which have proved their efficacy in preventing or cutting down losses suffered during storage. Storage, as ordinarily practised, consists in packing potatoes in gunny bags or heaping in lots in an ordinary godown. Of the improved methods of storage No. 2 is gradually getting popular and is much better than No. 1. Bright future awaits cold storage if Government and renowned commercial firms come forward to construct a chain of cold storage plants throughout the country and offer this facility of cold storage to cultivators at a nominal "premium". It is a happy sign that private concerns are coming up to construct cold storage plants in potato producing centres like Meerut, Patna, Jammu and Sialkot and they are finding these plants profitable from the business point of view also. But it is unfortunate that no such facility exists in Bengal outside Calcutta, which is far away from the producing localities.

METHODS OF STORAGE

1. In a dark, cool and well-ventilated room temporary shelves of bamboos or similar materials are constructed on which a layer of dry sand is spread 1 inch deep. Potatoes apparently healthy to the naked eye without any dirt, bruises, wounds or deformities are selected and arranged one deep on the shelves. The potatoes are now covered with another layer of dry sand of similar depth. Twelve to fifteen such shelves depending upon the height of the room may be arranged one above another. The potatoes are examined at interval of 10 to 15 days and the rotted potatoes are weeded out. Small sized potatoes keep better in this method than the bigger ones.

This method is an improvement upon the household method of storing potatoes covered inside 2 layers of sand on the floor itself.

2. A pit, circular or rectangular in shape, about 2 ft. to 2½ ft. deep is first dug in the ground, the floor space depending upon the quantity to be stored in a single pit. Water is sprinkled a day before they are to be stored with in order to bring down the temperature of the pit-walls; only a small quantity of water is to be used to make the sides and the floor feel slightly damp and cool to the touch next morning as too wet a pit is detrimental to the proper keeping of potatoes. The storing should be practised preferably early in the morning before the temperature rises.

Before putting in the potatoes, the floor and the sides of the pit should be lined with thoroughly dried leaves and sugarcane trashes so as to prevent the tubers from coming into direct touch with the soil. It is advisable to use a quantity of "Neem" (mango or *Melia Azadirachta*) leaves in the lining materials as these leaves have the property of repelling insects, which may otherwise be the source of trouble in future. But before actual storing operation the potatoes should be cooled and dried of any surface moisture by spreading them overnight in a cool but dry place. The pits are now filled up with such dried, healthy and unimbruised, well-ripened, dirt-free potatoes up to about 6 inches below their brim and then covered with a thick layer, 8 to 10 inches deep of dry leaves and trash. These covering materials are now kept in position by placing over them a closely woven frame work of split bamboo or sticks, which in their turn are kept *in situ* by tugging their margins to pegs dug into the ground. This would now secure the covering materials from being dislodged by wind or other extraneous agencies. To prevent stagnation of air inside and consequent "sweating" of potatoes and accumulation of moisture inside, pieces of hollow bamboos, 4 to 5 ft. long with septa at the nodes removed and having holes bored through sides, are used as "chimneys" for aeration. To guard against the possibility of any insect getting inside, the vent-hole at the top is covered with fine meshed gunny sacking; so also the holes on the sides. No chimney is to be used which has side holes exposed directly to the atmosphere outside without being covered. The pits are to be arranged under a spreading tree, if available, and protected from the heavy rains or the scorching rays of the summer sun by the temporary construction of a thatched shed over a group of pits. A trench, 4 inch deep and 4 inches wide is dug round a group of pits at a distance of 1 to 2 ft. Water is passed along this channel to prevent the temperature inside the pits to rise high during the heat spell of summer months. The number of irrigations and the intervals thereof depend upon the atmospheric temperature prevailing at the time. One irrigation in 2 to 3 weeks is usually considered sufficient.

In localities where stored potatoes usually suffer from potato-moth (*Phthorimaea operculella*) infestation it has been found highly beneficial, especially in cases when the produce is desired for storing longer as for seed purposes, to fumigate the selected potatoes with petrol before storing. This is an easy operation requiring the availability of an air-tight small chamber or room; in its absence large galvanised bins with tightly fitting lids will suitably do. The potatoes are now put inside the bin and a quantity of petrol, depending on the holding capacity of the bin, is placed in a container over the potatoes inside the bin and the lid then tightly adjusted. After a period of about 24 hours the potatoes are taken out. A second similar fumigation should be given after about 10 days to be sure of eradication of the pest germs completely. The potatoes should now be taken out and put inside the storing pit after some hours' exposure in a cool, dry and clean room. Petrol being highly inflammable, all necessary precautions should invariably be adopted. 1 pint of petrol for 200 cubic ft. of space is considered sufficient.

It is undesirable to store large quantities of potatoes in a single pit because if by chance rot sets in in any pit the whole lot inside may be lost.

The tubers can be taken out as required and the lining materials, etc., may be used over again next season. The condition of the tubers inside may occasionally be examined by easily opening a part of the top cover, and if it is seen that they are not keeping as they should be, they can be taken out and disposed of. This method of storage is extensively practised in Central Provinces. Only localities of Bengal with higher elevation and less rainfall are suitable for this method of potato preservation.

3. Cold Storage. This consists in keeping potatoes in chambers maintained at suitable temperature or temperatures, which have been determined earlier. By this process freshly harvested potatoes can be preserved without fear of sprouting for 3 to 4 months at a temperature of 50°F. By regulating the temperature to 45°F they can be similarly kept for 7 months. Investigations have further shown that at 35°F the potatoes keep good without sprouting for any length of period. Thus, when they are to be preserved for seed purposes they should be stored as early as possible because a big gap between harvest and putting in for storage induces sprouting after some time even though they are still inside the storage chamber. And it has been ascertained that if potatoes are stored soon after harvest at 40°F the tubers remain dormant for 7 months whereas if stored at the same temperature after 2 months' exposure, sprouting starts even while inside the cold storage plant after a period of 2 months.

If this facility becomes available to cultivators, they are to do nothing besides carrying their produce to the plant and leave the same to the charge of trained and experienced staff, who would do all things—technical or otherwise for them in exchange of the small charge paid.

MERITS AND COST OF STORAGE FOR DIFFERENT METHODS

The cost of storage in method No. 1 is about the same as in method No. 2 but is often ineffective in preventing losses. Under this method storage rots have been calculated to range from 40 to 90 per cent or even more sometimes.

Losses excepted, the cost of storage per maund in method No. 2 does not exceed more than As. 2 for any length of time; while for cold storage the cost, losses included, has been calculated at As. 4 per maund per month. Taking 3 months as the average period of storage the storing charges, including incidental charges, do not exceed Re. 1 per maund—then there still remains a good margin of difference between the price at "season" time and that prevailing after this period of 3 or 4 months

since harvest when this produce is released for sale. Further, this will benefit, besides the growers, the consuming public too in maintaining an even supply throughout the year and thereby lowering down the unreasonable rise in prices during "off season" time.

Though the cost is much less in process No. 2, it is fraught with many uncertainties as many of the external factors, viz., atmospheric temperature, humidity, etc., which predispose the stored produce to rots, can scarcely be controlled adequately. But in the process of cold storage all such and other factors can be controlled at will. Moreover there is no chance for rots setting in, and the losses in other ways (loss in weight, etc.), do not exceed 4 to 5 per cent for a period of 4 to 6 months and is, therefore, very negligible compared with any other method.

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MEDICINE AND PUBLIC HEALTH

TRANSFUSION OF STORED AND FRESH BLOOD

THERE is some difference of opinion as to the value of stored versus fresh blood. Stored blood has several disadvantages over fresh blood, and these are proportional to the duration of storage. The significance of most of them, however, is largely academic, and the major question is the fate of the red blood cells. According to Wasserman and his colleagues (Wasserman, L. R.; Volterra, Mario, and Rosenthal, Nathan; *American Journal of Medical Science*, September 1942), as reported in *Scientific News Letter*, an index of the viability of transfused erythrocytes can be obtained by studying one of the main end-products of the destruction of red blood cells in the body, namely, urobilinogen, which can be fairly accurately determined in the faeces and urine. In order to determine this point, the urobilinogen excretion was determined in 3 cases followed in the group of refractory anaemias, who

were given transfusions of stored blood. It was determined that the excretion of urobilinogen in the stool and urine after transfusion with stored blood is directly proportional to the length of time of blood storage. They further concluded that the use of blood stored for more than seven days is inadvisable for the treatment of anaemias.

HUMAN PLASMA IN SPINAL ANAESTHESIA

THE two most important problems concerning the use of spinal anaesthesia are the preferred technique necessary to produce the desired extent of anaesthesia in a manner predictable and with minimal dangers and to secure the desired duration of anaesthesia with doses of the agent that provide a wide margin of safety. As contribution to this subject, Papper and Rovenstine (*Journal of the American Medical Association*, August 15, 1942) report studies

on 5 normal male volunteers, employing human plasma as the solvent for the procaine employed in spinal anaesthesia, according to the *Scientific News Letter*. The technique was standardized as far as possible. A level table was used. Lumbar puncture was performed in the fourth lumbar interspace with the subject lying on his left side. The dose of procaine selected (3 subjects were given 100 mg. doses and 2 were given 50 mg. doses) was then dissolved in 2 c.c. of spinal fluid or 2 c.c. of plasma and injection was completed in exactly ten seconds. The subject was turned gradually and gently to the supine position. The sensory level of anaesthesia was noted at frequent intervals by response to pin-prick, and motor power of the lower extremities was observed at the same time. Two end points with regard to sensory anaesthesia were noted: the beginning of recession from the maximum height and the ability to perceive painful stimuli at the level of the twelfth thoracic vertebra. The return of motor power was indicated by any motor activity of the lower extremity. This technique was later employed for clinical anaesthesia on 70 patients. The majority of the latter were subjected to surgical procedures in the lower part of the abdomen and lower extremities. There have been no untoward manifestations during surgery or postoperatively that might be attributed to the plasma. Observations of these few cases have left the impression that dose for dose the duration of procaine spinal anaesthesia is prolonged when plasma rather than spinal fluid is the

diluent. Predominantly, motor or sensory anaesthesia can be obtained easily and as desired by appropriate adjustments of the position of the patient.

THE DISTRIBUTION OF THIAMINE IN THE WHEAT PLANT

ACCORDING to a report of the *Scientific News Letter*, the Minnesota Experiment Station, in co-operation with the U. S. Department of Agriculture, recently carried on some investigation on the thiamine concentration in kernels of early—and late-sown Thatcher and late-sown Ceres wheats. It was observed that the concentration of thiamine decreased slightly during the first few weeks after blossoming and then remained relatively constant, with an apparent slight increase at full maturity. Thiamine decreased markedly in glume and stem fractions as the kernels filled. The concentration in tillers as a whole changed little with maturity. Total thiamine in kernels increased while that in glume and stem fractions decreased greatly throughout the ripening period. The bulk of the thiamine in the mature plant was present 1 week after blossoming and was translocated from glumes, rachis, stems, and leaves into developing kernels. Thus, in early-sown Thatcher about 25 per cent of the total thiamine of the tiller was in the kernels, 15 in the glume, and 60 per cent in the stem fraction at 7 days after blossoming. In the mature tiller, kernels contained about 77, glume 2, and stem fraction 21 per cent.

TISSUE CULTURE: A BIOLOGICAL MEANS OF EXPERIMENTATION

N. N. DAS

CULTURES of the tissues of animals by artificial methods is really an important biological means which has developed during this century. Harrison conducted in 1907 the first experiment in frog's embryonic nerve in vitro; at that time it was barely suspected that the individual cell is capable of independent life. Now it is believed that the cell is potentially immortal.

Strangeways, showed that death is of more than one kind. Death of the body as a whole is not immediately followed by death of its component cells; all that has happened, at least in a physical sense, is that its organs are no longer capable of co-ordinated action. A body may be dead and cold, but its individual cells are still living, and if removed and placed in a suitable medium, many of them will continue to live and multiply indefinitely under favourable conditions. The strain of cells does not become old and die. Senescence is not a property of cell itself,

it is the product of environmental conditions of the body. The strain of fibroblasts isolated from the embryonic heart of a chick in 1911 at the Rockefeller Institute is still living, propagated, long after the time when the bird of which it should have formed a part would have died.

Growth also is dependent on influences outside the cell. As a subject of experimentation, the individual cell clearly has unexampled possibilities. Not only can the factors controlling its growth be studied, but the action of noxious agents, physical, (e.g., radium and neutron) and parasitic (e.g., micro-organisms and viruses) and the mutual relations of cells of different types. The problems of biology can be reduced in tissue culture to the simplest possible terms; experimentation on the animal as a whole is supplemented by experimentation with a single type of cell.

It is not possible to describe in detail the technique of tissue culture, here we deal only with the important information regarding the factor of cell growth and multiplication.

Two elements are necessary for growth, (1) supporting structure, and (2) a nutritive fluid.

It has been found experimentally that the cells of a fragment of tissue simply suspended in a nutrient fluid contract and exhibit no activity. They require a supporting frame-work for their growth. The cover-slip or other surface on which the culture is placed affords this support to some extent, but a fine net-work imitating the connective tissue of the body is the ideal. Various kinds of material were tried and it was found that a fibrin net-work was the ideal supporting structure. If with certain precautions to prevent clotting the blood is withdrawn from an animal by means of syringe and placed in a chilled tube and centrifuged in the cold, and if the plasma is separated and stored in the cold, it can be kept for a long time without coagulating. For culturing tissue, a drop of plasma is spread on a cover-slip, and the addition of the tissue to be cultivated with embryonic tissue juice another ingredient of the medium, causes coagulation within a few minutes. A network of fibrin is thus formed, which provides an ideal frame-work for subsequent growth.

Almost all media for tissue culture contain fluid ingredients of animal origin. It is necessary to have a solution of those inorganic salts which are present in blood, such as Ringer's solution, but in tissue culture work this has been replaced by Tyrode's and Pannet-Compton solutions. To this solution glucose is sometimes added.

Cell growth is controlled by a certain fluid present in the medium. This fluid generally contains growth-promoting hormone. This hormone is present in living tissue especially in embryonic tissues. Eggs of seven to ten-days incubation are opened, and the embryo is cut up finely with scissors and immersed in Tyrode's solution; the supernatant fluid after centrifugation is used as an embryonic extract. The other ingredient of a tissue culture is serum. When plasma is employed as a basis, the serum of course is already present.

Thus we find that embryonic tissue extract, plasma, and inorganic salts are employed in the cultivation of tissue, and the method of their use may be described in short. The "cover-slip" type of hanging drop preparation is generally used. The fluids required having been prepared, the fragment of tissue to be cultivated is removed from the embryo or other source and placed on the cover-slip together with plasma and whatever other materials are to be introduced, and the cover-slip is sealed over a hollow ground slide or a brass ring on an ordinary slide by

means of paraffin wax. It needs hardly be said that every operation in the preparation of the fluids used and in the making of the culture itself has to be carried out under the most strictly aseptic conditions.

With incubation growth takes place. To maintain the culture, sub-culture is done which consists in excising small fragments of the sheet of growth which has formed, and placing them on another cover-slip. This operation has to be carried out every two or three days if the culture is to be perpetuated. There are however methods by which it is possible to maintain the uninterrupted growth of a culture for several weeks. For this purpose it is necessary to have a large container, in which the fluid medium can be renewed repeatedly. The best known of these is Carrel's flask, a flat glass vessel with a rising outlet at one side. Growth may be studied either microscopically during its progress, Fig. 1 (the microscope being enclosed in an incubator) or by measurement of the area of growth with the help of a camera lucida. With cover-slip preparations it is possible to see through the culture because the growth consists of a flat sheet of cells (Fig. 2). Still more effective modern

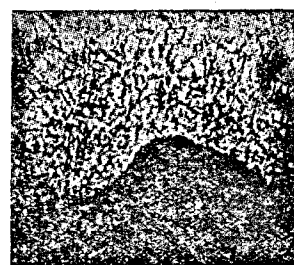


FIG. 1. Unstained preparation of hanging drop culture of fibroblast from heart muscle as seen under microscope.



FIG. 2. Stained preparation of hanging drop culture showing flat sheet of cells of fibroblast from a muscle. (Haematoxylin-eosin).

methods are in use, and involve the use of a Carrel pump (Fig. 3) or a Lindbergh gas-flasks (Fig. 4.)

The growth of cells, and the factors influencing it, are well studied in tissue cultures. Different types of cell vary in their capacity for proliferation. Only one type of cell the fibroblast can multiply indefinitely in vitro; some cells decline to multiply at all and we do not know all the specific conditions under which these cells thrive. Therefore it is a fact that the length of life of a strain of cell in vitro is conditioned by its identity. All tissues contain some fibroblast, and the immediate result of attempt at cultures are a multiplication of fibroblasts. If a culture be made from embryonic heart-muscle, the cell, which generally grows from it, is not the muscle cell, but a fibroblast. The cultivation of the mixed leucocytes of blood results even-

tually in the survival of the large mononuclear cells alone. This method of obtaining a "pure culture", to borrow an expression from bacteriology, has been described as the "physiological elective" method.

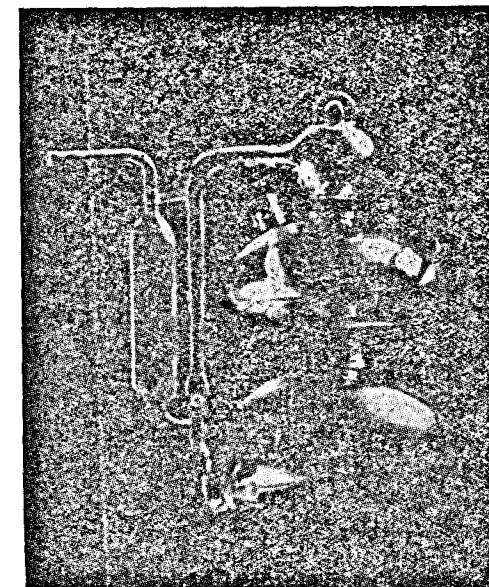


FIG. 3. Carrel pump flask (A device for continuous circulation of fluid media).

Pure strains of some cells can be easily obtained by repeated sub-cultivation. One of the important features of growth of any cell in vitro may be the

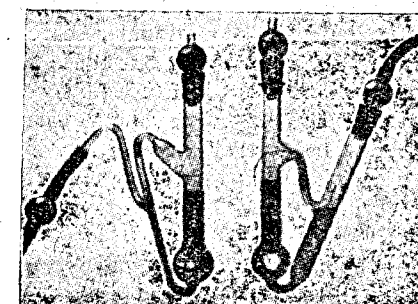


FIG. 4. Lindbergh gasleft flasks. (A device for continuous circulation of fluid media).

process known as "de-differentiation", i.e., the cells are so differentiated, as if they are laboratory trained. It is clear that maintenance of normal characters is dependent on a normal environment.

The uses of tissue culture may be conveniently divided, though by no means clearly, into physiological and pathological.

Studies of the life and multiplication of cells have been made with this method. It has been proved that there are substances which normally stimulate growth. The period of survival at different tempe-

ratures, the influence of hydrogen-ion concentration and osmotic tension on growth, the effect of drugs, and other simple and fundamental questions, have already been settled. The minute changes in cells have been studied by dark-ground illumination. Canti produced a cinema film by means of which one can see not only mitochondria and their movements, but any other particulate element in the cell throughout its mitotic cycle. Tissue culture has made these physiological studies possible.

Attempts have been made in various directions to investigate in tissue culture the processes of disease. Work has been done on body fluids in which certain substances affecting cell life have been detected. Blood serum contains both growth-promoting and growth-inhibiting factors, which differ in their susceptibility to heat. But there are other substances present, viz., the "cyto-toxin" which exerts an actually destructive action on living cells. The differences between the growth inhibiting and the cytotoxin factors may be made clear by analogy. With bacterial growth a certain substance present in a medium may not favour the growth of a particular micro-organism but does not kill it but a disinfectant, will destroy it. Cytotoxins are generally generated in the blood of an animal which receives injections of the cell on which they are to act, much in the same way as immune bodies are produced by inoculation with bacteria. If a serum having this cytotoxic action be added to a culture, not only may the growth and migration cease, but the cells may be observed to contract and actually disintegrate. The degree of such effect depends on the quantity of cytotoxin present. Such substances if present in small amount, can be detected by applying them to a tissue culture; they will prevent growth. Lambert and Hanes immunised rats with injections of mouse sarcoma and found that the rat serum inhibited the growth of tissue culture of the tumour cells and also of cultures of normal epithelium. It appeared, therefore, that the cytotoxin produced was one for rat cells generally. Now it has been found by experiment that cytotoxin for malignant and for normal cells are not identical.

The tissue culture technique has been more useful in studying the action of X-rays, neutron and radium on living cells. The reduction of a complex problem to a simple one is brought about by the use of a single type of cell and ascertaining its behaviour under standard conditions.

Tissue culture is also being utilised in bacteriological studies, and the filter-passing viruses, which are incapable of cultivation in ordinary media, are believed to multiply only in the presence of living cells. The mere presence of fresh tissue is not enough. The living tissue must be introduced in a medium in which it can grow, and in this condition

only, the inoculated virus will grow. Such growth has been demonstrated in case of the virus of vaccinia. Bacteria have been added to tissue cultures in order to study the cell reactions which they produce. In this way tubercle bacilli have been made to produce fair imitations of giant-cell proliferation which characterises the tuberculous lesions in the body.

The organisms which grow very rapidly cannot be used, because their activities would outpace those of the cell, and the result would be disorganisation. This simple fact perhaps shows the reason for the comparative failure of tissue culture as a pathological method. Further improvements in tissue culture technique are still needed.

BOOK REVIEWS

Recent Advances in Galactic Dynamics—By A. C. BANERJEE, Lucknow University, Series No. XV.

The Lucknow University in addition to its usual programme organises a number of extension lectures on different subjects every year which are later published in the form of monographs. The present one has been compiled from three lectures delivered by Prof. A. C. Banerjee of the University of Allahabad on "Recent Advances in Galactic Dynamics". Prof. Banerjee has treated three different topics: (i) polytropic configurations of gaseous matter; (ii) spiral nebula; and (iii) the origin of the solar system. In the first lecture the figures of equilibrium of rotating liquids have been very briefly discussed and then the equilibrium of slowly rotating polytropes. The results of Chandrasekhar for rigid body rotation and those of Bhatnagar for variable rotation have been fully discussed. Kopal's work has been referred to in this connection but his conclusions regarding density condensation have not been mentioned. The second lecture opens with Hubble's classification of nebulae. Then follow short accounts of the theories of spiral nebula due to Jeans, Lindblad, Brown, Vogt and Lambrecht and others. The chapter ends with an account of the work by Banerjee and his collaborators on the structure of spiral nebula. The third lecture on the origin of the solar system contains short accounts of the various theories on the subject from Kant upto the modern times. Only references could be made about these theories without any account of the line of mathematical investigation pursued. Only Bhatnagar's work in this line has received fair treatment in this respect. It appears the object of Prof. Banerjee has been to pack as much information as possible within these short chapters. The monograph contains a good bibliography and much useful information.

N. S.

Suggestive Studies in Education—By DEBNARAYAN MUKERJEE, Allenganj, Allahabad. Pp. i—iv, 1—101, 1—57. Price Rs. 1/8/-.

This book is mostly a collection of papers read or published by the author in different journals. Part I contains investigations of 'certain problems in a critical spirit and from the

point of view of the Indian teacher.' Part II is a complete monograph, on the reform of examinations, an amplified reprint of a former publication. Pt. Amarnath Jha, Vice-Chancellor, Allahabad University, in the introduction to this book writes, 'the papers included in the present volume bear eloquent testimony to the thoroughness and independence with which he has carried out his investigations.'

Mr Mukerjee advocates the application of scientific method to education, which is 'rapidly evolving into an exact and positive science.' He shows by the investigations he has carried out, how important it is to do so, and for what reasons. I value highly two of these, (i) Age-distribution in English Schools in the U. P., reprinted from All India Educational Bulletin of All India Federation of Teachers' Association, December 1933; and (ii) A survey of High School marks, reprinted from Teaching, December, 1936. For the sake of those alone I will recommend this book to Head Masters, Inspectors, Examiners, and others engaged in educational research.

Mr Mukerjee, in carrying out these two surveys, has done real pioneer work in the field of education, which is very much worth being carried on by others. We all know that there are boys of different ages in a class, but it is staggering to find that their ages may vary as much as 14 years or more, from 8 to over 21, class VII, (table 3, (1933), p. 63). The age range suggested by the author is worth of consideration.

As the school education in India is entirely dominated, one may even say thwarted, by examinations, any reform in the education system means primarily a reform of the examinations. Mr Mukerjee has surveyed high school marks in U. P. for three years and has written a monograph on the subject. In which (para 22) he says, "we should stop declaring 'passes' and 'failures' or awarding divisions. Instead of this, all should get a certificate showing the actual marks gained in the different subjects.' Other surveys and on a larger scale, will have to be carried out, before it will be possible to accept Mr Mukerjee's conclusions about examinations. He has shown a way of tackling this demon.

R. B. M.

LETTERS TO THE EDITOR

[The editors are not responsible for the views expressed in the letters.]

INVESTIGATIONS ON THE SAPONIN CONTENT OF THE INDIAN PULSES

WHILE preparing pure saponin from soap-nuts for the purpose of the 'Heading Liquid' and soapless shampoo I was reminded of a gradually dying custom of our country women-folk of washing their hair with a cold decoction of the 'Masuri dal' (*Lens esculenta*). This struck me with an idea that 'Masuri dal' might contain a saponin, and immediately I turned my attention to this subject.

To my great surprise I found that not only 'Masuri dal' but all the available dals or pulses contain saponin to an appreciable extent.

A comparative test of the saponin content of the pulses was made in the following way:

10 g. of each of the following pulses Masuri, Mator (*Pisum sativum* L.), Chhola (*Cicer arietinum* L.), Khesari (*Lathyrus sativa* L.), Aralar (*Cajanus Indica Spreng*), Kancha Mug (*Phaseolus radiatus* L.), Sona Mug (*Phaseolus radiatus*), and Mas Kalai (*Phaseolus Mungo radiatus* H.) were taken in 100 c.c. distilled water in a beaker, warmed on a waterbath for a few hours and then from each beaker 40 c.c. of the extract were taken, acidified with a few c.c. of glacial acetic acid to completely precipitate the soluble protein and then filtered.

20 c.c. of this clarified solution from each extract were taken in a 2 oz. narrow-mouthed phial and shaken violently for 2 minutes. In each phial profuse and persistent foam appeared. From the difference of foam-heads in the phials it was found that Masuri dal contains most and Kancha Mas Kalai dal the least amount of saponin. The following is the order of the saponin content of the pulses investigated:

Masuri, Khesari, Mator, Aralar, Chhola, Sona Mug, Kancha Mug and Mas Kalai.

The following attempts were then made at the isolation of the Masuri dal saponin:

(1) 4 oz. of roughly powdered Masuri dal were extracted thrice with 80% ethyl alcohol on a boiling water bath under reflux. The combined extracts were concentrated to dryness in vacuum, the residue was taken in water and dialysed through Graham's Dialyser. The dialysed liquid was evaporated to dryness on the water bath in vacuum and the

crude saponin was obtained as a brown hygroscopic substance.

(2) To 300 g. of Masuri dal (without powdering) 600 c.c. of distilled water was added and the mixture was heated on a steam bath for 2 hours. The extract was decanted off. Again the residue was treated with 400 c.c. of water and the extract collected as before. This was repeated twice more and the combined aqueous extracts were taken in a cylinder, and lead acetate was added till no more precipitate appeared. After removing the precipitate, H_2S was passed through the solution to remove the lead, as PbS . The filtered solution was then evaporated to dryness and attempts were made to further purify the brown residue and to obtain the stuff in a crystalline form from a suitable solvent.

Details of the findings will be published later on.

My best thanks are due to the authorities of the firm.

H. G. BISWAS.

Sir Prafulla Research Laboratory,
Bengal Chem. & Phar. Works, Ltd.
Calcutta, 26-6-1943.

ON THE OCCURRENCE OF *PSILOTUM TRIQUETRUM* SW. IN THE EAST GODAWARI DISTRICT

T. S. MAHABALE and G. S. Deshpande¹ observe that *Psilotum triquetrum* Sw. is known to occur in many parts of India but its distribution seems to be discontinuous as the plants are often both local and rare. The only accounts^{2, 3} dealing in detail with its distribution in India agree with the above statement. According to Raizada,³ it has been only recorded from the districts of Nilgiri, Coimbatore and Tinnevely previously in the Madras Presidency. It may not be uninteresting to those concerned in the distribution of the genus in the presidency that *Psilotum triquetrum* Sw. has been collected in last March 1942, on an excursion, in a forest near a village known as Vathangi in the East Godawari District. It has been found growing on a rock with its root-stock firmly spread inside the crevices, near a shady watercourse. *P. triquetrum* is described to be

generally 7-8 in. high, while under favourable conditions it often attains a height of 2-2.5 ft.

I am indebted to Prof. M. Sayeedud-Din, M.A., M.Sc. (Edin.), Head of the Department of Botany, Osmania University, for the supply of literature in this connection.

Department of Botany,
P. R. College,
Cocanada, 6-7-1943.

V. VENKATESWARLU.

¹ Mahabale, T. S. and Deshpande, G. S., *Psilotum triquetrum* Sw. at Lonavalla, Bombay Presidency. *Current Science*, 2, 466, 1942.

² Prain, D., The genus *Psilotum* Sw. in India. *Journ. Bom. Nat. Hist. Soc.*, 8, 428, 1894.

³ Raizada, M. B., The genus *Psilotum* in India. *Indian Forester*, 61, 654, 1935.

BASIC NITRATES OF RARE EARTHS

THOUGH the differential decomposition of nitrates had been utilised for the isolation of yttrium earths since the classical work of Berlin¹ (1860) no systematic study of the basic nitrates of rare earths has been made up till now. Search for the literature shows that only the basic nitrates of yttrium and gadolinium have been mentioned. From an iso-thermal study of the ternary system of $Y_2O_3-N_2O_5-H_2O$, James and Pratt² isolated the only basic nitrate of yttrium of the composition $3Y_2O_3, 4N_2O_5, 20H_2O$. From a detailed study of gadolinium and its compounds Sarkar³ isolated $3Gd_2O_3, 4N_2O_5, 20H_2O$ analogous to that of yttrium. The nitrates of rare earths are extremely deliquescent and soluble in alcohol, whereas the basic nitrates of Gd and Yt are non-hygroscopic and separate out on cooling from hot aqueous solutions in beautiful shining crystals. The basic nitrates of cerium earths differ from those of the yttrium group in that they are insoluble in water.

The analogy of bismuth salts with those of cerium earths and upto those of Gd has been beautifully demonstrated by late Prof. Urbain⁴. The phase rule study of the system $Bi_2O_3-N_2O_5-H_2O$ leads to the isolation of three basic nitrates of bismuth of the compositions (1) $BiONO_3, H_2O$, (2) $Bi_2O_3, 2BiONO_3, H_2O$, (3) $Bi_2O_3, 10BiONO_3, 9H_2O$. The present author has isolated two basic nitrates of each of the cerium earths (La, Ce, Pr, and Nd) analogous to those of Bi (Nos. 1 and 2). The first may be called the basic nitrate and the second the so-called super-basic nitrates of the early-workers in the rare earth chemistry.

The physico-chemical methods of thermometric⁵ and conductometric titrations of a solution of the

nitrate with caustic soda reveals two breaks, one corresponding to $RONO_3$ where the ratio of nitrate to NaOH is 1:2 and the other $R_2O_3, 2RONO_3$ where the ratio of nitrate to NaOH is 2:5 (Fig. 1, curve I and Fig. 2, curve I.) besides a third break in the region 1:3 corresponding to $R(OH)_3$.

Thermometric and conductometric titration curves of yttrium nitrate with NaOH (Fig. 1, curve II and Fig. 2 curve II) showed on the other

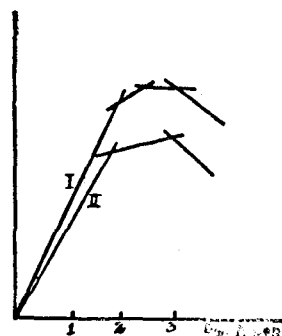


FIG. 1. Thermometric Titration.
I. $La(NO_3)_3$ with NaOH
II. $Yt(NO_3)_3$ with NaOH

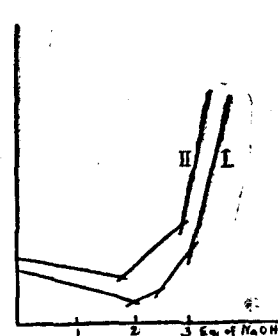


FIG. 2. Conductometric Titration.
I. $La(NO_3)_3$ with NaOH
II. $Yt(NO_3)_3$ with NaOH

hand only one break in the region 1:1.67 corresponding to the basic nitrate of James and Pratt² and another in the region 1:3 corresponding to $Yt(OH)_3$.

Thermal decomposition curve of $La(NO_3)_3$ with increasing temperature (Fig. 3) showed the presence

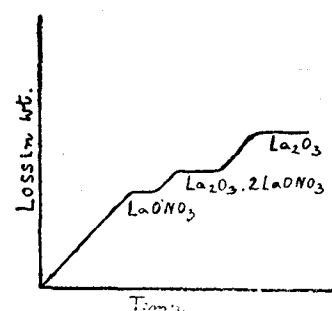


FIG. 3. Thermal Decomposition.

of two basic nitrates corresponding respectively to $LaONO_3, La_2O_3$, and $2LaONO_3$. Their temperatures of formation and range of stability have been studied. The first is formed at $330^\circ C$ and is stable up to $350^\circ C$ while the second is formed at $370^\circ C$ and stable up to $400^\circ C$. Chemical analysis confirmed the above compositions.

The individualities of the above compounds are also being studied by X-rays. Details will be published elsewhere.

My best thanks are due to Dr. P. B. Sarkar for suggesting the problem and giving me every facilities in his laboratory.

NIHAR KUMAR DUTT.

Inorganic Chemistry Laboratory,
University College of Science,
Calcutta, 24-8-1943.

¹ Berlin, *Forhandl. Scand. Naturf. Kjobenhavn*, 8, 448, 1860.

² James and Pratt, *J. Amer. Chem. Soc.*, 32, 873, 1910.

³ Sarkar, P. B., *Annales de Chimie*, p. 239, 1927.

⁴ Urbain, *Compt. Rend.*, 137, 792, 1903.

⁵ Dutoit, *J. de Chim. Phys.*, Tome, 19, 324, 1921.

POLYGALA CHINENSIS LINN, AS SUBSTITUTE FOR 'OFFICIAL' SENEGA

Senega, in the form of an infusion, liquid extract or tincture, is widely employed as an expectorant in medical practice and at least during pre-war days, a fairly large quantity of the dried roots of *Polygala senega* Linn (Fam. Polygalaceae), a perennial herbaceous plant indigenous to Southern Canada and the United States of America, used to be imported into India

Chopra¹, on the basis of previous work, suggested that *P. chinensis* Linn and *P. crotalarioides* Ham, which are found plentifully in various parts of the temperate Himalayas and the Nilgiri and Tipperah hills, could be used as substitutes for the B.P. and the B.P.C. drug. Bal², after a comparative pharmacognostical examination of three Indian species of *Polygala* (*P. chinensis*, *P. crotalarioides*, *P. rosmarinifolia*, W and A), recommended the adoption of *P. chinensis* as a suitable substitute for 'official' senega. No report is available on the systematic chemical and clinical examination of *P. chinensis* and its preparations in comparison to *P. senega*. In order that the Indian species be recognised in the B.P. and the B.P.C., the following experimental data are presented.

TABLE I
ANALYSIS OF SENEGA ROOT

	<i>Polygala chinensis</i>	<i>Polygala senega</i>
1. Ash	4.87%	4.8 to 5.0%
2. Alcohol (20%, extractive matter) ..	20.0%	27.0 to 28.0%
3. Petroleum-ether extractive matter ..	About 2.0%	About 4.5 to 5.0%
4. Polygallic acid ..	About 4.5%	About 2 to 3.5%*
5. Senegin	About 2.1%	About 2 to 3.5%*

* Figures from Thorpe's Dictionary of Applied Chemistry, 4, 657, 1913.

TABLE II
ANALYSIS OF TINCTURE SENEGA

	<i>P. chinensis</i>		<i>P. senega</i>
	A*	B†	
1. Sp. Gr. at $15.5^\circ C$.	0.9203	0.926	0.930 to 0.936
2. Total solids (per cent) ..	1.688	1.35	3 to 5
3. Alcohol (per cent) by volume ..	58.46	57.6	57 to 60

* Average of 2 determinations each from 3 samples of tincture prepared in the B. S. Laboratory according to standard method from authentic specimens of *P. chinensis*.

† Average of 2 determinations each from 18 commercial samples of Tinct. Senega (*P. chinensis*) received for assay in B. S. Laboratory.

From the tables, it will be apparent that *P. chinensis* roots contain the most important saponins, polygallic acid and senegin, which characterise *P. senega* and to which its pharmacological action as a 'reflex expectorant' is due. The quantity of the saponins present in the two species is also very similar.

The specific gravity and the total solid content of tinctures made from *P. chinensis* according to the approved B.P.C. process are slightly, though definitely, lower. The reason for this is not understood and further investigation is in progress.

Tinct. Senega (from *Polygala chinensis*) has now been in use in several Government hospitals and dispensaries for more than 6 months as an important constituent of 'stimulant expectorant' mixtures and physicians have not had any evidence of its lack of efficacy as compared to Tinct. Senega (from *P. senega*). This is an indirect evidence that the change of species is not of much therapeutic significance.

With slight modification in chemical standards, *P. chinensis* may therefore be included in the B.P. and B.P.C. and Indian manufacturers need not depend on imported *P. senega*.

We are grateful to Messrs. B. C. P. W. & Co., for supplying us the *P. chinensis* from their stock free of charge for our research work.

T. HOSSAIN
R. C. GUHA
B. MUKERJI.

Bio-chemical Standardisation Laboratory,
Government of India,
110, Chittaranjan Avenue,
Calcutta, 25-8-1943.

¹ Chopra, R. N., *Indigenous Drugs of India*, p. 46, 1933.

² Bal, S. N., *Indian Journal of Pharmacy*, 3, 55, 1941.

001 PARTING IN AMPHIBOLES IN TERTIARY SEDIMENTS OF ASSAM

A perfect set of parallel hairline cracks are met with from time to time in amphibole grains from the tertiary sediments of Assam. These cracks are always accompanied by another set of coarse interrupted cleavage cracks, the angle of intersection varying from 90° to 73° . From considerations given below, it appears that while the latter represent the traces of the prismatic cleavages on the zone parallel to the axis 'C', the fine hairline cracks represent the trace of ooi parting, which does not seem to have been recorded before in these amphiboles.

With convergent light the grains in which the angle of intersection of the two sets of cracks is 90° , (Fig. 1) give good interference figures, with the

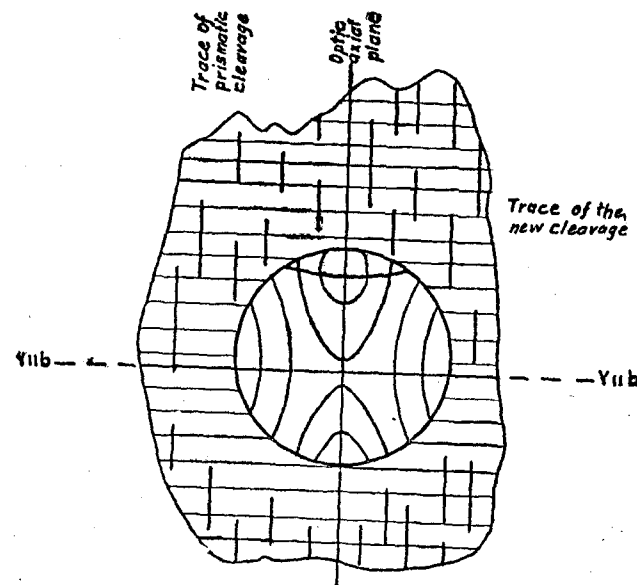


FIG. 1.

bisectrix 'X' emerging nearly through the centre. The optic axial plane in such cases is parallel to the coarser interrupted set of cleavage cracks while the other axis 'Y' is parallel to the other set. This orientation of the grains show that these are lying approximately on the 100 plane and that the coarser set of cleavage cracks form the trace of the prismatic cleavages on this plane. The finer set of hairline cracks, being parallel to 'Y', is the trace of a cleavage or a parting parallel to either the ooi face or the clinodomes.

The grains which show the highest polarisation colours may be taken as lying approximately on the 010 plane. The trace of a ooi cleavage in such grains should have an angle of intersection of about $73^\circ 58\frac{1}{4}'$ (Fig. 2) with the trace of the prismatic

cleavage, as that is the value of β in monoclinic amphiboles¹. The actual angles observed so far in similar grains have been 73° or very nearly so. Considering the amount of approximations involved, this may be taken as a sufficiently close value and it may be concluded that the set of fine hairline cracks in all these grains have been caused by the existence

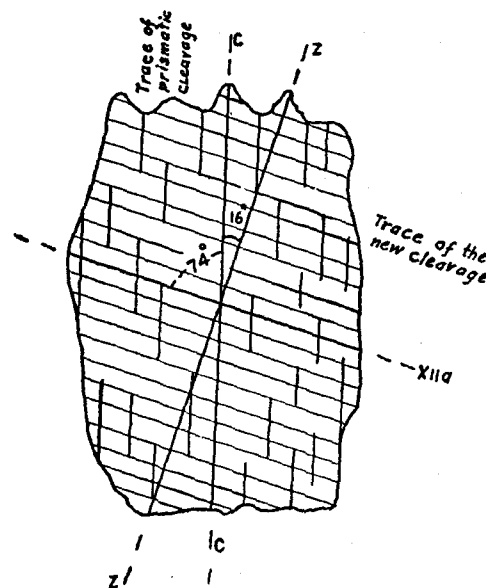


FIG. 2.

of a ooi parting or cleavage. As a ooi parting is known to exist in certain amphiboles² these hairline cracks in these amphiboles also can be regarded as partings.

A. B. DAS GUPTA.

Geology Dept.,
Burmah Oil Co., Digboi,
Assam, 26-8-1943.

¹ Iddings, Rock Minerals, p. 355, 1911.² Winchell, A. N., Elements of Optical Mineralogy, p. 249, 1933.DERIVATIVES OF CYCLOPENTANE CLOSELY ALLIED TO WIELAND'S TRICARBOXYLIC ACID $C_{15}H_{22}O_6$.

I

WITH reference to the above publication in this journal,¹ I wish to state the following facts.

All the compounds, with the exception of ethyl α -methyl- α' -dibromopimelate described in the note, had already been published in the form of a short note² in SCIENCE AND CULTURE, the fuller details of which were published later in the Journal of the Indian Chemical Society.³

I was rather surprised to find that no reference has been made to my work, although the author has referred to that of Bachmann and Struve.⁴ In this connection I should like to point out that Prof. Bachmann, did not fail to acknowledge the priority of my work to which he referred in the following terms. "After our investigations had been completed, we read that Dutta* had prepared the *cis* and *trans* forms of V. Dutta reported that he had obtained the *trans* acid by reducing the unsaturated acid IV by sodium amalgam and water. Apparently he was unable to effect the conversion of the *trans* acid to its diastereoisomer for he prepared the *cis* acid by an entirely different synthesis. The properties of his compounds agreed with those of ours in all respects."

I would also like to draw attention of the present author to my later publications⁵ in connection of the above work.

P. C. DUTTA

Sir P. C. Ray Research Fellow's Laboratory,
University College of Science and Technology,
92, Upper Circular Road,
Calcutta, 28-8-1943.

¹ Brahmachari, SCIENCE AND CULTURE, 9, 92, 1943.² Dutta, SCIENCE AND CULTURE, 5, 570, 1940.³ Dutta, J. Ind. Chem. Soc., 17, 611, 1940.⁴ Bachmann and Struve, J. Am. Chem. Soc., 63, 1262, 1941.⁵ Dutta, J. Ind. Chem. Soc., 19, 79, 1942; SCIENCE AND CULTURE, 7, 316, 1941.

* — SCIENCE AND CULTURE, 5, 570, 1940, C.A., 34, 6933, 1940.

II

A SHORT time ago the author published a simple synthesis of 1-methyl-cyclopentane -1:2-dicarboxylic acid,¹ the melting points of the *cis*- and the *trans*-modifications of which were in fair agreement with those recorded by Bachmann and Struve.² In a recent communication Dutta states that no reference has been made by the author to his earlier work on the subject. Bachmann and Struve have partly repeated the work of Dutta, and as the data recorded by them for the melting points of the acids appeared to me more reliable, these were quoted, and no reference to the earlier work of Dutta appeared to be necessary.

The latest publication³ of Dutta on the subject to which he has called the attention of the author

has no direct bearing on the work, outlined by the author.¹

NIRMAL BRAHMACHARI

University College of Science & Technology,
92, Upper Circular Road,
Calcutta, 7-9-43.

¹ Brahmachari, SCIENCE AND CULTURE, 9, 92, 1943.² Bachmann and Struve, J. Am. Chem. Soc., 63, 1262, 1941.³ Dutta, J. Ind. Chem. Soc., 17, 611, 1940; 19, 79, 1942.

[No further correspondence on the subject will be entertained.—Ed. Sci. & Cul.]

THE CULTURAL BASIS OF RULES OF INHERITANCE

In a paper which was published in this journal¹ I discussed the question of intestate succession of Hindus. I should like to add the following points for the sake of completeness:

(1) In the case of Hindus who make over a dowry at marriage, I have pointed out that it is a payment of the father's property in anticipation, and suggested that a daughter may in such case be excluded from a further share of the father's property by will. As this arrangement cannot work in case of intestacy, it is suggested that an agreement should be executed at the time of marriage, in the form of a marriage settlement and waiver of further rights.

(2) As it is the practice among Hindus in villages to continue to live for generations on the same homestead site, and a daughter normally does not stay after marriage in her father's house, her rights in this portion of the estate, should be a life interest only, limited to right of residence and enjoyment of the produce if any of the garden and tanks. But if her brothers or their heirs partition and sell their shares, she shall be entitled to do likewise. Ordinarily, the conferring of an absolute right in homestead lands on a daughter is likely to lead to sale of her share and hence to a break up of the family site. This is not desirable. The actual economic loss to her will be negligible as the average size of homestead land is less than two bighas and in a family of four children with an equal number of both sexes her share of the homestead land will be only a few kattahs. For the same reason a childless widow should have a similar limited right in homestead land, to be extinguished on death or remarriage. I have not considered the objection that inheritance by daughters will increase fragmentation, as the subdivision of cultivable land has already proceeded so

far that in normal times, agriculture will not pay unless a co-operative basis is adopted.

K. P. CHATTOPADHYAY.

Department of Anthropology,
University of Calcutta,
Calcutta, 7-9-1943.

¹ SCIENCE AND CULTURE, 9, 56, 1943.

PRODUCTION OF PENICILLIN

PENICILLIN, the antibacterial substance of Fleming¹ although highly potent as an anti-bacterial substance, becomes very unstable when stored up in the room temperature. The duration of production of penicillin seems to be fairly high and the process of extracting the pure form of the substance is laborious too.²

During our systematic investigation on the growth of twenty different species of *Penicillium* including *P. notatum* (Westl) and *P. citrinum*, it has been found that a little modification of the culture media (CZ-Dox) by adding plant extracts and organic acid salts brings about much better results. The period for production of maximum strength of the antibacterial substance at 24°C, in most cases, is between 4-7 days. The appearance of anti-bacterial substance is closely related to the following factors: (a) Increase in dry wt. of the mycelium, (b) Sporulation of the fungus, (c) Changes of pH of the media, (d) Production of clouring matter, (e) Utilisation of the carbohydrate, (f) Intensity of FeCl₃ reaction, (g) Rate of absorption of bromine.

Raistrick,³ Fleming and Abraham *et al*² showed in their experiments that the period necessary for production of maximum anti-bacterial activity was 20, 8, and 12 days respectively, and it has also been recorded by them that there is a correlation between the appearance of colouring matter in the media and the production of penicillin. Rao and De⁴ found this period to be 3 days when a semi-solid media was used and the appearance of colouring matter was not significantly correlated to the anti-bacterial property. We have found that the period for production of maximum anti-bacterial strength in different species of the fungi varies from 4-7 days which is shorter than that of Raistrick, Fleming and Abraham *et al*, and the production of colouring substance is invariably associated with the anti-bacterial property.

The very early attainment of the maximum anti-bacterial activity observed by Rao and De may be due to the high activity of the strain of the fungi

and or to the suitability of the semi-solid culture media used by them. The absence of any significant correlation found by them between strength of the anti-bacterial activity and the growth of colour in the media is not in agreement with the observations of the other investigators including ourselves.

Details of our experimental results will be published elsewhere.

P. NANDI.

Department of Microbiology,
Bose Research Institute,
Calcutta, 7-9-1943.

¹ Fleming, *Br. J. Exp. Path.*, 10, 226, 1929.

² Abraham *et al*, *Lancet*, 241, 177, 1941.

³ Raistrick, *Biochem. Jour.*, 26, 1907, 1932.

⁴ Rao and De, *Current Science*, 12, 209, 1943.

A COMPARISON OF THE VARIATIONS OF NIGHT SKY LUMINESCENCE AND OF REGION-F ELECTRON DENSITY AT NIGHT

IN the recent hypothesis¹ of the night sky luminescence proposed by Mitra, Region-F of the ionosphere has been identified as the luminescent layer. According to this hypothesis one should, therefore, expect the variations of the electron density of Region-F at night, as obtained by radio measurements, to show some correlation with the variations of intensity of night sky emission. A comparison of the two variations show, however, that there is little similarity between them. Typical variations of Region-F electron density at night is as follows. There is a rise in the electron density after nightfall which continues up to the midnight; the density then falls gradually to about one-fourth of its evening value before sunrise. The intensity of the night sky light, on the other hand, is fairly constant throughout the night and diminishes by only about 20 per cent of its evening value.² An explanation of this anomaly is given in the present note.

The variations of electron density as obtained by ionospheric measurements are those occurring in the region of maximum ionisation. These variations do not tell us anything about the nature of the variations of the total number of electrons present in a column of the ionised region. The intensity of the night sky emission, however, depends on this latter quantity. It is therefore not surprising that the two variations do not show any similarity. Indeed, it would have been surprising if it were otherwise. It is quite possible, for instance, that the total number of electrons in a column of unit cross-section remains constant but that the density in the region of maximum

ionisation increases due to the contraction of the layer as a whole due to cooling.

Again, for recombination according to the proposed reaction, the variation of electron density with time will be given by the formula³:

$$n(t) = \frac{n(o)}{1 + 10 \alpha_1 n(o)t}$$

where $n(o)$ is the initial value of electron density and α_1 the coefficient of recombination; assuming the efficiency of the proposed reaction is unity *i.e.*, every collision between N_2^+ and O^- is successful, the value of α_1 becomes 2×10^{-11} cm³/sec. The value of the ratio $n(t)/n(o)$ depends on the initial density $n(o)$, being smaller the greater its value. In a vertical column of the ionised region with a parabolic gradient of ion density the decay in the total number of electrons will therefore be far less than the decay in the density in the region of maximum ionisation. For instance, if the maximum concentration be 5×10^5 per c.c., its value will be reduced to about $1/3.2$ for a six-hour decay. On the otherhand, in the region in which the concentration is 10^5 per c.c., the value in the same length of time will be reduced only to $1/1.4$. It is therefore clear that the intensity of the night sky emission as controlled by the total number of ions present in the layer, will be far less variable than the ion density in the region of maximum ionisation as obtained by radio measurements.

We can make a quantitative comparison of intensity as expected from Mitra's hypothesis with the decrease of electron density in the region of maximum ionisation. At a height h above the region of maximum ionisation, the electron density will, after a time t , be given by,

$$n(h, t) = \frac{n(h, o)}{1 + 10 \alpha_1 n(h, o)t}$$

If we assume that the variation of electron density with height follows a parabolic law⁴ then,

$$n(h, o) = n(o, o) (1 - h^2/4H^2),$$

where H is the scale height which according to radio measurement is about 50 km. in Region-F. We then have,

$$n(h, t) = \frac{n(o, o) (1 - h^2/4H^2)}{1 + 10 \alpha_1 n(o, o) (1 - h^2/4H^2)t}$$

According to Mitra's hypothesis, the rate at which oxygen atoms and nitrogen molecules arrive in the excited states (¹S for O and B³π for N₂) is given by,

$$\alpha_1 n^+ n^-$$

where,

n^+ = concentration of N_2^+ ion in Region-F at night,

n^- = " " " " " " " "

In the condition of equilibrium between attachment of electrons to neutral oxygen atoms and detachment of same from negative ions so formed, the concentration of O^- in Region-F at night is 10 times that of electron density.³ Therefore, if the ionised region be considered as electrically neutral as a whole, the positive ion density is 11 times that of electron density. The positive ions in Region-F are N_2^+ and O^+ , of which N_2^+ ion density may be taken as one order less than that of O^+ . The above expression thus reduces to

$$10 \alpha_1 n^2.$$

The number of reactions in a column of unit cross-section of the atmosphere after time t is therefore equal to

$$10 \alpha_1 \int_{h=-2H}^{h=2H} n^2(h, t) dh$$

$$= 10 \alpha_1 n^2(o, o) \int_{h=-2H}^{h=2H} \frac{(1 - h^2/4H^2)^2}{\{1 + 10 \alpha_1 n(o, o) (1 - h^2/4H^2)t\}^2} dh$$

Putting $h=2Hx$ and $a=10 \alpha_1 n(o, o)t$, this becomes,

$$2n(o, o) aH \int_{x=-1}^{x=1} \frac{(1-x^2)^2}{\{1+a(1-x^2)\}^2} dx$$

This, on evaluation reduces to,

$$\frac{2n(o, o) H}{a(a+1)} \left[(2a+3) - \frac{4a+3}{\sqrt{a(a+1)}} \log(\sqrt{a+1} + \sqrt{a}) \right] \quad (A)$$

If the electron density in the region of maximum concentration is taken initially as 5×10^5 per c.c., then the total number of reactions taking place in a column of 1 sq. cm. cross-section per second is 2.1×10^8 after a period of 6 hours. The corresponding initial number is equal to

$$10 \alpha_1 \int_{h=-2H}^{h=2H} n^2(h, o) dh$$

$$= 10 \alpha_1 n^2(o, o) \int_{h=-2H}^{h=2H} (1 - h^2/4H^2)^2 dh$$

$$= \frac{54}{3} \alpha_1 n^2(o, o) H$$

$$= 5.3 \times 10^8$$

The intensity is thus reduced to $1/2.5$ of its original value. The value of the fraction is, however, too small. This is because it has been assumed that the electron density follows a parabolic law throughout the entire thickness of the layer. This is not

correct. It is only near the region of maximum density that the parabolic law holds with 5 per cent. accuracy within a thickness $2H$. Above height H , the electron density falls much less rapidly. If this is taken into account the intensity will not decrease to such a small fraction.

It should be mentioned that there are abnormal nights on which the intensity in the evening is much greater than that on average nights.² On such nights the intensity falls by a large fraction of its evening value. Unfortunately ionospheric data corresponding to these nights are not available. If, however, we make the very plausible assumption that on such nights the electron density is also abnormally high, then according to equation (A), the total number of electrons will also be reduced by a much larger fraction and the intensity of emission will also decrease by a large amount.

It should further be mentioned that on certain nights the intensity after decreasing to a minimum towards midnight rises again.² We are not yet in

a position to offer any explanation of this peculiar type of variation.

I have much pleasure in thanking the Adair, Dutt Research Fund of the Indian Science News Association for granting me a scholarship which enabled me to carry out this work.

I also thank Prof. S. K. Mitra for suggesting the problem to me and for helpful discussions.

Wireless Laboratory,
University College of Science,
92, Upper Circular Road,
Calcutta, 7-9-1943.

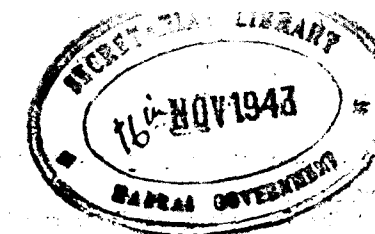
S. N. GHOSH.

¹ Mitra, *SCIENCE AND CULTURE*, 9, 46, 1943.

² Elvey, *Astr. Phys. J.*, 97, 65, 1943.

³ Bates, Buckingham, Massey and Unwin, *Proc. Roy. Soc. A*, 170, 322, 1939.

⁴ Appleton, Transactions of the Washington Meeting (1939) of the Int. Union of Geodesy and Geophysics, Bull. No. 11, p. 516.



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BASIC PRINCIPLES OF ORGANISATION OF SCIENTIFIC RESEARCH*

THE movement for organisation of scientific research in the interests of the people has not a long history behind it. If we wish to have a clear grasp of the basic principles of organisation, which must be followed in order that the movement in this country may lead to success, we must not forget the elements in human character which are responsible for the growth of science. It need hardly be told that growth of scientific knowledge since medieval times has been mostly due to private enterprise, and the greatest contributions have been almost exclusively due to the efforts of persons of outstanding ability actuated by a spirit of enquiry, enterprise and exploration. But this is as much true of modern as of earlier times. If we take a stock of the fundamental discoveries in science for the last 50 years, we can hardly dissociate personality from any grand achievement. And it seems to be a fundamental axiom that if progress in science, which is the basis of all technical advancement, is to be maintained, the personal element has to be fostered, and given the fullest scope for development.

It appears to be otherwise when we turn to the steps by which great discoveries in pure science have been translated to industry. It is well-known that almost all the discoveries in the physical and chemical sciences which have given birth to the great industries of steam engine transport, power, fuel, synthetic chemicals, and metals, telegraphy, telephony, radio, automotive engineering—have their roots in researches carried out almost exclusively by persons actuated by the spirit of search after Truth

and with no motive for profit, but the methods of big business which translated these to industry appeared almost to run diametrically opposed to the principles of advancement of science. Here success appeared to depend on finance, routine, organisation, secretiveness, and suppression of personality. The great basic discoveries in the medical and biological sciences have followed the same course, though their utilisation by Big Business, has followed somewhat more tardily.

It was first the German industrialists who sensed the advantage of employing scientific men for inventing new processes and improving older ones. The stories of synthetic indigo, and synthetic ammonia, both the result of happy union of scientists and industrialists is so well-known that they need no repetition.

The German State was not behind their industrialists. It is true that whenever any new invention or discovery has held out prospects of increase of political and industrial power, States and potentates have not hesitated to take advantage of them. The best known examples are those of the French Governments during the French Revolution, and the various scientific expeditions sent out by the British, French and Dutch Governments to the south and the Pacific Oceans during the eighteenth and nineteenth centuries. But these lessons were apparently forgotten by the end of the nineteenth century, probably owing to the dazzling growth of new industries by private enterprise. It was Germany which first saw the advantage of organising scientific research in the interest of industry and national work and the movement found a concrete expression in the organisations known as the Kaiser Wilhelm Institutes. The object of the organisation was described by Dr Glum,

* Address of Prof. M. N. Saha delivered at the Symposium on Post-war Organisation of Scientific Research in India held under the auspices of the National Institute of Sciences of India, Calcutta, on September 27 and 28, 1943.

the general director of the Society in the following words:

"The society's work is to supplement those done by universities, polytechnics, academies, libraries and museums and not to compete with those.

"This is sought to be achieved firstly by undertaking those studies which cannot be done in the above mentioned institutions, secondly, by providing research institutes for those gifted investigators whose time is too much taken up by the routine work of teaching and administration in universities and high schools, and thirdly, by providing places for those young academicians of promise who have taken their doctorates from the universities, but have not yet got any situation where they can develop their natural gifts and carry on further research work in their own lines.

"In order that these ideals may be fulfilled it is necessary that the Society should keep an intelligent watch on the newer currents in scientific investigations and try to further its ideals by creating facilities for new lines of investigation and getting the right man for them. The object has thus been expressed by the President, Adolf V. Harnack, 'The K. W. Society shall not first build an institute for research and then seek out the suitable man, but shall first pick up an outstanding man, and then build an institute for him.' Experience has often shown that it is rather useful not only to call an outstanding man to the headship of an institution, but also to a group of associated institutions at one place and under a loose federation. This should be the case for a very big science like biology, which can be satisfactorily advanced only if the various associated sub-groups work in co-operation for a long time. Therefore it is necessary to unite in one institute experts in different lines who are otherwise quite independent of one another. The directors of these institutes are, therefore, chosen from the ranks of experienced investigators who have retired or given up their teaching work in the universities, high schools, and other places, and the workers are to be chosen from such graduate doctors who have shown exceptional ability in a certain line of work. It has very often happened that after working for some time in the K. W. Institutes, they have qualified for professorships in the universities. In this way, the K. W. Institutes have served a very useful purpose in the educational and scientific life of Modern Germany.

"The group of K. W. Institutes, so far in operation, include two types: one for carrying on pure researches on basic sciences like chemistry, physics, zoology, botany, and medicine; the other group for applying the knowledge of theoretical sciences and to industry, and thereby making them useful to the economic life of the nation."

The State organisation of scientific research in Germany has undergone wide expansions since the last War, and during the Nazi regime but there is no reason to suppose, as it is often given out, that the basic principles enunciated above have undergone any wide variation. Pure research is as much encouraged as research in applied subjects, e.g., one of the greatest discoveries in Physics, viz., that of Uranium Fission was made in the Kaiser Wilhelm Institute for Physics in Berlin-Dahlem in 1939.

THE WORLD WAR OF 1914.

The World War of 1914 was a great eye-opener, and all other great States of the world as well as the big industrial concerns woke up to the necessity of

large-scale organisation of scientific research in the interest of industries, and national welfare, as pointed out by our President.* These organisations, viz., the Department of Scientific and Industrial Research in the U. K., and the National Research Councils in the U. S. A. and other countries have now been working for over a quarter of a century, and it is desirable to make a critical examination of their fundamental policies, organisation and experience. In India, though the movement started during the last War, it was at first confined to agriculture and medicine. The Indian Research Fund Association was started in 1911 and the Imperial Council of Agricultural Research in 1920. The larger question of general organisation of all scientific researches in the interest of the people has been engaging the attention of Indian scientists since 1925, but the public and the Government have been alive to it only during the last three or four years and that also in a spirit of hesitancy and indecision. I consider that our efforts are still in the experimental stage, and unless the new born baby is properly cared for, it may become a permanent invalid.

LORD RUTHERFORD ON THE ORGANISATION OF SCIENTIFIC AND INDUSTRIAL RESEARCH IN INDIA

Fortunately for myself, I found most of these basic principles clearly enunciated in the presidential address which the late Lord Rutherford wrote for the Silver Jubilee Session of the Indian Science Congress and probably for the consumption of the rulers of India. I need hardly remind you that Rutherford was not only one of the greatest experimental scientists of all times, but he acted as Chairman of the Advisory Committee of the Department of Scientific and Industrial Research of the United Kingdom for eight years from 1920-1938. Coming from a great man and a great scientist and one who had devoted a lot of his time to actual direction of the work of organisation of scientific research in the United Kingdom, the observations are entitled to the most serious consideration by all who have to deal with such work. A good deal of his address to the Silver Jubilee Session was devoted to the question of organisation of scientific research in India on the lines of the Department of Scientific and Industrial Research, the necessity for which he foresaw clearly, as a result of his talks with some Indian scientists. The first necessity in this connection was the question of scientific personnel, their recruitment and training and ultimate absorption. To quote his views in his own words:

"This is in a sense a scientific age where there is an ever-increasing recognition throughout the world of the importance of science to national development. A number

* See the leading article in the last issue entitled 'Post-War Organisation of Scientific Research in India' by Sir Jnan Chandra Ghosh.

of great nations are now expending large sums in financing scientific and industrial research with a view to using their natural resources to the best advantage. Much attention is also paid to the improvement of industrial processes and also to conducting researches in pure science which it is hoped may ultimately lead to the rise of new industries.

"It is natural to look to the universities and technical institutions for the selection and training of the scientific men required for this development. In India, as in many other countries, there is likely to be a greater demand in the near future for well trained scientific man. With the growth of responsible government in India, it is to be anticipated that the staff required for the scientific services in India and for industrial research will more and more be drawn from students trained in the Indian universities. It is thus imperative that the universities should be in a position not only to give a sound theoretical and practical instruction in the various branches of science but, what is more difficult, to select from the main body of scientific students those who are to be trained in the methods of research. It is from this relatively small group that we may expect to obtain the future leaders of research both for the universities and for general research organisation. This is a case where quality is more important than quantity, for experience has shown that the progress of science depends in no small degree on the emergence of men of outstanding originality of mind who are endowed with a natural capacity for scientific investigation and for stimulating and directing the work of others along fruitful lines. Leaders of this type are rare but essential for the success of any research organisation. With inefficient leadership, it is as fatally easy to waste money in research as in other branches of human activity."

TRAINING AND MAINTENANCE OF THE RESEARCH WORKER

"The selection of such potential investigators and leaders is not an easy task, for success in the examinations in science is no certain criterion that the student is fitted for a research career. A preliminary training in research methods for a year or two is required to select those who possess the requisite qualities of originality and aptitude for investigation. A system of grants-in-aid of scholarships to approved students may be required for such post-graduate training. In Great Britain the financial help given by the universities and other educational institutions for training in research is in many cases supplemented by maintenance grants to promising students, awarded by the Department of Scientific and Industrial Research. This system has proved of much value both in developing the research activities of the universities and in providing a supply of competent men both for research in pure science and in industry."

You will admit that the whole of this quotation is an eloquent plea for the training of a large scientific personnel in the universities in the methods of pure science under persons of outstanding originality by a large-scale system of grants-in-aid to approved students by the State with a view to their absorption later in industries and national scientific organisations. This maxim has been accepted as a basic one by the D. S. I. R.

RESEARCH IN PURE SCIENCE

The question of encouragement of pure research has unfortunately taken a controversial turn in our

Indian organisations, owing to the unfortunate large influx in our most important research bodies of industrialists, and officials, the large majority of whom are unfortunately ignorant of science and incapable of appreciating its spirit. Let us again examine the British experience. It appears that in the earlier years of the inception of the D. S. I. R., the claims of pure research appear to have been in some danger of being swamped by those of applied research. The danger was so great that the Royal Society was compelled to send a deputation to the Lord President of the Council, the Earl of Balfour, under the leadership of the great Physicist Sir J. J. Thomson, then President of the Royal Society who pleaded for the claims of pure research in the following memorable words:

"Pure science is the seed of applied science and to neglect pure science in a thing of this kind would be like spending a very large amount on manuring and ploughing the land, and then to omit the sowing of any kind."

Fortunately there was a Balfour at the head of affairs, and the Cabinet had no difficulty in adopting the principle whole-heartedly. The Lord President in the first report of the D. S. I. R. says:

"We accept the analogy and we trust that the absence of extended reference to pure science in this report will not be taken as indicating our lack of appreciation of its importance."

According to a writer in SCIENCE AND CULTURE (Vol. VIII, No. 10, 1943):

"If the records of investigations financed by the D. S. I. R. of England during the last twenty-five years are examined, it will be found that nearly three-fourths of the investigations are on 'Pure Science'. This is of course exclusive of investigations published by such specialized institutions under the D. S. I. R. as the National Physical Laboratory, the Fuel Research Laboratories, the Food Investigation Board, Central Glass Research Institute, most of whose publications are naturally of a practical nature, though even they have very frequently carried out 'Pure Science Research.'"

"The D. S. I. R. has financed schemes on various branches of atomic physics (e.g., Spectroscopy, X-rays), nuclear physics, investigations of the ionosphere, vitamin studies, photo-chemistry, organic synthesis and even sometimes purely mathematical researches."

PLANNING OF PROGRAMMES OF RESEARCH

Let us again quote passages from Lord Rutherford's Address about the organisation, and planning of research:

"In Great Britain, the responsibility for planning the programmes of research, even when the cost is borne directly by the Government, rests with research councils or committees who are not themselves State servants but distinguished representatives of pure science and industry. It is to be hoped that if any comparable organization is developed in India, there will be a proper representation of scientific men from the universities directly concerned. It is of the highest importance that the detailed planning of research should be left entirely in the hands of those who

have the requisite specialized knowledge of the problems which require attack. In the British organizations there is no political atmosphere but of course the responsibility for allocating the necessary funds ultimately rests with the Government."

Lord Rutherford devoted a good deal of his address to the working of the National Research Institutes—e.g., the laboratories under the Fuel Research Board, Food Investigation Board, the National Physical Laboratory, the Radio Research Board. I am not aware whether the sponsors of these schemes had ever to answer the question which is often asked of us, "Will these researches help us in making money?" or whether they had to waste half an hour in explaining to industrialists, legislators, and officials who are found in large numbers in many research bodies the difference between biochemistry and biology and such other elementary things as has been unfortunately frequently our experience.

Some of these laboratories dated before the first World War, but most had sprung during the War or just after the War. They were established with a view to serve national as against private industrial interests for which a separate set of bodies known as Research Associations were brought into existence. Though the purposes for which these national laboratories were ushered into existence were specific, the planning of research was left entirely in the hands of expert scientists as mentioned by Lord Rutherford, and they were free to carry out any researches on pure sciences if they thought that these would be helpful to their subject. As a matter of fact, most of the methods evolved, say in a subject like food technology, like the refrigerated gas storage of preserving perishable fruit, vegetables, and meat, the large-scale use of vitamins in national foods had their roots in pure researches carried out under the auspices of the Food Investigation Board by professors in their laboratories. It is probably no exaggeration to say that but for these researches, and the methods evolved out of them, and prompt measures taken by the State to implement them, England would have had to beg for peace, with the bread-basket hanging before her like a Tantalus's cup, as Paul Banse had wishfully expected.

Let me place before you the work of another of these national research boards, viz., the Radio Research Board which had financed liberally the researches of Appleton on the Ionosphere, that of Watson-Watt on reflections of wireless waves from the lower regions, and other professors whose schemes were on pure research.

But it is these experiments on pure research, particularly those of Watson-Watt on the low level reflections of e.m. waves which led to the invention of the Radio-locator, and according to the testimony

of Lord Beaverbrook, the then Air-Minister, this invention has helped substantially in defeating the air-onslaught of the Luftwaffe on England during the terrible days of 1940-1941.

THE NATIONAL RESEARCH COUNCILS

You will probably observe that in spite of the wide difference in the conditions between Germany and England, the basic principles of organisation of scientific research evolved in the two countries at wide intervals of time have been identical. Our President has referred to the organisations known as the National Research Councils in the U. S. A., Canada, and Japan. Of these bodies, the N. R. C. for the U. S. A. appears to have been the model for the remaining bodies though there are important differences. It will suffice therefore to examine the N. R. C. of U. S. A. It must be remembered, however, that conditions in the U. S. A. are widely different from those in any European country. The U. S. A. is pre-eminently the country of private enterprise, of enormous surplus wealth in the hands of private citizens, a large part of which goes to private benefactions. Scientific organisations have grown there largely out of private benefactions of which the Rockefeller and Carnegie foundations, the Research Laboratories of huge industrial trusts, are the most well-known examples. The State was mostly content to watch the growth with benevolent indifference or forgetfulness. But the attitude had to be abandoned, as a result of the impact of the World War of 1914, and the present War, and now the State is taking as much interest in the control of organisations of scientific research as England or Germany, though of course without much interference with private bodies. It will be interesting to note how in spite of wide variations in conditions the same basic principles for organisation of scientific research have been evolved as in England and Germany. Let me give a brief account.

In the U. S. A., the National Academy of Sciences, under its congressional charter is the supreme body of scientists recognised by the State.

The Charter of the National Academy of Sciences, passed by Congress and approved by President Lincoln in 1863, provides that

"* * * the Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States."

The National Academy of Sciences has a maximum membership of 450, but the actual maximum has never exceeded 350. Most of the

members are senior scientists and the seat of the Academy is in Washington D.C. The use of the Academy by the State, in the words of President Compton was "Spotty" up to the outbreak of the first World War.

The National Research Council was created during the first World War (1916) by the National Academy of Sciences at the request of President Wilson, as the active agent of the Academy to assist the Government in organising the scientific resources of the country. After the war, it was perpetuated under the following terms:

"1. In general, they stimulate research in the mathematical, physical and biological sciences, and in the application of these sciences to engineering, agriculture, medicine and other useful arts, with the object of increasing knowledge, of strengthening the national defence, and of contributing in other ways to the public welfare.

2. To survey the larger possibilities of science, to formulate comprehensive projects of research, and to develop effective means of utilizing the scientific and technical resources of the country for dealing with these projects.

3. To promote co-operation in research, at home and abroad, in order to secure concentration of effort, minimize duplication, and stimulate progress; but in all co-operative undertakings to give encouragement to individual initiative, as fundamentally important to the advancement of science.

4. To serve as a means of bringing American and foreign investigators into active co-operation with the scientific and technical services of the War and Navy Departments and with those of the civil branches of the Government.

5. To direct the attention of scientific and technical investigators to the present importance of military and industrial problems in connection with the war, and to aid in the solution of these problems by organizing specific researches.

6. To gather and collate scientific and technical information, at home and abroad, in co-operation with governmental and other agencies, and to render such information available to duly accredited persons.

Effective prosecution of the Council's work requires the cordial collaboration of the scientific and technical branches of the Government, both military and civil. To this end representatives of the Government, upon the nomination of the National Academy of Sciences, will be designated by the President as members of the Council, as heretofore, and the heads of the departments immediately concerned will continue to co-operate in every way that may be required.

(Signed) WOODROW WILSON."

The White House,
11th May, 1918.

The National Research Council is a co-operative organization of the scientific men of America. Its members include, however, not only scientific and technical men but also business men interested in engineering and industry, and lately Government servants have also been included. The total per-

sonnel is 250, and the members are appointed for three years. But if the personnel of the Committees appointed by the N. R. C. be included the number is well over thousand. But the supreme direction is in the hands of the senior scientists constituting the National Academy of Sciences. It will probably shock Delhi to hear how Government members are nominated:

"The representatives of the Government shall be nominated by the president of the National Academy of Sciences, after conference with the secretaries of the departments concerned, and the names of those nominated shall be presented to the President of the United States for designation by him for service with the National Research Council. Each Government representative shall serve during the pleasure of the President of the United States, not to exceed a term of 3 years, and a vacancy from any cause shall be filled for the remainder of the term in the same manner as in the case of the original designation."

During the year 1932-33 the National Research Council was reorganized for the purpose of making its structure simpler and more compact than its former organization had been, but with the retention of the two major features of its earlier plan of organization. These are: (1) the democratic character of the Council, representative of the great body of scientific men of the United States through affiliation with their national scientific societies; and (2) the maintenance of Chairman of the several divisions of the Council charged with the scrutiny of their respective fields with a view to the timely encouragement of research in these fields.

Under its present organization the work of administration of the Research Council is carried on by a small group of officers and an Executive Board, with an Administrative Committee which acts for the Board between its annual meetings. The Council itself is composed of nine major divisions arranged in two groups. One group comprises seven divisions of science and technology representing respectively, physics, mathematics, and astronomy; engineering and industrial research; chemistry and chemical technology; geology and geography; the medical sciences; biology and agriculture; and anthropology and psychology. The other group comprises two divisions of general relations, representing foreign relations and educational relations. With these divisions are associated various technical committees, appointed to take charge of projects undertaken by the Council. There are certain other committees, administrative and technical, which affiliate directly with the Executive Board of the Council. The Library of the Council, a limited collection of directories and source books in science, is available for reference services in so far as its facilities extend.

But neither the National Academy of Sciences nor the National Research Council receive grants from the State, but are advisory bodies. But the Global

War has changed all that. We quote from an article by H. Grundfest in *Science and Society*:

"All forms of scientific and technological research have expanded greatly since the first World War, particularly in the government and industrial laboratories. Much of the research being done in the present war is being carried on in these laboratories and directly by the army and navy. To co-ordinate all this and to utilize the facilities of the university laboratories there has now been created a new organization which works through the National Academy and National Research Council, but which has money to initiate research and to promote that going on. The top structure is the Office of Scientific Research and Development (O. S. R. D.); under it are the National Defence Research Committee (N. D. R. C.) supervising physical and chemical research and the Committee on Medical Research (C. M. R.). About 1,200 scientists are serving on some 100 advisory committees of these bodies. O. S. R. D. has placed over 1,000 contracts with university and industrial laboratories, and has spent about 40 million dollars. In 1943 alone its budget will be 73 million dollars."

SUMMARY OF THE BASIC PRINCIPLES OF ORGANISATION OF SCIENTIFIC RESEARCH

Let me now therefore summarise the basic principles of organisation of scientific research which have been evolved and are followed in all advanced countries of the world. Science is the same all over the world and the really efficient methods of promoting science, of harnessing science to the needs of national work, of industry and general economy, cannot be a function of the latitude and longitude of the place, or a function of the psychological make-up of the individuals who happen to possess the requisite power. The basic principles must be the same, though they may require some modifications in actual application.

SCIENCE AND TRAINING IN CITIZENSHIP*

IN 1916, the late Maharaja of revered memory, inaugurated the University of Mysore. The world was then, as now, in the grips of a totalitarian war. Its rumblings could be heard from not far-off Mesopotamia. Yet that sagacious ruler and his wise advisers decided that educational progress in the State should not be retarded on the plea that a war was on. In countries where every able-bodied under-graduate had been drafted to national service, a policy of educational stagnation in war time was inevitable. But they felt that it was un-

* Adapted from the Convocation Address delivered by Sir Jnan Chandra Ghosh at the Mysore University before the graduates of the year 1943.

(1) The planning of programmes of research, even when the cost is borne by the Government, should be in the hands of research committees or councils composed of members who may not be State servants, but the majority should be distinguished representatives of pure and applied science, likely to be of use in the subject under investigation and a smaller number of scientific men, connected with corresponding industries.

(2) A very large scientific personnel is required for national scientific work, and for manning modern industries; for this purpose, a large-scale system of grants-in-aid should be given by the State to approved students, to be trained in the methods of pure science in the universities and research institutes under persons of outstanding originality.

(3) There should be no restrictions whatsoever on Researches in Pure Science if the research committees consider them desirable for the fulfilment of their objective; on the other hand, it is in the interests of the country to develop schools of pure research under persons who have made outstanding contributions to Science.

(4) The administration of all organised research institutions should be in the hands of scientists—as dissociation of power from responsibility, as is unfortunately followed in this country, leads to frustration and failure.

(5) Co-operation of all existing scientific institutions in India:—e.g., universities, academies and scientific societies, technical institutions, industrial research laboratories should be secured in all schemes of organisation of scientific research in this country.

wise to apply the same policy to an Indian State where conditions were so different, where the leeway to be made up in the field of education was so obvious, where ignorance might be said, without exaggeration, to be colossal in magnitude. And if one got down to actual figures it would not take any time to discover that such expenditure on higher education was a mere drop in the ocean compared with that involved in the defence of the country.

The University is very young yet; its Silver Jubilee was celebrated in this Hall only two years ago; that occasion may be considered as its coming of age. It has sent out to the the world in increas-

ing numbers educated young men who have done well in life, and have advanced by their devoted labours the prosperity of the State. Some of them have achieved great distinction in public life and in high positions of trust under the ruler. It has given a great incentive to higher education among women—as I can personally testify. Much has been done to improve the Kannada language; and the University is now well recognised as a centre of learning and of research. It now budgets for an annual expenditure of 15 lakhs of rupees and controls higher education in all its aspects through its Faculties of Arts, Science, Law, Medicine, Engineering and its several Diploma Courses. It has shown that much can be achieved with comparatively little resources.

If one takes, however, a wider view of men and things in India to-day, one becomes impatient at the slow progress that we are making. In many countries the human race has made more progress in the last 125 years after the Napoleonic wars than in the ten thousand years before it; and this has been primarily due to the impact of science on the economic life and the mental outlook of the ordinary men and women. Anatole France used to say that civilisation is based on the patience of the poor. But thanks to science, it can now be broad-based on the average man's contentment. Human slavery is now absolutely unnecessary for civilisation. A machine can easily take the place of the slave and human muscles need no longer bear the drudgery that machines can bear. * "The total output of work per capita in England per year is roughly equivalent to that which may be done by 1800 units of electric energy (kilowatt-hour). Of this work, only 5 per cent is done by man and animal power and the rest by natural power—gas, electricity and steam. Now, each unit of electric energy represents roughly the work of two men per day. We may, therefore, say that every inhabitant of England has, as it were, 8 mechanical slaves working for him. What do these slaves do? They produce for their master commodities either for his own use or for exchange with commodities from abroad and also help in their distribution. Now imagine for a moment, that these mechanical slaves for some reason struck work and the inhabitants of England are compelled to do all the work themselves by manual labour. The output of work will at once fall down to one-twentieth of its original value, and the outturn of commodities also in the same proportion. You can well imagine what disaster this will lead to. Now take the case of India. Compared with England's figure of 1800 units, India's is only

* Extract from a speech by Prof. S. K. Mitra at the Calcutta Rotary Club.

120 units; and of this 70 per cent is done by man and animal power and only 30 per cent by natural power. India has only one mechanical slave for every 6 persons, instead of 8 for each person in England." This is primarily the reason why England is rich and India is poor.

There is no reason why the people of every country should not now enjoy a fuller and more satisfying life, provided that it possesses sufficient natural resources and the people have the genius to explore and exploit these resources. The Red Indians who lived in North America barely three centuries ago, never had the idea that their problems of food and living could be satisfactorily solved, except by continuous wars of extermination between the tribes for the possession of small fields of maize and corn. And to-day the same country maintains 160 million human beings, with food in such excess that to keep up price-level maize has sometimes to be burnt and milk thrown into streams, with standards of living so high that each family of three has a motor car of its own for going out on business or pleasure trips, and with sanitary and prophylactic measures so perfect that the average expectation of life is more than 55 years. All this has been due to the genius of the people in harnessing the knowledge that science has placed at their disposal.

For us in India, this example should be an object lesson. Science has only touched the fringe of our economic life and has scarcely influenced the mental outlook of more than 0.01 per cent of the population. That outlook, I may bring out, in bold belief from some facts of my personal experience. Just after the last war, I happened to be talking in the Union of the University College, London, about the poverty of the Indian masses—as most Indian students often do; I was asked this question by an enterprising member of the audience, "When the monsoon fails, do not the fodder crops fail along with the food crops?" I said "Yes".—"Do not then the cattle die along with men?" I again said "Yes".—"Why do not the men live by taking the cattle?" That evening I tried long to convince the bright youths of the Union that in India maintenance of cattle was not judged from the canons of economics, that cattle was held in high reverence, that with the Hindus it was an article of faith that beef should not be taken, that men and women would rather die than commit this sin. I knew from the incredulous smile on their lips that I was not being taken seriously.

A few weeks later, the British Government released for publication the authentic account of the voyage of a convoy in 1916 to Russia through the northern route in summer when the Arctic ceases

to be ice-bound. Some of the ships were manned by seamen from India—mostly Muslims from Eastern Bengal. The Ramzan happened to fall in summer that year. The sun did not set completely in the polar skies and the Muslim seamen would not touch food in Ramzan month if the sun could be seen. There was no recrimination as to who was to blame; somebody must have bungled, but theirs not to reason why; some died with mute resignation and calm suffering; others reached Russian ports in a collapsing state; but they were all loyal both to their King and to their Faith. I hastened to read out this narrative in the Union and concluded with the following line from their immortal poet "Upon such a sacrifice, Cordelia, the gods themselves throw incense"; and the incredulous smile on the mouth before gave place to sombre meditation.

I recall another incident when I was travelling in Holland. The Dutch are great linguists, and the last war had made them rich beyond the dreams of avarice. One evening a University teacher asked me the question—"where did I come from"? I said "From India". "Which India, our India?". I was taken aback by this question; in the University of London no British student or teacher after the last war, talked of "Our India". But the lesser powers of Western Europe took an unconscious pride in calling their colonial possessions not by their geographical names but as their Indias. I put the cross question if he had read the 'Outline of History' by H. G. Wells. The Dutchman said, "Yes".—"I come from that India, which more than two thousand years ago was the home of Emperor Asoka and his people". I might have scored off a debating point, but there were heart searchings that night.

Pride for the past is justified, if it gives an incentive for bettering the present without delay. But how few of us think of our past glories in that spirit! Not so, at least some of the legislators of the Indian Assembly! The Behar Earthquake was responsible for the destruction beyond repairs of one of the finest buildings in that Province—the Imperial Institute of Agricultural Research at Pusa; the experimental research farm was, however, in excellent condition; the research plots had been carefully laid out, and for thirty years, experiments on a prearranged plan of manurial treatment, crop rotation, etc., had been pursued there. The Government of India thought that the Institute after the earthquake be better transferred to New Delhi; but many men of science felt that to discontinue the experiments which have been pursued for thirty years would be a kind of vandalism. Some of the legislators, whom I approached, surprisingly took the same view as Government; not because they

believed that such a transference was advantageous from administrative point of view, but because a period of thirty years was to them of little significance. "What does a period of thirty years matter in the life of a nation which traces its civilisation and culture from at least two millenniums B.C.?" I threw up my case in despair!

I cannot help sharing with you to-day another experience—that of a visit to Calcutta a fortnight ago. On the hundred streets and foot-paths of the city of palaces, a vast drama moves before our eyes; a drama played by men and women of every condition of life—the newly rich, the well-fed worker, the hungry and the dying poor;—generous citizens and noble volunteers working hard in hundreds of free kitchens which receive from Governmental stores on payment, 4-oz of cereals per day for each person fed;—and behind the curtain in the homes of the petty clerk, the ill-paid school master, and the impecunious lawyer, men, women and children half-starving, but too proud to come out in the open and beg for food;—a Government caught in this trap by lamentable short-sight and unable yet to discover a way out of this food famine in the midst of plentiful money. This is a grim tragedy; but to one who looks deeper, it portrays, as nothing else can, the character and culture of the Indian people. The *Statesman* of Calcutta thunders that it is a man-made famine, accuses a helpless administration of the murder of thousands of men, women and children, and demands that the famine be unmade immediately. The poor sufferers, if you talk to them, think otherwise. They take it that it is the wish of God that they should pass through this ordeal. There are, even on an optimistic estimate, 5 million starving persons in Bengal; but there has not yet been reported a single case of food riot, or an increase in theft cases. Naked men, except for a strip of loin-cloth, are walking on the streets of Calcutta; the women with no shelter but the trees in the parks, get drenched in monsoon rains, wear one-half of their *sarees* and expose the other half to the fugitive sun for drying. Yet there are thousands of shops in Calcutta where the windows display huge stocks of cloth for sale; and not one is pilfered. A young woman wearied of life takes shelter in a vacant garage, covers herself completely with a sheet of cloth and waits motionless for death; three days later she is discovered by a volunteer who takes her to the hospital; there she dies, blessing the volunteer, not for the food and the treatment which proved ineffectual, but for giving her some water from the Ganges at the last moment.

There is a tendency among philosophers to consider the world as a play-ground of God, and life as a game played by Him. This is particularly a

Hindu belief. In some parts of India even the diety is worshipped as "*Parihasa Kesava*"—the God of inscrutable ways who is holding up to ridicule all our actions and efforts. This mentality is responsible for the saying, "that life is a tragedy for those who feel and a comedy to those who think". It does not really matter what happens as I am also

"*Ajo Nityah Shashvatoyam Purano
Na Hanyate Hanyamane Shareere*"

eternal and ever lasting, who cannot be killed even though the body is destroyed! The common man of India is no philosopher in that sense. He is rather a living embodiment of the doctrine preached in another Upanishada, thousands of years ago—

"*Thakhtena Bhunjeethah Ma Gridhah
Kasyasvidhanam*"

cast off the desire to possess what belongs to another—enjoy your life by renunciation, by sacrifice even unto death. Therein lies the heroism of this common man of India—his real majesty!

Any State that now plans for the welfare of its citizens should begin with food—adequate food for all. First things first. Such a policy should be the spear-head of a movement for all-round prosperity. Thinking persons have viewed with alarm the increasing tendency in India to grow money crops like cotton, jute, groundnut, castor, linseed, etc., in place of food crops and depend on import of rice from abroad for feeding the population. The Nemesis has come. There is enough labour in rural areas which makes possible the cultivation of good soil as intensively as a kitchen garden; and soils of India except those under high floods in Bengal, respond quickly to manures. *It is a crime in the circumstances not to get the most that you can out of the soil.* In Japan, holdings are as fragmented as in India—a farm rarely exceeds 2½ acres. But the cultivated lands of Japan which do not exceed in area those of a major Indian Province, receive annually more than a million tons of ammonium sulphate and also an adequate quantity of phosphates. In the whole of India, we use barely one-tenth of this quantity of manure, and that mostly for favoured money crops; the inevitable result is our chronic malnutrition. This State has an enlightened water-conservation policy; not a drop is allowed to go to waste. May I suggest the adoption also of policy of subvention which will bring fertilisers in adequate quantities within the purchasing power of the cultivators? Such a subvention will bring a return, many times over in the shape of increased prosperity and better health. In England they have gone a step further—they have started giving subventions for food. On the 8th February, 1940, Sir John Simon reported that England was spending

eight million pounds a year for free milk in schools and about 65 million pounds a year for subsidies on foodstuffs which have kept down price levels within twenty per cent of prewar rates. By the end of 1942, England has even made considerable progress in the direction of communal feeding; subsidised school canteens, factory canteens, and British restaurants have sprung up almost everywhere. In Nazi Germany, the State provides every day for each citizen, during the war, food having an equivalent in calories between 2500 and 3200. The Bengal ration in the free kitchens provides only 800 calories which can keep a man alive for no more than a month. The British socialists are demanding, as the first measure of social security, that food shall not in future be sold but distributed according to rations. This would be the consummation of the old Hindu ideal of kingship so eloquently expressed by Kalidasa.

"*Prajanam Benoyadhanat Rakshnathvaranadapi
Sa Pita, pitarastasam Kevalam Janmahethava*"

For the maintenance, education and protection of the citizens the King is the real Father; their parents are mere progenitors.

The question will be asked—"Can we in India afford, for all, such security?" I come back to my old theme. The answer would be an unhesitating "yes", if modern knowledge of science and technology is allowed to play its full part in the affairs of men in India, and not merely, as I have said before, touch the outermost fringe of our life. More than a century ago, Raja Rammohan Roy pleaded for a synthesis of the cultures of the East and the West. Since then, the West has proceeded in its own way with accelerated speed and the East has remained practically stagnant. To-day it is idle to talk of such synthesis. Considered as an abstract proposition, our people have many virtues which are admirable; and I yield to none in my admiration of them; but they are of little value in the struggle for survival in this world. We have now come to the parting of ways. The war and the famine have created a universal yearning for a new order. We have to make a decision between a philosophy of life which leads to pathetic contentment and fatal complacency and a philosophy which makes human society a purely secular and rational organisation thriving on scientific knowledge and efficiency.

Nowhere has planned development met with greater success in India than in the model State of Mysore. As a member of the National Planning Committee, which is now defunct, I remember well how often in our deliberations we were heartened by the example of Mysore. Here the State has deve-

loped and is developing with great foresight its natural resources in power, water, minerals and forest products. Government is the owner of the transport system, the key industries and manages most of the large-scale industries; private interests have little chance of capturing the agencies of production and exploiting them for their benefit. The foundations have been truly laid; things of vital importance belong to no one in particular, but are there for the good of all; here the State and the People are one, even though in moments of passion they may say that they are not one. What is now wanted is the incentive of the masses to improve their lot. A heavy responsibility rests with those who have enjoyed the blessings of a liberal education. Among a people whose history goes back to many millenniums, in a society upon which the fetters of custom are so firmly bound, it is they who can overcome the inertia of centuries by enthusiasm, sustained efforts, effective leadership and ready self-sacrifice. The time has manifestly come for a great effort. It has become a matter of great urgency to run counter to long established customs and opinions. The mass of men in the State will have to be animated by the living hope that life from now will take an essentially new quality. Let us look Truth in the face; we have been, for too long a time, the living fossils of the world. Such an existence is better ended if not soon mended.

They say that Truth is the first casualty in a war. Science teaches that it is a crime to declare a moratorium on Truth even in times of war. It stands for detachment and suspended judgment; in a world swayed by emotions and passion, it shows what the weighing of evidence means. It is the sole guarantee against wholesale misleading by propaganda. The future of democracy is intimately bound up with the spread of scientific attitude. If democracy were to survive, to the eight points of President Roosevelt must be added a ninth—which is the elimination from the future world of all attempts at mass hypnotism by interested propaganda. The Germans are a very intelligent and able people. But look at the spell that Hitler has cast over them by the magic of his eloquent speeches broadcast almost every day and listened to with rapt attention in millions of German homes! For the safety of the world, it is necessary to strike at the root of this evil, and evolve a system of juvenile and adult education which aims at the widest possible diffusion of scientific outlook.

Every belligerent country in this Global War has now realised that trained and intelligent man power is the greatest of all assets, and that the foremost aim of all State economy is to bring down the wastage of human resources to a minimum. Science is

definite that ability above the average is very widely distributed in the community; that it would be of the greatest advantage to the country as a whole, if provision for satisfactory training, and scope for the play of such abilities are most widely spread. Let poverty be no bar to real talent receiving the highest education and the fullest opportunities for self-expression! Parring such cases, I would however envisage education for the average person primarily as a process of preparation for social service and not as a means of developing only the private aptitudes of the individual. I know I am treading on very controversial grounds. To-day the purpose and content of education should not be the spread of a culture which is mostly the relic of a dead past, when science for practical everyday purposes did not exist. The aim should be to find out what an average boy or girl is good for, what can he or she do that is useful and worth doing, and how can he or she be helped and fitted to be able to do so. I get tired of the perpetual distinction which is made in our country between cultural and technical subjects. There are no such things as "cultural subjects" and "non-cultural subjects". There are only cultural and uncultural ways of teaching all subjects. No one ought to be allowed to grow up to-day without a reasonable facility in writing and speaking the mother tongue, without some understanding of the principles of science, without being machine-minded so as to be capable of productive work in future, and without some working knowledge of the social and economic structure of the country in which one lives. We have to be practical people winning our battle against so called fate by mastering our environment, by bending our energies to the tasks of better living. Nothing else matters now; nothing else should divert our minds from this central purpose.

New adjustments have also become imperative in our higher education. It should primarily aim at the moving target of the future employment market, if it were not to miss its mark. According to Sir John Orr, *employment for the individual is a psychological necessity*. The output from each type of higher educational institution must be planned ahead in relation to anticipated requirements of highly trained personnel for industries, transport, agriculture, credit corporations, public health, State services and the so-called learned professions. We in India are familiar with the tragedy of thousands of educated men who fail to get employment suited to their training and then try to eke out a miserable living in the over-crowded law courts. Some have to spend half their lives in getting employment and the next half in repenting, as one victim told me some time ago. The conviction has now become

universal in England and also in U. S. A. that finding employment for the individual is a national obligation; and the Beveridge plan of social security is possible of fulfilment only on this basis.

Where do we stand? Orthodox economists and cautious administrators will ask the question "Where are the resources to implement these day dreams". I am no economist. Perhaps the Viceroy-designate is also not one; otherwise he would not have made these significant remarks at the Pilgrims Luncheon a month ago—"It has always seemed to me a curious fact that money is forthcoming in any quantity for the war, but that no nation has ever yet produced money on the same scale to fight the evils of peace—poverty, lack of education, un-

employment, ill-health. When we are prepared to spend, to this end, our money and our efforts as freely and with the same spirit as against Hitler we shall really be making progress. In the country to which I go, these evils have to be met on possibly in a greater scale than anywhere else".

The defeat of the Axis powers is in sight. But in this land will remain after the peace, the powerful Axis Combination of Poverty, Ignorance and Disease. We shall continue to require a Government with a war mentality to defeat this evil Combination and liquidate them within a fixed period of time. We hope and trust that this decision will be taken.

THE NEED OF THE STUDY OF THE PREHISTORIC ARCHAEOLOGY IN INDIA

B. K. CHATTERJEE

THE importance of pre-historic archaeology was long overlooked by the archaeologists in India. This is today most clearly evident from an almost complete lack of systematic excavations or explorations, except in a very few cases, on the part of the trained pre-historic archaeologists. Such excavations or explorations would have doubtless brought to light an wealth of valuable material and information relating to the ethnic type of people and also to the habits, culture and the daily life of the pre-historic man in India of which our present idea is extremely hazy and confused. An early recognition of the importance of such investigations would have made available probable solution of such controversial questions as the racial history of the pre-and proto-historic people of India.

STONE AGE

The discovery of Palaeolithic implements, however, dates back from as early as about the middle of the last century. Thus, as early as May 30, 1863, Bruce Foote, of the Geological Survey of India, discovered certain Palaeolithic stone implements at Pallavaram near Madras. This was followed by the discovery of many other Palaeolithic implements which were either picked up from the surface or unscientifically excavated from different parts of India. But the most interesting finds of the earlier periods are from the Narbada (Fig. 1a) and the Godavari (Fig. 1b) valleys. Most of the finds have however, hardly

any archaeological value owing to the unscientific nature of their extraction and to lack of sufficient evidence as to their specified antiquity. Hackett and Wynne were respectively responsible for the Narbada and the Godavari finds. These Palaeolithic implements were associated with the remains of certain extinct types of mammals, such as the Southern Elephant, proto-type of Elephant Ganesha and the hippopotamus. These finds throw some light on one of the interglacial periods of India and give some indication of the approximate period to which these stone implements belong. Typologically, most of the Palaeolithic finds of India bear some semblance with those from the Chello-Abbevillean, Acheulean and the Mousterian periods of Europe.

The majority of the Palaeolithic implements of India were discovered either from the high level gravels or older alluvium of the rivers or lakes, or sometimes in association with high level lateritic formation of the Coromandal coast. It appears that the Palaeolithic people of India preferred light-coloured quartzite for their implements, whereas the Neolithic people favoured dark trap rocks for certain implements. But so far as other implements, such as milling-stones, hammer-stones etc. were concerned they preferred various materials, e.g., granites, gneiss, hamaetite, quartzite and grits of the Dharwar and the Gondwana systems. Certain archaeologists had an idea that the Palaeolithic relics are localised to a great extent in Southern

India, but the recent discovery of the Soan valley, Rohri and Sukkur cultures (Fig. 1c), our recent discovery of the Sabarmati valley cultures, Col. Todd's Palaeolithic finds at Kandivli near Bombay and certain other finds of Northern India do not appear to encourage that view. It is to be noted that the Palaeolithic finds, so far discovered, do not contain any definite human remains, except the so-called Jalampur cranium discovered by Bruce Foote in Gujrat, which is itself of a questionable character.

The Yale-Cambridge India Expedition very recently surveyed the Pleistocene in Kashmir and North-Western India. They have got sufficient proof of human occupation of that area from the early

that Yale-Cambridge Expeditionists' chronology of the Soan valley cultures, which was published not long ago, was challenged immediately by eminent geologists like Pilgrim and others.

The Stone Age people have also left certain other evidences other than the implements in the form of cave-paintings and rock-carvings at Singanpur, Edakal Cave and Hoshangabad etc., which give some idea of their daily life and activities as well as their innate artistic capacity and aesthetic sense.

MEGALITHIC TOMBS

Megalithic tombs of a great variety of forms occur in the central, eastern and the southern

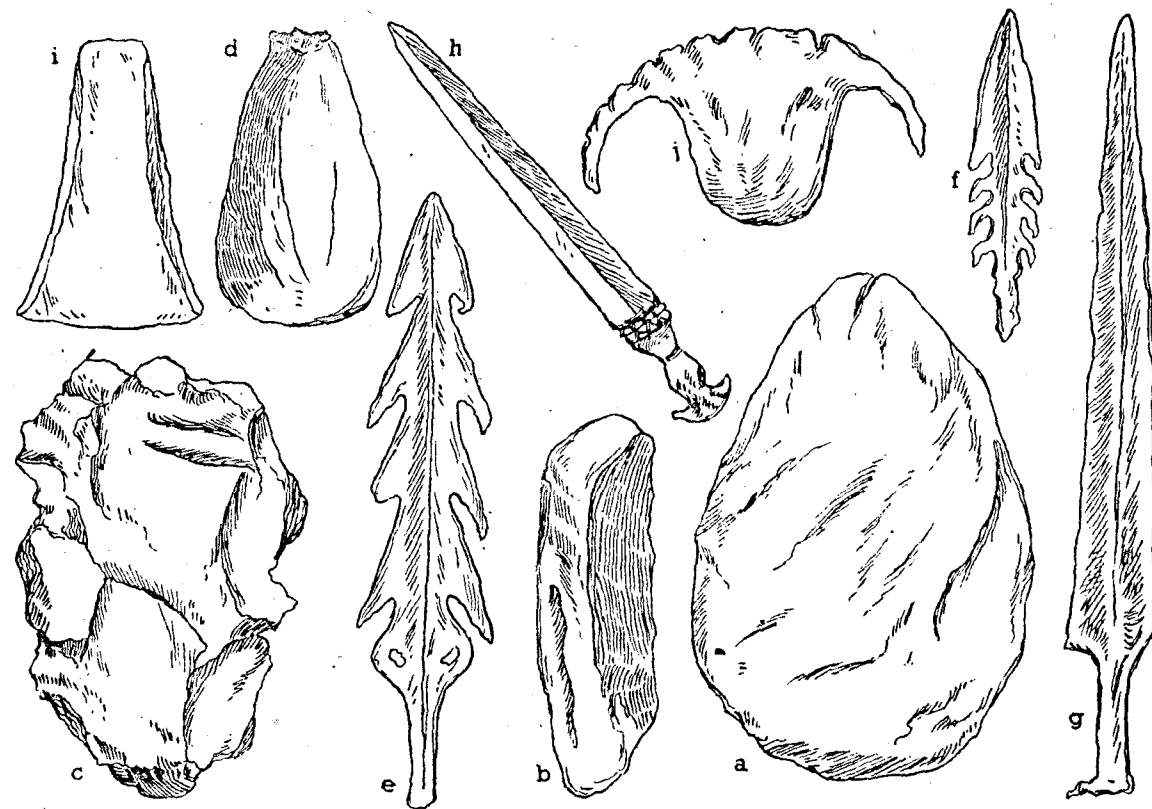


Fig. 1. Prehistoric Implements. a. Hand axe of Stone (from Narbada). b. Stone Flake (from Godavari). c. Stone hand axe (from Sukkar Soan Culture). d. Neolithic Celt (from Hyderabad State). e. Copper Harpoon (from Bithur). f. Copper barbed Spear-head (from U. P.). g. Copper Dagger (from Fatehgarh). h. Bronze Dagger (from Punjab). i. Copper Celt (from Gungeria). j. Silver Object (from Gungeria).

Palaeolithic period to the late Neolithic times (Fig. 1d) and are of opinion that in the Himalayan region there were four major glaciations with three inter-glacial periods. The Yale-Cambridge Expeditionists further claim to have obtained evidences regarding the existence of cultures similar to the Mousterian, Microlithic, Proto-Neolithic and Early Neolithic Industries of Europe and North Africa. The breathlessness with which the work in these fields was pursued may be judged from the fact

parts of India. Other two thousand such tombs have been recorded from the Bellary district alone. Majority of them belong to modern times, others to the Iron Age, while a few may be attributed to the Neolithic period. The most characteristic feature of the Megalithic South Indian tombs is that they possess a small hole in one of the walls similar to those distributed throughout Britain, France, Central Germany, Scandinavia, Sardinia, Syria and the Caucasus. Further, the cup-markings found on

the stone of dolmens in some countries are not unknown in India. Moreover, the similarity of interment in earthenware coffins with marked identity in their shape, size and material has given rise to interesting speculations regarding the relation of archaic Indian civilization with that of ancient Babylonian and Assyrian.

COPPER AND BRONZE AGE

We do not find any evidence of the actual Copper and Bronze Age cultures in South India. Archaeologists put forward a theory that the Neolithic phase of culture of South India passed directly to the Iron Age culture. It is to be remarked here that South India is not the only country in which Iron Age culture was not preceded by the Copper (Fig. 1e, 1f, 1g) or Bronze Age cultures (Fig. 1h). Eighteen sites having Copper Age cultures were discovered from Northern India, e.g. 8 in the Upper Gangetic valley, 4 in Bengal and Orissa, 1 in the Central Provinces, 2 in Baluchistan and 2 in N. W. F. Province. But the most important Copper Age finds are the Gungeric hoard (Fig. 1i, 1j). Archaeologists are of opinion that the Gungeric hoard of copper finds contains the largest quantity of copper found in any pre-historic site. The numerous types of instruments for agricultural and domestic and for offensive and defensive purposes, discovered from the same place of Gungeria, lead one to conclude that the manufacture of copper instruments used to be conducted on

a gigantic scale in India at such an early date. Heine Gildern in his monograph on Copper Age finds tried to show the co-relation of the Copper Age finds of India with those of South Russian-Caspian area. The copper and the bronze tools and implements along with the objects of different stone industries were discovered at Mohenjo-daro and Harappa. Similar Chalcolithic finds have been unearthed from almost the entire Indus basin extending up to Harappa and as far as to Siestan in the west through Baluchistan and Waziristan.

Convincing evidence of a Bronze Age culture in India is at present lacking. Only seven bronze implements, apparently belonging to the pre-historic age, are so far available. The Jubblepur celt, however, is the only undoubted example of true bronze whose pre-historic origin can be inferred with certain amount of confidence. But no definite conclusion can be drawn from a simple example, however, confident one might feel about its pre-historic origin. Vincent Smith is of opinion that the Jubblepur celt must be of foreign origin. The lack of some positive evidence as to the existence of a Bronze Age culture in India leads to the view that in Southern India the Neolithic period passed directly into the Iron Age culture, whereas in Northern India Copper Age intervened between the Neolithic period and the Iron Age. Besides no definite evidence is available at the present moment as to the places where the Palaeolithic, Neolithic and Copper Age cultures originated, the period of their existence and the nature of their final decadence.

RURAL RECONSTRUCTION IN CHINA*

SHORT HISTORY OF THE NATIONAL COLLEGE OF RURAL RECONSTRUCTION

THE National College of Rural Reconstruction was established in 1940 by the Chinese National Association of the Mass Education Movement. The origin of this Movement goes back to the First World War when Dr Y. C. James Yen, its founder and General Director, serving as a volunteer in the army Y. M. C. A. "huts" with the Chinese Labour Corps in the battlefields of France, caught his first vision of the problems and potentialities of China's vast unlettered population. On his return to China he and his colleagues, working during the initial period under the auspices of the National Committee, Y. M. C. A., started the first nation-wide campaign for the elimination of illiteracy, first in the leading cities and later in selected rural areas. The work grew to

such proportions that a national convention was called in Peking in 1923, and as a result the Chinese National Association of the Mass Education Movement was organized to conduct educational research and systematic promotion and supervision in the provinces.

In 1929, in recognition of the fact that the great bulk of the people of China lived in the rural districts and that an effective programme for the uplift of life must embrace life in all its aspects, a shift of emphasis was made from the extensive promotion of adult education in the cities to an intensive and correlated tackling of the problem of rural reconstruction.

* Through the courtesy of Dr Y. C. James Yen, founder and General Director and Mr Shih-yin Ch'u, acting President of the Chinese National Association of the Mass Education Movement (obtained through one of our Editors).

tion. Tingsien, a typical North China district, was selected for a "social laboratory", later known to the world as the Tingsien Experiment. Through three types of education (school type, social type and home type) the Tingsien Experiment made its correlated approach to what were believed to be the four fundamental aspects of rural reconstruction, the cultural, economic, health and political. Special attention was directed towards the young people of Tingsien, who have since achieved international fame for civic service in the days of peace and for the most gallant guerrilla warfare against the Japanese invaders during the present war.

In 1931 the Movement, in response to earnest requests from various provinces, embarked upon a programme of national expansion to apply the results of Tingsien Experiment on a nation-wide scale. The programme adopted differed from province to province according to the needs felt and opportunities available. In Chekiang it was confined to assisting a local project of rural improvement at Chikow, the birthplace of the Generalissimo, and in Manchuria to the conduct of Shenyang Experiment Hsien. In Kwangsi it included the conduct of the Provincial Foundation Educational Research Institute and the direction of a "Min Tuan" (people's militia) area composed of ten hsien. In Kiangsi it was participation in the Provincial Institute of Local Government and the conduct of the Experiment Hsien of Suichuan. In Szechuen it was embodied in the Provincial Planning Commission which was to make comprehensive plan for social reconstruction and the reform of local government throughout the province, with Hsintu Experiment Hsien as its main demonstration centre. In Hunan where the Movement had its best opportunity for conducting a province-wide programme, the work grew in field practice from the Hengshan Experiment Hsien into the Hengyang Experiment Prefecture (comprising ten hsien) and in training from an experimental normal school into the Hunan Provincial School of Public Administration where all the local government officials, including magistrates, bureau heads, administrative and technical supervisors, and community leaders, received training before taking up their respective posts.

Some of these provincial projects were started well before the outbreak of the present war. Others are definite efforts on the part of the Mass Education Movement to render assistance to the government for the prosecution of it, especially along the line of training young men and women who in turn will train the masses for more conscious and effective participation in the national struggle. As the demand for trained personnel grew greater each day since the promulgation of the government's twofold policy

of simultaneous resistance to Japanese aggression and national reconstruction, the training programme of the Movement has received increasing attention until, embodied in the National College of Rural Reconstruction, it became the central feature of its work in 1940.

The National College of Rural Reconstruction includes in its plan the development of a full collegiate course for those who look to rural reconstruction as their life vocation. But years and perhaps decades will elapse before there will be college graduates in sufficient numbers to serve all of China's vast rural areas. It is doubtful whether this will ever be economically possible or technically necessary, except for key positions involving the formulation of policies and supervision of field activities. So pending the consummation of the collegiate division and in order to meet the pressing needs of the present time, it is concentrating its efforts on its two other divisions, the Graduate Division and the Junior College Division.

The Graduate Division, which is the continuation of the Institute of Rural Reconstruction started at Tingsien, is to prepare high grade personnel for the important administrative and technical positions within the rural reconstruction movement. It enlists both men of the returned student type and graduates of colleges in China and provides them with opportunities for actual participation in rural reconstruction work or for social internship.

The main purpose of the Junior College Division is to prepare the administrative and technical personnel for the hsien-unit social reconstruction programme. There are now four departments in this division.

The Department of Rural Education has as its aim the training of hsien educational administrators, principals and teachers of junior normal schools, principals of rural higher primary schools and supervisors of hsien adult education. The Department of Agriculture trains directors of local agricultural stations, extension workers, teachers of junior agricultural schools and workers in colonization and other agricultural projects. These two departments have been in operation since 1940 and have already graduated their first batch of students.

The Departments of Hydraulic Engineering and Social Administration have just been inaugurated. The former, which is conducted with the co-operation of the Szechuen Provincial Government, is to prepare personnel for the provincial bureau of hydraulic engineering and similar organizations that are seeking to develop the numerous rivers and rivulets of Szechuen for industrial and irrigation purposes. The latter will train personnel

for the many government and private projects of social service that have sprung up during the present war and will doubtless be incorporated into the forthcoming programme, of post-war rehabilitation. For the conduct of this department the College is assured of the close cooperation of the Ministry of Social Affairs.

The distinguishing emphases of the training programme of the College are on normal and spiritual discipline and close correlation between training as it is given in the class room and life as it is lived in the community. The first emphasis is of obvious timely significance in view of the distressingly prevalent spirit of calculation among the nation's educated youths at a time when the pathos of an unprecedented national struggle should be reflected in an attitude of heightened idealism and selfless devotion on their part. For the second emphasis the College attempts to provide its students with adequate opportunities not only for field observation and practice, but also for actual participation in the field work of the Movement so that their field experience may be acquired in real life situations rather than under artificially created conditions.

CURRICULA

1. Graduate Division

Graduate students enrolled in the various departments work under the joint supervision of the Research Director and the heads of the departments concerned. According to individual needs and aptitudes, special projects are worked out for each student, all projects involving assignments for special readings, field observation, and participation in actual field service.

2. Junior College Division

General Required Courses.—1. San-Min-Chu I (Three Principles of the People by San Yat Sen), 2. Military Training (for men), Social work (for women), 3. Chinese, 4. Rural Reconstruction in Theory and Practice, 5. Rural Economics, 6. Social Work Methods, 7. Public Health, 8. Educational Guidance, 9. General Agriculture (for non-agricultural students) and Rural Education (for students of agriculture).

The Curriculum of the Department of Rural Reconstruction

Required Courses.—Introduction to Education, Educational Psychology, Educational Measurement and Statistics, Rural Adult Education, Child Education, Secondary Education, Local Educational Administration, School Administration.

Electives.—Social and Political Reconstruction and Education (lectures and field work), Economic Reconstruction, and Education (lectures and field work), Cultural Reconstruction and Education (lectures and field work), Teaching of Social Sciences, Teaching of Natural Sciences, Teaching of Art and Literature, Youth's Training and Organization (lectures and field work), Rural Teachers' Education (lectures and field work), Experimental Rural Schools (lectures and field work).

The Curriculum of the Department of Agriculture

Courses in Plant Production and Crop Improvement.—Principles of Crop Production, Farm Crops, Vegetable Growing and Floriculture, Pomology, Genetics, Plant Breeding, Botany Farm Management.

Courses in Soils and Land Amelioration.—Soil, Fertilizers.

Courses in Plant and Insect Pests.—Plant Pathology, General Entomology, Economic Entomology.

Courses for Practice in Agricultural Experimentation and Extension.—Project (I), Project (II), Extension.

The Curriculum of the Department of Hydraulic Engineering

Courses in Hydraulic Engineering.—Hydraulics, Hydrology, Irrigation of Engineering, River Regulation, Water Power Engineering, Hydraulic Structure Designs, Water Supply Engineering.

Courses in Civil Engineering.—Highway Engineering, Elementary Structures, Reinforced Concrete, Structure Designs, Reinforced Concrete Designs.

Courses for General Training and Practice.—Engineering Mathematics, Engineering Drawings, Surveying and Field Practice, Engineering Materials, Applied Mechanics, Strength of Materials.

The Curriculum of the Department of Social Administration

General Orientation Courses.—General Sociology, Social Psychology and Mental Hygiene, History of Social Thought, Contemporary Sociological Schools.

Courses for Methodological Discipline and Field Observation.—Social Statistics, Social Investigation (emphasis on field work), Methods of Case Study (emphasis on field work), Comparative Methodology of the Social Sciences.

Courses for the Understanding of Chinese Rural Society.—Rural Sociology (lectures and field observa-

tion), Rural Social Organization (lectures and field practice), Rural Social Pathology, Rural Local Government, Rural Economics, Rural Education.

Courses for Practical Social Service.—Historical Survey of Community Welfare in China, Modern Social Work Administration (field practice in co-operation with specialized organizations), Child Welfare (field practice in co-operation with specialized organizations), Rural Cooperative Organization, Rural Reconstruction Projects.

NUMBER OF GRADUATES

Graduate Division.—Research Associates 24, Graduate Fellows 76.

Junior College Division.—Department of Rural Education 18, Department of Agriculture 11.

PRESENT ENROLLMENT

Department of Rural Education 32, Department of Agriculture 36, Department of Social Administration 27, Department of Hydraulic Engineering 42.

STRUCTURE AND SOIL CONSERVATION

A. SREENIVASAN,

INSTITUTE OF PLANT INDUSTRY, INDORE, C. I.

ALTHOUGH there has been a general awakening in regard to the need for soil conservation by erosion control and prevention measures suited to different localities, yet it is only during recent years that the influence of factors other than declivity or length of slope is being understood. This has resulted in a certain amount of fundamental study of the causes favouring soil erosion on the one hand and of the changes in physical properties resulting from such erosion on the other.¹⁻⁶

The more important among the soil properties affecting erodibility and, therefore conversely, conservation, are: (i) texture, (ii) structure, (iii) organic matter content, and (iv) chemical composition. Of these, texture in itself has comparatively little significance while the greatest effect of organic matter in respect of erodibility is on structure; thus, its most important effect is in forming water-stable aggregates that produce increased porosity and permeability of the soil.

The black cotton soil, like others of similar physical and chemical properties, is highly erodible. Evidence of rain wash is seen everywhere in the monsoon-affected regions of Central India⁶ as well as

in other black cotton tracts.⁸ The influence of erosive forces in particular areas is however obviously deter-



FIG. 1.—Photographs are of five feet deep profile blocks of a good, well-drained soil and a badly drained soil. Notice the fine, granular structure developed in the rich field (left) as compared to the cloddy or fragmental structure in the poor field.

¹ Bennett, H. H., "Soil Conservation", McGraw-Hill Book Co., Inc., New York, 1939.

² ———, *Soil Sci.*, 21, 349, 1926.

³ Bayer, L. D., *Agric. Eng.*, 14, 51, 1933.

⁴ Middleton, H. E., *U. S., Dept., Agric., Tech. Bull.*, 178, 1930.

⁵ Bouyoucos, G. J., *Jour. Amer. Soc. Agron.*, 27, 738, 1935.

⁶ Wou, H. C. Wang, W. K. and Li, C. W., *National Geol. Surv., China, Special Soils Publ.*, No. 4, 71, 1938.

⁷ Wad, Y. D. and Tambe, G. C., *Agric. and Live-Stock in India*, 3, 238, 1933.

⁸ Joshi, K. V. and Kanitkar, N. V., *Ibid.*, 9, 10, 1939.

mined by the topographical aspect and drainage conditions of the fields with the result that even diverse soil types are often seen to exist side by side in spite of apparently uniform conditions of environment and parent material.⁹

At Indore, the positive effect of a manurial or cultural treatment observed in one experiment on a particular field has very frequently been negated in the same season on another. It soon became apparent that the difference was mainly due to the existence,

extends below the surface; the thickness of the loose, friable surface layer is more down the profile of a rich field than in a poor field (Fig. 1).

2. The percentages of water-stable aggregates (of particles 0.05 mm. dr.) in an eroded field are far less than in a good field.¹⁰
3. There is greater uniformity with depth in the physical properties of the soil layers from a fertile field.¹⁰

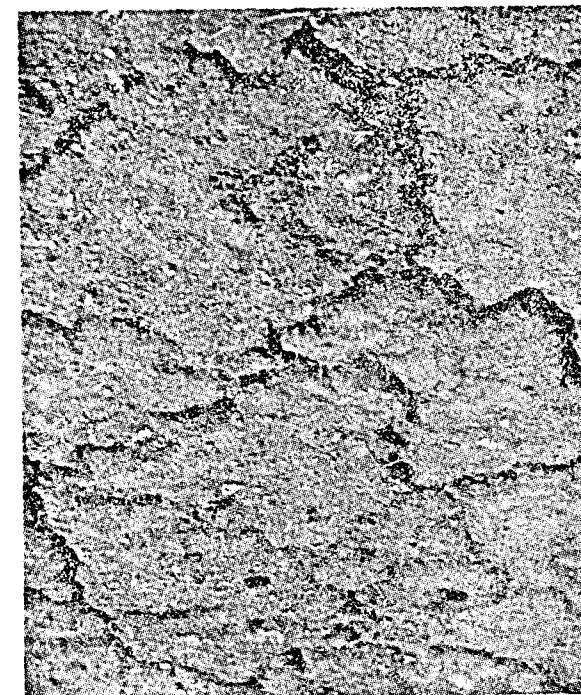
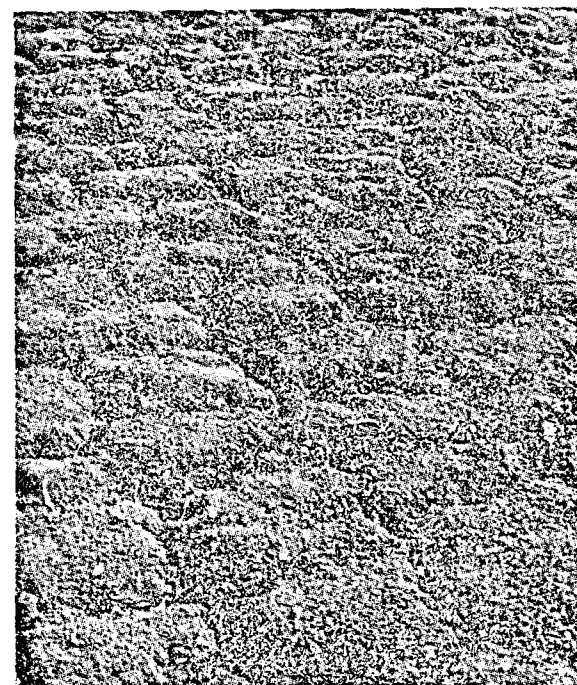


FIG. 2.—The cracking of field soils during hot dry months is Nature's method of improving the field structure of soils and increasing their fertility. Photographs show the surface cracking in fields of good (left) and poor (right) fertility. A rich field cracks more extensively and to a greater depth than one poor in fertility on account of water-logging or erosion losses.

in reality, of two types of fields, one rich and well-drained and the other poor, eroded and waterlogged. The average yields of seed cotton for the two types of fields, over a period of years, were approximately 414 lbs. and 194 lbs. per acre respectively. Attempts have been made at the Institute within the last few years to ascertain the nature and behaviour of eroded and erodible soils and to evolve practical methods of improving such areas for better yields by suitable agronomic adjustments. Some of the results obtained are summarised here:—

1. The main difference, morphologically, between a well-drained and an ill-drained field lies in the depth to which good tilth

4. The nitrogen and organic matter contents of eroded soils are somewhat lower than those of undisturbed soils.¹⁰

5. The proportion of replaceable sodium over total replaceable bases is highest under conditions of impeded drainage.¹⁰

6. There is an accumulation of weathered silica in the surface layers of eroded soils while well-drained and rich fields are characterized by excess of sesqui-oxides in their surface soils. The weathering processes are also more vigorous in good fields than in fields of low fertility.¹⁰

⁹ Basu, J. K. and Sirur, S. S., *Ind. Jour. Agric. Sci.*, 8, 637, 1938.

¹⁰ *Annual Reports, Institute of Plant Industry, Indore, 1942.*

7. Cracking in the fields during summer fallow is more extensive in a rich field as compared to an infertile field (Fig. 2). Further, the depth to which these cracks extend is least in the latter case; in other words, cracking tends to be superficial with these fields.¹¹
8. Addition of loose, hand-gathered surface soil from the same field and thus building up artificially the thickness of the surface layer, evokes better response to yield from a poorly drained field than from a well-drained field.¹²
9. The results of manurial trials carried out since 1936 have shown that, with very few exceptions, both artificial nitrogenous fertilizers and organic manures produce a good response on the more fertile fields and a very much smaller or sometimes no response from poor fields.¹³ This is apparently con-

trary to the expectation that poor fields should be more responsive to manuring than rich fields. When closely examined however, these results only confirm the earlier observation that poor fields are characterized not so much by a deficiency of essential elements as by a loss in structure resulting from bad drainage and waterlogging.

10. When the surface soil in a poor field is kept open by dressings of lightly fired soil, increased yields are obtained without manuring; the response to manures is also greater on soils so treated.¹⁴
11. Other soil improvers that have given increased yields of cotton in preliminary trials on eroded lands are superphosphate¹⁵ and chemical oxidizers like potassium permanganate and ferric oxide.¹⁶

¹⁴ Sreenivasan, A., *Indian Farming*, 2, 530, 1941; Sreenivasan, A. and Aurangabadkar, R. K., *Soil Sci.*, 50, 449, 1940; *Annual Reports, Institute of Plant Industry, Indore*, 1943.

¹⁵ *Annual Reports, Institute of Plant Industry, Indore*, 1938.

¹⁶ Unpublished data.

¹¹ Sreenivasan, A., *Nature*, 150, 409, 1942.

¹² *Ibid.*, 148, 144, 1941.

¹³ Panse, V. G., *Report on the results of cotton manurial trials in India*, India Central Cotton Committee, 1942.

OBITUARY: RAMANANDA CHATTERJEE

WE deeply regret the death of S. J. Ramananda Chatterjee, the eminent journalist and ardent lover of India's freedom. India has hardly seen a truer journalist than S. J. Chatterjee who applied himself with single-minded devotion to the cause of India's uplift in all spheres of a dependent nation's activity, political, economic, social, and above all, cultural. His forceful and fearless writings which always bore the stamp of profound learning, impartial judgment and critical analysis and which touched almost every dynamic field of human knowledge and activity never failed to create among the reading public a lively and abiding interest in the problems of the day. His death has created a vacuum in the field of Indian journalism which it will take a long time to be filled up.

S. J. Ramananda Chatterjee was born of a respectable Brahmin family of Sanskrit scholars on May 28, 1865 in the village of Pathakpara in Bankura. He had a distinguished academic career and took his M.A. in English standing first in first class. S. J. Chatterjee was awarded the States Scholarship to enable him to proceed to England for the prosecution of higher studies. But he developed so strong a dislike for Government service that he did not hesitate to refuse the scholarship. But a great man

that he was destined to be, he had not to wait for such opportunities to go abroad. In 1926, by which time his reputation as an able journalist reached far and wide, he was invited by the League of Nations in Geneva to attend its sessions, and made a tour of the European continent. He preferred the teaching profession and accordingly joined the City College as a Lecturer in English. In the very early beginning of his career he came in contact with eminent personalities, such as Keshab Chandra Sen, Pandit Sibnath Sastry, Ananda Mohan Bose, Durga Mohan Das, Krishna Kumar Mitra, Heramba Chandra Maitra and other leaders of the Brahma Samaj, who not only influenced his ideas but largely inspired his subsequent contribution to the cause of education and social and political uplift. It was as a result of his contact with these men that he was drawn to the Brahma Samaj and gave up his caste prejudices.

In 1895 he left the City College and went to Allahabad as the Principal of the Kayastha Pathshala College, a charge which he held for thirteen years. As Principal, he gained universal esteem by the uprightness of his character, his devotion to college work, and efficiency and concern for the welfare of the Institution. But his heart revolted to find the rigid way in which official control was exercised on

juvenile education, which did not even permit the educational institution to hold examinations of their own boys. It was the need for the recording of his criticism of the existing inequitable systems through suitable public organs which led him to a career in journalism. Owing to acute differences with the educational authorities he resigned the post of Principal of the Kayastha Pathshala in 1908, a fact which was universally regretted not only by the authorities and students of Kayastha Pathshala and the Bengalee community, but by all communities of the city. Since then journalism became his life's pursuit and thought.

He developed a strong liking for journalism from his college days and worked in *Dharmabandhu* even before he took his B.A. degree. He started first a Bengali monthly called *Dasi* in 1891, while in Calcutta. He was for some time assistant editor to *Indian Messenger*, the weekly mouth-piece of Eralma Samaj. In 1896, while in Allahabad, he started another Bengali monthly *Pradeep* of which he was the proprietor and editor. For these journals, he was able to enlist the services of such distinguished Bengalees of the last generation as the poet Rabindranath Tagore, and the scientist Sir Jagadish Chandra Bose. With the knowledge and experience gained in these journals, he embarked on his first great venture, the well-known Bengali illustrated monthly *Prabashi* in 1901, which is now running the 42nd year of its existence. It at once won the hearts of the Bengalee reading public by its fine printing, attractively coloured illustrations by the master artists of the day like Abanindra Nath Tagore and Nandalal Bose, the proper selection of articles, and his carefully written notes on current topics, and above all, by the strict punctuality in its publication. There were Bengali monthlies of note earlier, but they all suffered from extreme irregularity in publication; in fact, it was very common to find that three or four issues came out in a joint format after intervals of three to four months. The poet was a regular writer, and most of the Bengalee men of letters and science of the past generation were regular contributors. The editor's own notes on current topics were eagerly read by the public. At Allahabad, he formed a life long friendship with Major Bamandas Bose, I.M.S. (ret'd.), a scholar, and student of ancient and modern history, who had settled at Allahabad and published a large number of historical works from original sources on the history of India.

While running the *Prabashi*, he had felt that his organ did not reach the general educated community of India. So in 1907, he started the English monthly

Modern Review. All the features of the *Prabashi* were reproduced in this journal; only it enlisted the co-operation of a far larger number of writers, and reached a far wider circle of readers. Amongst contributors may be mentioned Rabindranath Tagore, Sri Aurobindo, Lala Lajpat Rai, Sister Nivedita, Sir J. C. Bose, Sir P. C. Ray, C. F. Andrews, J. T. Sunderland and St. Nihal Singh. The journal had earned him international fame and still enjoys an unchallenged position as the mouth-piece of educated India on political, social and economic problems.

He was the first great champion of the Indian Art. He wrote in the first issue of *Prabashi* the first Bengalee article on the paintings of the Ajanta cave, which attracted considerable attention and created in his readers great interest in Indian art. In the face of strongest criticism he made his journals the vehicle for popularising the picture of Robi Varma, Abanindranath Tagore, Gaganendranath Tagore, Nandalal Bose, Asit Kumar Halder and similar other champions of Indian Art.

He was deeply interested in the progress of juvenile literature. Earlier in his journalistic career he helped in the publication of the juvenile periodical *Mukul*. Though he was not in favour of Hindi being established as the lingua franca of India, his interest in the development of this language was abiding. The Hindi monthly *Vishal Bharat* which he conducted for the last thirteen years and which now ranks high among the first class Hindi journals throughout India bears testimony to his profound interest in the language.

Though not a man of science himself, he appreciated the supreme need of scientific developments in this country and accordingly encouraged propagation of scientific knowledge among his country men. He was one of the greatest well-wishers of SCIENCE AND CULTURE since its inception and showed deep interest in its articles and editorial comments and discussions. Extracts of articles published in SCIENCE AND CULTURE have regularly appeared in the columns of *Modern Review* and often formed subjects of favourable comments in its editorial notes.

In the death of S. J. Ramananda Chatterjee, India has lost a great son who has been a well-balanced exponent of Indian culture and civilisation, a great patriot, and a fearless critic of the methods of Imperialistic Bureaucracy. A man of few words, unostentatious in his habits, devoted to his friends, but unsparing in his criticisms, he earned more enemies than friends, but even his bitterest enemies had sincere and profound regard for his high moral purpose, and the greatness of his character.

Notes and News

THE UNITED STATES NATIONAL MUSEUM

THE report of the Assistant Secretary of the Smithsonian Institution, in charge of the U. S. National Museum, has placed on record the progress and condition of the Museum for the fiscal year ending June 30, 1942. The report includes a general review of the operations for the year, with reference to appropriations, collections, exploration and field work, publications and printing, the effect of war on the Museum's activities, etc., and has further incorporated detailed reports on the collections under the Departments of Anthropology, Biology, Geology, Engineering and Industries and the Division of History, together with a list of accessions. During the year under review the impact of war had no great effect on the receipt of specimens as additions to the vast and valuable collections in the United States National Museum. New materials accessioned came principally through expeditions financed and arranged by the Smithsonian Institution under funds contributed by the Institution or by its friends. The total number received is about average for recent years. New materials came in 1,388 separate accessions, with a total of 284,582 specimens distributed among the five departments mentioned. The year's explorations and field work by members of the staff yielded much valuable new information and useful series of specimens in various fields. The active participation of the country in the war, however, meant definite curtailment of the programme for field work. Expeditions were restricted to those working at the time or those required because of commitments previously made. Valuable results were obtained despite such reduction in the scope of the work.

NATIONAL RESEARCH COUNCIL FOR INDIA

WE note with satisfaction that at the symposium on post-war organisation of scientific research, recently sponsored by the Council of the National Institute of Sciences, the Council has been authorised to take necessary steps for the establishment of a National Research Council to be constituted under the statutory authority of the Government of India. It was decided in the symposium that the Government of India should come forward with a grant of five crores of rupees annually to enable the proposed National Research Council to execute successfully the policy of scientific development in this country. It has been proposed that the National Research Council should be directly responsible to the Government and that its functions should be to assess the national

needs in various directions and accordingly plan the main lines of scientific research so as to secure a balanced development of all branches of science. The Council will also be required to advise on the type of training and the amount of supply of scientific personnel for pure and applied research. The Council should consist of scientific and technical experts not exceeding sixty in number, the majority of whom should be elected by the non-official scientific organisations, including universities. It was also recommended that Boards of research should be constituted for each sphere of work, and each Board should be authorised to frame research committees for all important subjects (for details see the supplement at the end).

Magnificent as the proposal for the formation of a National Research Council in India is, such a Council was indeed long overdue. The proposed National Research Council, we hope, will be constituted after the National Research Council of U. S. A., which has proved a useful organisation in planning and directing research in the United States of America. It may be recalled that, during the War of 1914-18, President Wilson requested the National Academy of Sciences to establish the National Research Council as a measure of national preparedness. The Council proved so useful and efficient an organisation that the N. R. C. was allowed to continue its work after the war and it has now become one of the most potent central organisations of the country. U. S. A. is, however, not the only instance of a country to derive full benefit from the existence of such a Research Council. Similar National Research Councils have also been set up in Canada and Japan to the immense benefit of the countries in question so far as nation-wide research and development are concerned. The active role Canada has so far played in the United Nation's war effort in this global war is in no small measure due to the timely creation of such a Research Council. An early creation of a similar Research Council in this country would have enabled India to contribute immensely to the war-effort. Nonetheless the need for the formation of a National Research Council remains today all the more urgent and glaring in view of the much needed scientific and industrial development in India in the post-war period, and as such we welcome this significant move on the part of a competent scientific organisation like the Council of National Institute of Sciences of India. We hope the Government will fully realise the importance of

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the proposed National Research Council and will take necessary action for an early fruition of the scheme.

AXIS PRODUCTION OF OIL

A SOMEWHAT reliable estimate of the production of oils, both mineral and synthetic, in the Axis countries during 1941-42, as presented at a recent meeting of the American Institute of Mining and Metallurgical Engineers, is reported in *Science News Letter* of June 26, 1943. A steady increase in the output of synthetic and mineral oils, particularly the former, is recorded in Japan, Germany and the Axis occupied countries. The production of petroleum in Japan in 1941 is estimated at 8,800,000 barrels, of which petroleum substitutes alone amounted to as much as 5,500,000 barrels. Japan's output of 10,000,000 barrels in 1942 has been ascribed to her ever increasing production of synthetic oils. Since the Japanese occupation of Burma and Netherlands Indies, which meant serious dislocation of the oil refineries and other equipments for production, the output of oils from these sources has sharply declined from the peace time figure of about 78,000,000 barrels a year to only 23,000,000 barrels in 1942. Thus Japan commands at present at least some 33,000,000 barrels of oils annually, which is reported to have placed at her disposal about 8,000,000 barrels more than her greatest peace time annual consumption.

The production of oils in occupied Europe, as Mr Garfias and his associates revealed, indicated an increase of 20 per cent or greater over the previous year's production, the actual figure for output being 112,000,000 barrels. Of this figure, synthetic oils represent as much as 46,000,000 barrels. This is sufficient indication of the extent to which the production of synthetic oils in Germany has been pushed in recent years.

SOVIET BOTANISTS IN THIS WAR

IN a special correspondence to *Science*, April 16, 1943, B. Shishkin, Director of the Institute of Botany of the Academy of Science of the U. S. S. R. has given an account of some of the important works carried on by the Soviet botanists since the outbreak of the war. These works have important bearing on the successful prosecution of the war, and as such have contributed largely to the Soviet Union's war-effort. The Institute of Botany of the Academy of Sciences of the U. S. S. R. has carried out much important work regarding the use of sphagnum as a bandaging material. Sphagnum has excellent absorbent qualities and the bandages made of it cause a much more rapid healing of the wounds. The moss

is available in large quantities in the Leningrad district, from which sphagnum bandages are now prepared on a large scale in the northern regions of the Soviet Union.

Equally conspicuous is the work of the Soviet botanists in the direction of the search for vitamin bearing plants. Before the war the wild rose hip was known to be one of the richest sources of vitamin C. Since the war vitamin contents of hips in the eastern and northern districts of U. S. S. R. have been studied and wild roses planted in various places to produce hips rich in vitamin. Vitamin C has recently been discovered in a fairly large quantity in the needles of ordinary pine trees, and the biochemists in Moscow and Leningrad have successfully organised a mass production of vitamin C concentrate. It is reported that, during the siege of Leningrad when a lack of food containing vitamin C was particularly felt, decoction made from pine needles played a significant role in the prevention of scurvy.

Researches on the roots of plants rich in starch and inulin and fruits of a number of wild trees and shrubs, such as bird cherry, hawthorn and rowan have further resulted in the preparation of a flour from dried rowan berries which may be added to ordinary flour in proportion up to 25 per cent and used for baking pastry, etc. The preparation of fir balsam from the sap of the fir trees, the wide cultivation of new medicinal plants, particularly plants for the manufacture of insecticides, and the search for substitutes for tea and coffee among wild-growing flowers are some of the important works which have engaged the attention of the Soviet botanists in this war.

RESEARCH IN THE UNITED STATES

THE intensity and extensiveness of research carried on in the United States in recent years has been reflected in a report based on the statement made by Sir Earnest Simon before the Parliamentary and Scientific Committee and published in a recent issue of *Nature*. It is estimated that in U. S. A. per capita expenditure on university and industrial research is five times as great as in Great Britain. The American public opinion is so thoroughly convinced of the benefit of research in industry and national life in general that during the great depression the research budget was the last to be cut. According to an official report there were in 1940 some 2,200 research laboratories under the industries with a research staff of about 70,000. The annual cost of maintaining these laboratories amounted to the astronomical figure of three hundred million dollars. The result has been that America now finds herself in the leading position in several important

branches of research and development. Sir Earnest has cited the example of hydro-carbon research in which U. S. A. now leads, with Germany, Russia and Great Britain following her in order of importance.

Research in America is today conducted partly by the industrial organisations and partly by the universities. The research conducted by the universities is mostly financed by liberal grants from Government authorities as well as private generosity. The Government grants, Sir Earnest revealed, are ten times and the grants from private sources twenty times as great as Great Britain. During 1937-38 the number of students in the universities in England was about 50,000, whereas in the American universities some one million students were at that time receiving higher education. During the same period the engineering schools of England produced about 800 graduates as against 12,000 graduates from American engineering schools. The figures quoted above are significant if we bear in mind that the population of U. S. A. is only three times greater than that of Great Britain.

POWER FROM FALLS ON INDIAN CANALS

In a recent address to the Research Committee of the Central Board of Irrigation Sir William Stampe referred to the possibility of developing power from falls on Indian canals. For the generation of power coal is now largely used throughout India. The growing shortage of coal and the increased transport difficulties necessitate a saving of coal and large-scale development of hydro-electric power. Many of the larger Indian canals have falls, especially in the upper regions near the hills, where power can be developed either directly from individual falls or by modifications of the canals, for example, by combining two or more adjacent falls. A number of falls on the canals in the United Provinces have

already been used for this purpose, and in view of the coal shortage there is an urgent need to develop the falls which have not been used so far. Such power developments would not only relieve the Indian coal position as a whole, but would contribute immensely to the provincial power system. According to Sir William Stampe's calculation, 68,000 tons of coal would have been required in U. P. annually during the last seven or eight years if the tube-well system had been energised from coal. Moreover, 400 wagons would have had to have been permanently reserved to carry this coal from the coal fields to the power station.

It is needless to point out that the development of such power would be of immense benefit to the cultivators and to the country as a whole. It is, however, not for the first time that the need for the installation of further hydro-electric power stations has been emphasised by an official like Sir William Stampe. Experts, both official as well as non-official, have from time to time stressed the need of the development of hydro-electric power in this country and have also offered workable suggestions and plans of action. But is the time not yet sufficiently ripe for the materialisation of these suggestions and plans regarding such an important development of immense national importance?

ANNOUNCEMENT

We are glad to learn that Dr H. J. Bhabha has been awarded the Adams Prize by the University of Cambridge on the Physical Theory of Cosmic Rays. This is a very unique distinction which has been conferred on persons like Maxwell, J. J. Thomson, Dirac and Darwin and other physicists in previous occasions. We congratulate Dr Bhabha for the signal honour he has achieved for India and the Indian scientists.

SCIENCE IN INDUSTRY

SMELTING WITHOUT COKE

HITHERTO coke has been regarded as an indispensable requirement for smelting operations. Thomas V. Moore, of Houston, Texas, has recently patented a new smelting process, according to a report in *Science*, in which coke is completely dispensed with and is replaced by natural gas and hydrogen. In the old process, now widely in use, the blast furnace is charged with alternating layers of coke, iron ore and limestone. In the process developed by Mr Moore, fine'y-ground iron ore is introduced into the furnace through a hopper at the top. An up-sweeping blast of flaming gas is maintained within the furnace to render the fine particles of ore incandescent and ready for chemical reaction. The particles then pass into the region of high temperature where hydrogen reacts on the ore and reduces it to metallic iron in a molten state. The hydrogen required in the process can be obtained from some types of natural gas. At this stage the ore also reacts with the fluxing material, such as limestone introduced through the same hopper. The molten mass then passes through a third zone of hot gases containing an excess of uncombined carbon particles to be taken up by iron to form pig iron. As in the old arrangement, molten iron and liquid slag can be drained from the furnace through separate openings at the bottom.

The newly developed process has not yet come into general use. The development is significant inasmuch as it opens up the possibility of setting up iron and steel industry in regions with reasonable deposits of iron ore but with little or no reserve of coal.

EPHEDRA CONCENTRATE AND THE EXTRACTION OF EPHEDRINE

SUGGESTIONS for a better utilisation of the herb ephedra growing in India have been outlined in the Indian Forest leaflet No. 48, recently issued by the Forest Research Institute, Dehra Dun. It is recommended that better utilisation will be possible if the total crop of Indian ephedra, both the rich as well as the poor grades, is converted into a concentrate at the source of supply. India is an important source of supply of this drug, but the Indian ephedra has to face competition from Chinese and Spanish ephedras which are generally considered better and fetch better prices. The ephedrine content of Indian ephedras varies with the species and with the locality.

Thus, *Ephedra gerardiana* and *E. nebrodensis* are rich in ephedrine whereas *F. intermedia* is rich in pseudo-ephedrine, an isomeric alkaloid present in varying proportions in all species of ephedra. The reputation of Indian ephedra can, however, be established if henceforward attention is directed to the collection of the richer varieties of the herb in proper localities. But this practice would leave the poorer variety of ephedra unutilised. Fuller utilisation of the herb can be easily effected if the ephedra concentrate first prepared at the source of supply be supplied to factories manufacturing ephedrine salts in place of the raw herb.

Methods of preparing the concentrate, developed in the laboratories of the Forest Research Institute, have been detailed in the leaflet. The series of experiments have finally led to the following process which guarantees the best results. The powdered herb is soaked in 0.5 per cent aqueous sulphuric acid and kept as such overnight. The acid extract is then squeezed out and the whole operation repeated twice. One kilo of the herb requires 3 litres of the acid for the first extraction and 2 litres for each of the second and the third, thus requiring a total of 7 litres containing 35 grams of the acid. The extract is then made distinctly alkaline by adding slaked lime (paste). This operation causes precipitation of much of the colouring matter, but ephedra alkaloids remain in solution in this large bulk of the alkaline extract. The precipitated colouring matter is filtered and washed with water, the washings being transferred to the extract. The extract is then made faintly acidic to congo and concentrated by evaporation in tin lined copper pans. The initial evaporation may be carried on over direct fire till the concentrate is reduced to about one-fourth of the original bulk, but subsequent evaporation must be done on a water bath. When the extract has become semi-solid syrup like mass, it is removed from the water bath and triturated with lime till it becomes a sticky solid mass. The stickiness is removed by adding a little methylated spirit at this stage and the whole mass dried in the sun. The powdered material thus obtained is the first concentrate representing about 22-25 per cent of the weight of the crude herb and contains, if carefully prepared, as much as 95 per cent of the total alkaloids originally present in the herb. Such a concentrate prepared from ephedra of 1 per cent assay will contain about 4.3 per cent of total alkaloids.

A second much richer concentrate is obtained by allowing the finely powdered first concentrate to be suspended in rectified spirit (92 per cent) overnight after warming and thoroughly shaking the mixture. The alcoholic extract is filtered off, acidified with sulphuric acid till it is faintly acidic to congo and then distilled to remove alcohol. Any calcium sulphate that may separate during concentration is removed and any acidity that may develop is neutralised with sodium carbonate solution. When the complete removal of alcohol has been ensured, the residue is triturated with powdered slaked lime to dryness. The second concentrate thus prepared represents 5.6 per cent of the weight of the herb and contains about 15 to 18 per cent of total alkaloids.

Thus the above method guarantees a standardised material of high alkaloidal content for foreign markets. Furthermore, the manufacturers are relieved of the troubles of going through these preliminary necessary steps in their final preparation of the pure alkaloids. The leaflet also contains methods for the extraction of ephedrine. It is stated that for the extraction of the alkaloids directly from the herb, alkaline extraction is found to be more convenient and economical since it considerably shortens the steps necessary to eliminate the associated colouring matter, sugar, etc. For all these details the original leaflet may be referred to.

SANDLESS OPTICAL GLASS

In our February issue we reported the successful preparation by Eastman Kodak Co. of a new type of glass, known as the 'Sandless' glass, in which the use of silica was completely dispensed with. Further news on the subject of sandless glass is available in the August issue of the *Scientific American*. The new sandless glass has been developed by the American Optical Company, Southbridge, as a result of ten years of research and is claimed to possess optical properties in some respects more remarkable than those of the familiar silica glass. The primary ingredients used for the preparation of the new glass are boric acid, zinc oxide and aluminium hydroxide or beryllium oxide. In another variety of the sandless glass, the use of cadmium oxide in place of zinc oxide is reported. The use of cadmium is very significant inasmuch as it is for the first time that this element has been used as a major ingredient in glass. It might be recalled that in the new sandless glass announced by the Eastman Kodak Co. tungsten, tantalum and lanthanum were the ingredients used in place of silica. Thus it is to be noted that in all the varieties of sandless glass the metals, with the exception of boric acid, have invariably substituted sand.

The new sandless glasses have a much higher refractive index, but produce a lower dispersion in comparison with silica glass. These properties have naturally reduced the chromatic defects of ordinary glass to a minimum. The low melting point,—sandless glass becoming soft at about 150°C—, stability to weathering and corrosion are some of the important properties of the sandless glass. The better lustre of the new glasses has made them suitable for use as gems. These glasses, it is reported, will be henceforward used in lenses for spectacles, high-speed cameras and scientific instruments.

PROSPECTING FOR SCHEELITE WITH ULTRAVIOLET RAYS

PROSPECTING with ultra-violet radiation is a new geo-physical method recently developed and applied with varying degrees of success in Canada and Australia. The method has proved successful in the prospecting for minerals which fluoresce in ultra-violet rays. Notable results have been obtained in the case of scheelite, a form of calcium tungstate, in whose prospecting the ultra-violet ray method has been so far applied in Canada and Australia with conspicuous success, according to a report in the *Chemical Age*.

The ever increasing demand for tungsten in this war necessitating intensive search for new deposits of scheelite, wolframite, etc. attracted the attention of Canadian mining engineers and prospectors to this method. Canadian scheelite, as the results of investigation indicate, fluoresces a characteristic bluish-white. The nature of fluorescence, however, depends markedly on the presence of impurities, such as molybdenum, copper, etc. and also on their percentages. Thus scheelite containing 0.35—1 per cent of Mo fluoresces white. If the percentage of Mo exceeds 1 per cent, the fluorescence is pale yellow, and for higher Mo content the colour gradually changes into yellow. The presence of copper in scheelites produces a green fluorescence. So far as molybdenum is concerned, the Geological Survey in America, has prepared standard colour cards to enable the amount of Mo to be ascertained by comparison. But the prospecting of scheelite with ultra-violet light is sometimes rendered difficult by the fact that some minerals other than scheelite, such as cerussite, diopside, wollastonite, hydrozincite, some varieties of opal, calcite, dolomite, brucite, barytes, and gypsum and also some lichens, mosses, oils and greases produce the same characteristic bluish-white fluorescence. In the Canadian practice, mercury vapour lamp weighing 1½ lb. complete with battery requirements has been found suitable for the purpose. The use of light-weight hood of black cloth in the

lamp has made possible prospecting work even in sunlight.

The application of the ultra-violet ray method in the prospecting for scheelite in Australia at first produced negative results. This led to the suggestion that the characteristic bluish-white fluorescence in scheelite is probably due to some unknown impurities and not to pure calcium tungstate. Later investigations undertaken by the Minerals Resources Branch of the Department of Supply and Development showed that Australian scheelites also fluoresce with the characteristic glow under suitable conditions and that this fluorescence is an intrinsic property of the mineral calcium tungstate and not of any impurity. In the Australian practice, quartz mercury vapour lamp operating at about 3,000 volts and using a current of about 50 milli-amperes is reported to have yielded desired results. The lamp with its electrodes set wide apart employs a cold arc. The transformer and the choke coil connected to a 240 a.c. supply are two auxiliary equipments required for the purpose. The spectral line 2536.5 A.u. constitutes 80 per cent of the total radiation. The lamps are further provided with 'liquid filter' prepared by dissolving 47 gm. of nickel sulphate and 14 gm. of cobalt sulphate in 100 c.c. of water and contained in quartz containers. The use of such a filter limits the radiation to the spectral region from 3,300 A.u. to 2,350 A.u. and has been found to be

very satisfactory. Their investigations also indicated that irradiation with ultra-violet light of wave length greater than 2,750 A.u. produces no fluorescence in scheelite, which explains the initial negative results.

According to the Australian experience, it has been found worth while to apply the ultra-violet method in all mines where regional geology only indicates the remotest possibility of the existence of scheelite. The method only requires traversing a mine with the ultra-violet lamp designed for the purpose. The characteristic glow will then at once suggest the existence of scheelite deposit. As a matter of fact, a rough quantitative estimate, as is possible in sampling, can also be made under favourable circumstances by this method. The ratio of the area of fluorescence in a rock face to the total area of the face gives an approximate measure of the grade, provided that allowance is made for the densities of the scheelite and the gangue. The fluorescent area can also be photographed, producing a permanent record which can be subsequently analysed by planimetric methods to ascertain the grade of the deposit. Ultra-violet light has also been used to promote efficiency in the hand picking of scheelite ores. In such works, ultra-violet lamps operated from a power supply are arranged throughout the belts of scheelite deposits where the hand picking is done, extreme care being taken to protect the workers' eyes.

MAGNESIUM—THE NEW INDUSTRIAL METAL

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THE War has focussed attention on the production of magnesium whose importance as an industrial metal was quite insignificant even before the outbreak of the present hostilities. The metal was first extracted by Sir Humphry Davy in 1808, and it was not until 1857 that magnesium could be produced on a commercial scale by the French chemists Caron and Deville. Even some ten years ago, as a report on magnesium output appearing in *The Times, Trade and Engineering*, December 1942, reveals, the world production of magnesium did not exceed 3,000 metric tons, which reflects the scant utilisation of the metal until recently. Judged against this background, the world output of 39,880 metric tons in 1940, which has been several times increased by 1943, must be described as phenomenal. The adjoining table taken from *Trade and Engineering* would indicate the sharp rise in the production in some of the leading magnesium producing countries of the world.

WORLD MAGNESIUM OUTPUT

Countries	1937	1938	1939	1940
France	1,500	1,800	2,500	2,000
Germany	12,080	14,100	16,500	19,000
Italy	66	102	300	500
Japan	1,200	1,500	2,000	4,000
Switzerland	230	300	700	700
Russia	700	1,000	1,000	1,500
U. K.	2,000	3,000	5,000	6,500
U. S. A.	2,059*	2,918	3,039	5,680
Total	19,835	24,720	31,039	39,880

* Sales.

The first lead in the expansion of the sphere of industrial application of this metal and consequently in its increased production was taken by Germany, ever since the establishment of Nazi regime with its programme of intensive and all-round militarisation. The lead was shortly followed up in U. S. A., U. K., Japan, France, U. S. S. R. and other countries. Previously the use of this metal was largely restricted to the spheres of pyrotechnics and flash-light photography. The recrudescence of interest in magnesium is due to several factors. Magnesium is the lightest structural metal, having 1.74 as its specific gravity which is one-third less than that of aluminium (2.7) and is soft and of little strength in the pure state. But alloyed with metals, such as aluminium, zinc and manganese, it gives rise to great strength and rigidity in addition to the characteristic lightness of structure. This important property suggested to German technologists the usefulness of magnesium in aircraft construction, particularly for the construction of such parts as the landing wheel dust covers, the seats, the petrol and oil tanks, carburettor bodies, crankcases, propellers, etc. Though the aircraft industry is at present by far the greatest consumer of magnesium and its alloys and will apparently remain so in future, the application of this metal in various non-aircraft industries has also considerably grown in recent years. The most notable among them are the motor vehicle industries and those manufacturing portable machines, equipments and tools, textile machinery, foundry equipment and stationery machinery. Furthermore, the remarkable affinity of magnesium for oxygen has recommended the metal as the most satisfactory base for incendiary bombs, flares, star shells and other types of signal munitions.

SOME MODERN PRACTICES OF MAGNESIUM EXTRACTION

The principal raw materials from which magnesium is extracted are magnesite, dolomite and carnallite. The pure carbonate is only of local occurrence, but there are large deposits of workable carbonate with a lower degree of purity. But the most important ore is dolomite, the double carbonate of calcium and magnesium, which is widely distributed in nature, and largely employed for the extraction of metal. Sea water provides an almost inexhaustible source of magnesium chloride, e.g., carnallite, in a very dilute form, the percentage of magnesium being around 0.14. In certain oceanic regions of the world, for instance the Dead Sea, the magnesium salts occur in a fair degree of concentration. Methods for the extraction of the metal from sea water were developed quite early, but only in recent years sea water has come to be recog-

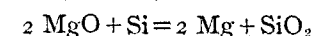
nised as an important source. The relatively insoluble magnesium hydroxide is precipitated by lime. The use of calcined dolomite in place of lime has been found to produce a great yield.

The extraction of magnesium is generally effected in two ways. The first method consists in the preparation of magnesia and its subsequent reduction by suitable reducing agents. The second method is the electrolytic decomposition of anhydrous magnesium chloride in the molten state.

(a) *The Reduction Method.*—Magnesium is a volatile metal boiling at 1097°C. Accordingly, the reduction of the oxide by a non-volatile reducing agent to magnesium metal in the gaseous state, which can be subsequently condensed, came as a natural suggestion to many workers with this problem. The earlier methods of reducing magnesia by an alkali metal is now only of historical interest. Carbon, calcium carbide, ferro-silicon, aluminium etc. have been later on employed as reducing agents with conspicuous success. The use of carbon was, however, first suggested and the carbon reduction process has been widely practised for several years. There are, however, many inherent difficulties besetting this method, and as such the use of carbon has lately been systematically discouraged. The first great objection is the very high temperature, namely about 2,000°C, required in the process, at which the metal is diffused in the gaseous state and is condensed with difficulty. Moreover, the reaction is reversible and some oxide is produced during condensation, which could not be completely prevented even by using an efficient condenser and diluting the vapour with an inert gas. A quick cooling device consisting in the use of a jet of strongly cooled hydrogen, which can reduce the temperature of the vapour to 200°C within a very short time, failed to produce magnesium dust containing more than 90 per cent of the metal. Redistillation in an atmosphere of hydrogen or natural gas and direct condensation to the liquid state is necessary to obtain the pure metal, but there are risks of serious explosions.

Dr. Huigi Amati, the Italian technologist made a significant advance by suggesting the use of ferro-silicon, calcium carbide and aluminium in place of carbon. Ferro-silicon has particularly proved a very suitable reducing agent so far as the extraction of magnesium is concerned and is now being widely employed in Italy, Canada, U. S. A., England and other countries, with slight differences in the technical details. Reduction with ferro-silicon takes place at a temperature of 1200-1400°C and calcined dolomite can be employed. In a new process developed by Dr L. M. Pidgeon, of the Canadian National Research Council, reported in SCIENCE AND CULTURE,

Vol. VIII, No. 10, ground ferro-silicon containing not less than 75 per cent silicon is briquetted with dead burnt dolomite, and the whole mixture heated in an alloy steel retort to about 1,150°C. Silicon dioxide produced, according to the reaction,



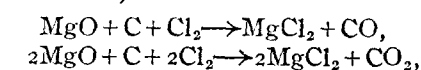
forms infusible dicalcium silicate with calcium oxide of the charge, which can be easily removed without further slagging. A low pressure, less than 1 m.m., is maintained in the retort and the condenser. During the reaction, magnesium in the pure state condenses in the lining of the condenser which is removed along with the deposit at the end of the operation requiring about 6 hours for completion. Magnesium separates from steel in a very high degree of purity during the differential contraction of the two metals and does not require further purification for use in the foundry.

In the Italian practice,* the mixture of calcined dolomite and ferro-silicon is heated under vacuum in electric muffle furnaces at 1300°C, when metallic magnesium is set free in the gaseous state and is condensed in the form of a compact crystalline mass. The mass is collected by mechanical blowers under heat, a process which prevents reoxidation of magnesium by atmospheric oxygen and is melted down in electric furnaces to be finally collected in ingots. In this way the metal is formed, it is claimed, in an exceptionally pure state, the percentage of impurity not exceeding 0.035.

The use of calcium carbide has the advantage in that the formation of a gaseous product is eliminated. The mixture of magnesia and carbide is heated in a vertical gas-fired retort of heat-resisting steel in which a vacuum is maintained. The metal condenses in a compact form and not as dust. The reduction of magnesia with aluminium offers another interesting method now employed by some manufacturers. Ground and calcined magnesia is mixed with aluminium or aluminium clay, briquetted under pressure and charged into crucibles. The crucible provided with downward central outlet connected to the condenser is electrically heated in a vertical cylindrical furnace to about 1100-1250°C under a pressure of less than 4 mm., when magnesium distils over into the water-cooled condenser and solidifies as a crystalline mass of high purity. The mass is transferred to another furnace where it is remelted and cast into ingots.

(b) *The Electrolytic Method.*—The electrolytic decomposition of molten magnesium chloride was first carried out by Faraday in 1830 and considerably improved by Buusen in 1852. A short

account of the modern electrolytic method of producing magnesium has been given in *Nature*, June 19, 1943, by F. C. Thompson, to which the reader may be referred. The success of the method depends on the preparation of anhydrous magnesium chloride in the molten state. Anhydrous magnesium chloride can be prepared by chlorinating the mixture of ground magnesia with carbon added in the form of coke or anthracite dust together with saw dust, peat or some material of this type to make the mass porous. The mixture has to be heated but the heat required is not very great, as the reactions represented as under,



are exothermic. The chlorination process is self-sufficient from the view point of chlorine inasmuch as chlorine used up in the reactions is recovered from the electrolytic cell. The recovery is not, however, complete owing to the formation of hydrochloric acid, but can be greatly enhanced by introducing some washing plant to absorb the acid fumes.

Rectangular steel cells with graphite anodes and iron cathodes are used as electrolytic cells. Chlorides of alkali or alkali-earth metals in the fused state are added to the molten mass of magnesium chloride (1) to lower the melting point and (2) to reduce the decomposition of the pure magnesium chloride in the fused state. Magnesium metal produced during electrolysis floats on the surface owing to its low density and has a chance to be contaminated with the liberated chlorine. Accordingly, partitions of ceramic materials are immersed into the cell from above to effect complete separation of the upper parts of the anode and cathode compartments. Large electrodes of good design are necessary for successful operation. Each cell carries a current of 15-20,000 amp. under a potential difference of 7-9 volts. The bath temperature varies from 670°C to 750°C and the energy consumption amounts to about 20 kwh. per kgm. of metal. The metal in the liquid form is removed from the surface from time to time and remelted to obtain very pure magnesium. Attempts were recently made in the United States to prepare magnesium by a process analogous to that employed in the manufacture of aluminium, but proved abortive.

RECENT PROGRESS IN MAGNESIUM OUTPUT

Detailed statistical information regarding the production of magnesium and the introduction of new projects is not available owing to obvious reasons. This is particularly so with respect to Axis occupied countries, though up-to-date information has been so far received from North America. The

* SCIENCE AND CULTURE, Vol. IX, No. 2.

German lead in the magnesium production is largely due to her abundant deposits of magnesite, dolomite and carnallite. Since 1933 she has continually expanded her magnesium industry, and her old established works at Bitterfeld and Heringen, both in Central Germany, have systematically increased their output capacity. The explosion in the pilot plant at Radenthein in Austria in August, 1939, led, it is understood, to a temporary suspension of the development programme which has in all probability been resumed in recent years. From scrappy information released from time to time through neutral sources it appears that German production of magnesium during these years must have far exceeded her production in 1940, as recorded in the table.

Italy appears to have made notable advance in magnesium production since 1940. In that year, so far as our information goes, three new plants erected at Bolzano, Cogne (Aosta Valley) and Apaunia (near Rome) started production and expected to score an annual production of 3,600 tons. Nothing of importance is known about France since her military collapse. In 1939 Japan framed schemes for building new plants in Korea and Manchuria, but nothing has been heard since then about these projects.

Though exact figures for the production of magnesium in U. S. S. R. are lacking, she must have made considerable headway in recent years despite the destruction of some of her important plants on the Dnieper, as the principal works are situated in the Urals. It should be noted that U. S. S. R. is at present the world's largest producer of magnesite,* producing some 800,000 tons from her well-known Satka deposit near Cheliabinsk in the Central Urals alone. The total estimated reserve stands at 250 million tons. At present only a small percentage of magnesite goes to the production of magnesium metal, the major portion being used for refractory purposes. Besides there is a rich deposit of carnallite in Solikamsk in the Western Urals. Whatever her present production, U. S. S. R. is certain of commanding a very favourable position, if not of taking the very lead in the output of magnesium and the magnesium industry as a whole in the near future.

We have preferred to discuss last the progress made by U. S. A. in magnesium production, as her recent intensive drive has profoundly disturbed the balance of world magnesium output. There are reasons to believe that since the mobilisation of the United States the centre of gravity of the inter-

national magnesium production has shifted from Europe to the other side of the Atlantic. As late as the end of 1940, the Dow Chemical Company, with its works at Midland (Michigan), was the only concern to produce magnesium for U. S. A. Soon after the same company completed the erection of a new plant at Freeport (Texas), which started production by January, 1941. With these expansions, the company aimed at increasing its output from 15,000 to 26,250 short tons by the beginning of 1942. This is followed by the construction in 1941 of a new magnesium factory at Permanente (California) by the Todd California Shipbuilding Corporation.

These are instances of private expansion projects. In the summer of 1941, the Government came forward with its extensive development programme that would ensure production of about 362,500 short tons of magnesium by the end of 1943 to meet the nation's growing need for the metal. According to this programme, henceforward the Government was to own, through the Defense Plant Corporation, all works that would be undertaken in the country, with the exception of the three existing works at Midland, Freeport and Permanente. The construction and development of new plants may, however, be entrusted to private companies. As a matter of fact, the new works that have come into existence in the beginning of 1942, through the operation of the scheme, are now managed on behalf of the Government by private companies, such as Basic Magnesium Inc., in Nevada, the Dow Chemical Company in Texas, the Ford Motor Company in Michigan, the Permanents Metals Corporation in California and the New England Lime Company in Connecticut. It is understood that the construction of seven more works was undertaken in the same year, of which three are expected to have started production before 1943. With all these new developments, U. S. A. was scheduled to produce some 85,000 short tons in 1942. According to *Times, Trade and Engineering*, a total sum of \$339,000,000, of which private capital represents only \$20,000,000, has been provided for the execution of the magnesium development programme,—an astronomical sum which the United States alone is capable of spending in one single direction of development.

It is apprehended that though magnesium has proved a solution in this war it may become a problem in the post-war world. We refer to a probable magnesium surplus problem. If, however, the future of aviation and the aircraft industry be not eclipsed with the return of peace, we may as well expect a future for magnesium after the last shot has been fired.

* Organisation of Science in the Soviet Union—SCIENCE AND CULTURE, Vol. IX, No. 1.

MEDICINE AND PUBLIC HEALTH

PROGRESS IN PUBLIC HEALTH RESEARCH IN WARTIME CHINA

THE first half-yearly report of the Chinese National Institute of Health at Chunking for the year 1943, just received, makes very interesting reading.

The following sections are operating:—(1) Institute of Epidemiology with statistics, laboratory and field research sections, (2) Nutrition Section, (3) Department of Chemistry and Pharmacology, (4) Department of Sanitary Engineering, (5) Department of Maternity and Child Health, (6) Department of Health Education, (7) Department of Nursing, (8) Division of Mental Hygiene, (9) Training of Public Health Personnel, (10) Urban Health Demonstration Centre at She-Tze with clinics, maternity and child health, preventive inoculation, school health, social service, dental hygiene and industrial health sections, and (11) a Rural Health Demonstration Centre at Pishan, which is being run in cooperation with the Szechuan Provincial Health Administration, to develop methods for improving rural health.

It is interesting to note that the Institute not only trains technical personnel at its laboratories and its field centres but also undertakes demonstration of methods for purchasing public health within the budgetary capacity of the people. Such an outlook is not unfortunately present in most public health institutes in India. For example, the Department of Sanitary Engineering at Chunking has made successful experiments with bamboo and wooden pipes in making sewage filters and rural water pumps. The problem of sewage disposal is an essential procedure to improve sanitation but cheaper methods have to be devised for economically backward countries. The problem of rural housing also engaged the attention of the Institute.

The Pharmacological Laboratories have undertaken to revise the standards of the Chinese Pharmacopoeia with special emphasis on their being adapted to Chinese raw materials and standards. India does not yet possess a Pharmacopoeia of her own in which her indigenous resources have been utilised.

An investigation of the nutrition of students in the suburban schools of Chunking showed that their dietary was 50 per cent deficient in protein and fat and 20 per cent deficient in calories, besides a certain degree of nutritional anaemia, deficiencies in calcium

and Vitamin C. It has been shown that Chinese green tea is twice as rich as red tea in carotene, which is a precursor of Vitamin A. An economical method of making yeast (Vitamin B) from crude cane sugar has been worked out.

The teaching of nursing is being carried out along practical lines, quite different from those followed in India. All nurses under training there are required to work at urban and rural Health Demonstration Centres. Undergraduate nurses are given a course in public health nursing, a subject which has not yet been developed in India. Training is also imparted in family health.

Training of Public Health Personnel section gives a course for sanitary engineers, sanitary overseers, public health courses for physicians and nurses, public health administration course, and several other allied courses. This orientation which is essential in any public health planning is almost absent in India.

The Mental Hygiene section by survey of psychological problems, education and consultation in clinics is doing good work.

The Department of Health Education has prepared a number of very useful films, charts, posters, models and brochures on public health experiments and their results and on facts and figures obtained from the country. Two of the films are interesting—(1) on "Wartime health activities", and (2) on "National Health Salvation through Health Promotion". This department is also responsible for the publication of the Quarterly Bulletin of the National Institute of Health.

The workers at the Institute are to be congratulated on the excellent planning and execution of various lines of work in spite of seven years of war in their midst. They are sending their workers for advanced study to India and America, in fact wherever they can get food for enriching their knowledge. If they can show such vitality in the midst of a devastating war, India could have made many useful advances to meet both peace time and war-time needs. We wish every Public Health Department and Institute to make a critical study of the methods being employed by China for her public health salvation. It would be much better if some of them can go over to China to study and assess the methods and results in the domain of public health.

CHEMOTHERAPEUTIC AGENTS AND EXPERIMENTAL TUBERCULOSIS

THE usefulness of chemotherapy in the treatment of some infectious diseases has strengthened the belief that chemical compounds may yet be found which will effectively combat the tubercle bacillus. The development of the sulfonamides has increased the fervour of those who seek such chemical weapons.

In 1938 sulfanilamide itself was found to exert an inhibitory effect on the development of tuberculosis in the highly susceptible guinea pig. The drug did not prevent completely the growth of the bacilli, but fewer organisms and less extensive lesions were observed in the treated animals. Toxic doses of the chemical were required to achieve this result. The sulfone promin has also been reported to have a notable inhibitory effect on the course of the disease in guinea pig. In the meantime a number of sulfonamides and related compounds have been studied with regard to their effect in experimental tuberculosis.

A recent report of Smith and his collaborators of the National Institute of Health merits especial attention because it deals with a large number of compounds, including sulfonamides, sulfones and comparable phosphorus containing compounds, and because it serves as a progress report on the problem of chemotherapy in experimental tuberculosis. Therapeutic tests carried out by these investigators on experimental animals infected with a virulent human strain of tubercle bacilli showed a favourable effect with the three drugs diaminodiphenylsulfone, promin and sulfadiazine as regards both the survival time and the retardation of progress of the disease. The mortality of an untreated group of infected animals was 81 per cent after one hundred and seven days, while the comparable percentage mortality of animals treated with promin was 44 and of those treated with either of the other drugs was 56. Notably

the extent of tuberculous involvement, as indicated by examination of several organs, was found to be much less in the animals treated with diaminodiphenylsulfone than in animals in the former group and presented an uninterrupted growth curve after cessation of treatment, indicating attenuation of the tubercle bacillus or arrest of infection. As pointed out by Smith and his co-workers, the toxicity of diaminodiphenylsulfone, which exerts its effect at 50 to 75 per cent of the lethal dose, makes it desirable to develop derivatives capable of producing the same or better effects with dosages further removed from the toxic level. According to these investigators promin does not fulfil this requirement but appears to be a step in the right direction. It is perhaps pertinent to mention that a phosphorylated derivative of diaminodiphenylsulfone has recently been prepared which, on the one hand, possesses only one-half to one-fifth the toxicity of the parent sulfone and, on the other hand, has a chemotherapeutic action against experimental pneumococcal infection which is superior to that of the original sulfone. Whether or not this phosphorylated derivative will prove effective against experimental tuberculosis remains to be seen.

Work on the problem of chemotherapy in experimental tuberculosis is still in the early stage. The more recent attacks on the problem have, however, yielded encouraging results and further developments are awaited. It is hardly necessary to point out here that tuberculosis induced experimentally in guinea pigs is dissimilar to tuberculosis in human beings. The progress of studies on the chemotherapy of tuberculosis in experimental animal is nevertheless of obvious importance. While the results of these investigations and the conclusions based on them cannot be directly applied to chemotherapy of tuberculosis in man, they do lead the way in the study of the latter problem.—(Editorial, *J.A.M.A.*, March 6, 1943).

DIAGNOSIS OF DISEASE BY ULTRACENTRIFUGE

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A METHOD of diagnosis of disease by centrifuging blood serum is being developed by A. S. McFarlane at the Lister Institute, London. Important preliminary works have been done with Svedberg's oil turbine ultracentrifuge at Upsala, Sweden, and these experiments have shown a very promising future of the new method. The principle lies in sorting out the protein molecules of albumin and globulin in the blood serum by high speed ultracentrifuging. This process shows changes in the sedimentation heads characteristic to a particular disease or the pathological condition of the blood.

Protein is the most important building mortar of the animal or plant body. The well-being of an individual depends obviously on the proper maintenance of the important organic constituents. As a matter of fact, a disease would affect not only the chemical properties of the constituents but also the physical characteristics of the molecules or colloidal particles which are found in abundance in the fluids of the living bodies.

Among the physical properties of proteins, their size and molecular weight stand out prominently. Professor Svedberg of Upsala in course of his exhaustive study on the physical properties of protein molecules, developed the epoch-making machine, the Ultracentrifuge, driven by oil turbine. The subsequent development of the air-driven vacuum ultracentrifuge by Beams and his collaborators at the Virginia University gives more convenience as regards the technique of the machine and its operation.

THE ULTRACENTRIFUGE

Just to give an introduction to the use of such machines it may be said that when extremely small particles of matter are suspended or emulsified in a bulk of liquid solvent, they cannot be precipitated by simply standing in a test tube, even when kept for years. Protein particles are of such small dimensions. Serum albumins are nearly $34 \text{ \AA}$ or 0.0000034 cm. in size. They may be precipitated out of the solvent only under a high speed of rotation in a centrifuge. The centrifuge, in fact, generates a high centrifugal field which is very similar to gravitational pull that brings sedimentation of the particles out of the suspension in a liquid. The higher the speed of rotation or larger the size of the rotor (the spinning container in which the liquid cell is put for analysis) the greater is the sedimenting centri-

fugal field. It is, however, customary to express the centrifugal field in terms of gravity: for instance, Svedberg's oil turbine ultracentrifuge gives a field of about 750,000 times gravity when spinning at a speed of 2,500 revolutions per second.

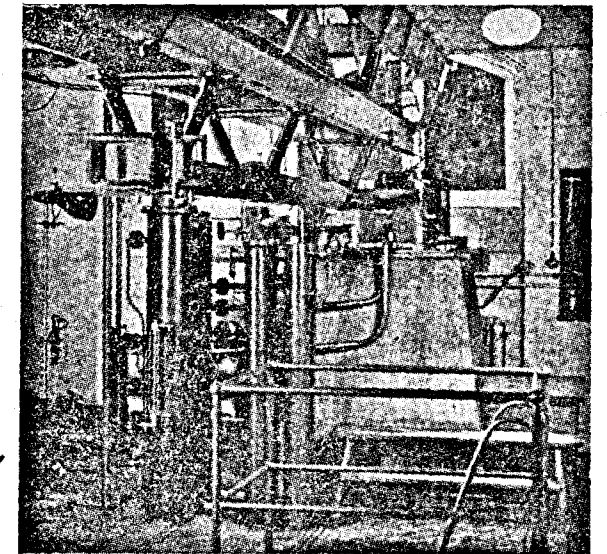


FIG. 1.—Oil-turbine ultracentrifuge laboratory at Upsala.

The ultracentrifuge shows, it is very important to note, that as regards molecular weight the proteins fall into two classes, first, those with molecular weights approximating to a multiple (*i.e.* twice, thrice, four times, etc.) of 35,000, and those with weights approximating to a multiple of 400,000. It is interesting to speculate how these fundamental units of colloidal particles come in the significant process of 'life'. We are, however, not at present much interested in this point. But it may be noted that under chemical and pathological conditions the physical characteristics of the protein molecules of living organisms may undergo remarkable changes by clustering together or breaking down to form heavier or lighter particles, retaining approximately the usual multiplicities. On the other hand, the Russian scientists have suggested, on the chemical aspects, that cancer can possibly be diagnosed by the quantitative analysis of different proteins by chemical method.*

* See the article on Biochemistry of Cancer—B. Zbarsky. —SCIENCE AND CULTURE, 6, 635, 1941.

CENTRIFUGING THE BLOOD SERUM

We shall discuss now the physical analysis of serum proteins in a centrifuge. When the red haemoglobin is removed, the pale

may be diluted with saline or distilled water. When subjected to the high speed spinning, the protein molecules in the solution begin to move radially towards the remote end of the containing cell. If

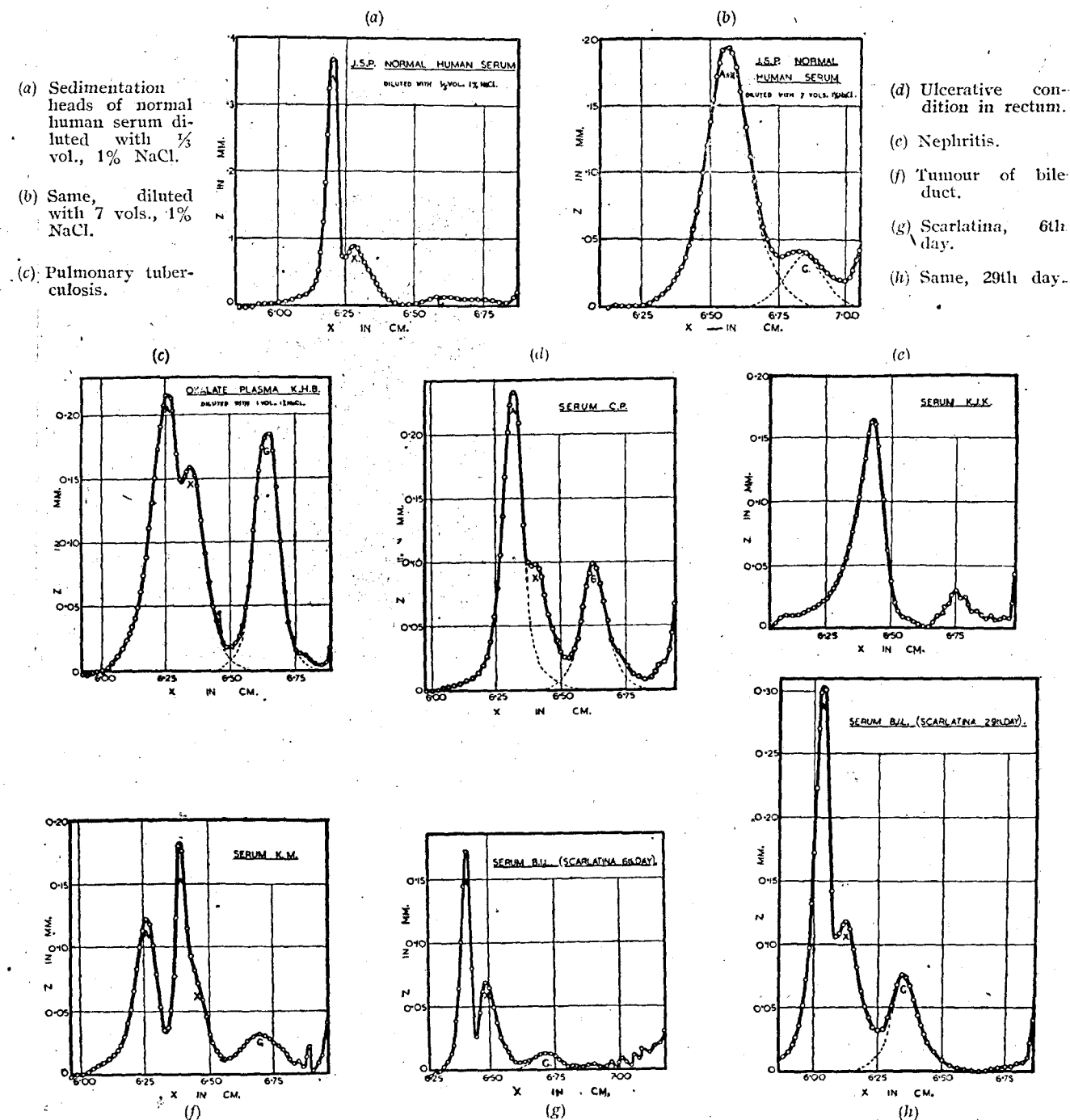


FIG. 2. Sedimentation diagrams of normal and pathological human sera.

amber fluid of the blood, called the serum remains behind. The serum may be directly filled full strength into the centrifuge cell, or

all the particles were identical, all of them would move equally and would leave the solvent (water) at the inner meniscus. The 'sedimentation head'

would be found to move slowly with progress of time, and the velocity of sedimentation under the centrifugal field could be measured with optical devices. If, on the otherhand, the particles are of different weights and sizes, they will show up a number of sedimentation heads. The distribution of these heads are measured, while rotating, either by observing the change of refractive indices of the fluid at different radial distances or by their optical transparencies. In the accompanying figures the ordinate (Z) represents the scale deflections in mm. indicating the kinks in the refractive indices due to the sedimentation heads. The abscissa (x) indicates the distance from the centre of rotation in cm.

It is interesting that the ultracentrifuge separates out the two types of proteins, namely, albumin, and globulin out of the dilute solution of blood plasma in saline water. It was found by P. Von Mutzenbecher in 1933 from the centrifuge experiments that the albumin is lighter than the globulin, and that they have molecular weights approximately 70,000 and 160,000 respectively, in terms of molecular weight units, with their corresponding sedimentation constants 4.5×10^{-13} and 7.1×10^{-13} . As a matter of fact the globulin settles faster than albumin, so that the sedimentation head of the globulin appears further towards the tip of the cell, while that due to albumin forms behind it and is nearer to the centre of rotation. K. O. Pedersen found that in concentrated sera the globulin molecules dissociated and created a feebler sedimentation head (x) between the main heads of albumin (A) and globulin (G), (see fig. 2, a) and even the effect had been different for different species of animal such as for horse, cow or man,—the globulin contents of the blood serum decreasing in order.

NORMAL AND PATHOLOGICAL SERA

A comparison of normal human serum with pathological sera has been made by McFarlane with ultracentrifuge to reveal a number of interesting differences. We have the general trend as follows:

(a) *Globulin content.*—The globulin content of the serum drawn from a diseased person is found to have generally increased to a great extent. In fig. 2, c the globulin head is almost as intense as the albumin head in the case of pulmonary tuberculosis.

(b) *New sedimentation heads.*—New heads in the sedimentation appear for some disease, as has been

found in the case of tumour of the bile duct. (Fig. f). The sedimentation heads are thus indicators of the particular disease.

(c) *Asymmetry of Albumin head.*—In normal serum, the sedimentation head is fairly symmetrical. But in certain diseases the head becomes unsymmetrical. For the particular disease 'nephritis' of the kidney, the slope of the curve (fig. e) becomes more flat towards the centre of rotation indicating the presence of smaller particles. This is caused probably due to the dissociation of the protein molecules of the albumin under particular pathological condition.

(d) *Increase of Globulin and Immunization.*—It is interesting that the globulin content usually increases in the bloods of the diseased persons, as we have noted in paragraph (a). It is quite likely that the globulins carry the immunity. A comparative centrifugal study of the serum from scarlet fever patients shows how the globulin head rises with the progress of time, as is found on examination on the 6th day and the 29th day after the attack. (Figs. g, h.)

Heidelberger and Pedersen have studied the immune sera and have shown that the antibody activity is carried by a globulin component of one of the sedimentation constants found in normal sera.

(e) *Globulin and its dissociated component.*—The dissociated globulin (the x-inflexion of the curves) varies in relative strengths in the case of different diseases.

We can therefore see that a large varieties of characteristic changes can be observed by the centrifugal study of blood sera affected differently under different conditions of diseases. Thus the method of diagnosis of disease by ultracentrifuge gives a new tool which is expected to be of great value when it has been more fully developed.

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BOOK REVIEWS

Algebra—By F. W. Levi, Published by the University of Calcutta.

Though Algebra has figured prominently in the course of studies for higher mathematical degrees of the Indian Universities for many years the study of modern Algebra has been started very recently. Much attention was previously paid only to the attainment of skill in manipulation, and less probably none to the immense possibilities of generalisations of the theorems and propositions established. Even in the text-books for the very advanced students there is not a casual remark that the truth of some theorem proved is not necessarily limited to the class of ordinary numbers. Professor Levi has done a signal service to the study of higher mathematics in the Indian Universities by compiling his lectures on Algebra delivered to the Post-Graduate Classes in the form of his present "Algebra". It may be hoped apart from supplying a much needed text-book on the subject in India it would bring about a permanent change in the point of view from which algebra should be studied in our schools and universities.

One cannot help mentioning the two very interesting dialogues which the author has introduced in the book. In them by a Socratic method the teacher exposes the erroneous arguments of the pupil who at first refuses to recognise the necessity for a general and strictly logical development of his subject and later sees no connection of what he has learnt with the mathematics of practical life. In the pupil one easily recognises the ordinary learner of algebra in our colleges. There are many students and even teachers who still argue like the pupil, to whom a perusal of these dialogues may be recommended.

The book is divided into six chapters. Chapter I is on systems of linear equations which is dealt with by the introduction of n -vector space, matrices etc.; in Chapter II the notions of modules, rings and fields are introduced, and the fundamentals of general algebra are developed; Chapter III contains sections on cyclotomic polynomials, Galoisfields, field $K(i)$, irreducibility of polynomials, symmetric polynomials, treatment of the cubic and the biquadratic, and the resultant; Chapter IV contains a brief development of the theory of continued fractions; in Chapter V the theory and practice of numerical solution of algebraic equations have been discussed; Chapter VI, the closing chapter of the book is on matrices.

It is hoped the book will prove an inspiration to those students and research workers who desire to study higher algebra.

N. S.

British Agricultural Research: Rothamsted—By Sir E. John Russell, F.R.S., Director, Rothamsted Experimental Station. "Science in Britain" Series, Published for the British Council by Longmans Green Company, 1942, Pp. 32. Price one shilling.

This is a pamphlet in the series "Science in Britain" whose object is to describe Scientific Institutions in Britain, and the life and work of the great British scientists of the present and the past. In this booklet Sir John describes the famous Rothamsted Experimental Station which is regarded as the senior of all Agricultural Research Institutions in the world.

The Rothamsted Experimental Station was started in 1843, out of the activities of a young English landowner of Rothamsted, John Bennett Lawes, who was "inspired by an insatiable curiosity about the plants and animals he saw growing around him, and also urged by the need of getting on." During the early days of his experiments, Lawes observed that bones when treated with sulphuric acid was converted into a substance called the superphosphate of lime which was found excellent as a fertiliser. This discovery of superphosphate has proved to be one of the greatest innovations in Agricultural Science and from this discovery has developed the great artificial fertiliser industry of the world.

The field experiments were actually started on a broad basis in June, 1843, by Lawes in collaboration with a young chemist, Joseph Henry Gilbert, with the chief crops of the time, wheat and turnip, to which they soon added barley, clover and meadow hay. In one series of classical experiments, "the crops were grown continuously, on the same land, receiving the same treatment, year after year; in another, they were grown in rotation. The purpose of the continuous experiments was to study the effects of the various fertilisers on the crops, and the consequences of omitting any of them; also to study the effects of soil exhaustion." The results showed that different crops require different additions of the plant food materials, nitrogen, phosphate and potash.

Lawes and Gilbert carried out extensive experiments, in those early days on animals, especially to find out the value of the different constituents of the food stuffs, about which, at that time, there was no precise knowledge. For this work, a number of farm animals were fed, and afterwards slaughtered and analysed to show the changes in chemical composition during growth and fattening. For a long time, the results of these painstaking experiments remained as the standard data on which several generations of students were brought up.

For the first eight years the chemical work had to be done in a barn which was fitted up as a laboratory. The British farmers were however so much impressed by the value of the work of Lawes and Gilbert, and specially by the use of superphosphate, that in 1854 they collected a sum of, nearly £1200, to build Lawes a larger and much better laboratory. This was opened in 1855 and remained in use till 1912. In 1889, Lawes set up a Trust, called the Lawes Agricultural Trust, and endowed it with £100,000, for the purpose of carrying on agricultural experiments, "wisely making the terms so wide that no limitation of work need arise, whatever direction science might take in the future." For the purpose of continuing his classical experiments he also gave to the Trust, the use of the fields on which they were conducted, 52 acres in all, for 100 years.

Lawes died on August 31st, 1900 and Gilbert on December 20th, 1901 and A. D. Hall became the Director of the Rothamsted Laboratory and Farm from 1902. Upto Hall's time agricultural science had been regarded in Britain mainly as a branch of chemistry, but Hall gradually secured the co-operation of a botanist, a bacteriologist, a soil chemist and an organic chemist and these workers, like a team, approached the problem of plant growth from different standpoints. One of the greatest achievements of Hall was to summarise the results of Rothamsted field plots and put them in a form in which they could be used by farmers, teachers and research workers alike. In 1907, the Goldsmith's Company gave a munificent donation of £10,000, for additional endowment and in 1911, the Development Commission set up by the British Government, in which Hall was appointed one of the Commissioners, gave a grant of £2,500 per annum to Rothamsted for research in soil and plant nutrition, which was raised to £2,850 in 1914. The farm and laboratory had to be extended at a cost of £6,000, of which half was given out of the Development Fund. In October, 1912, Hall left the post of Director of Rothamsted to be able to devote his time whole-heartedly as a Commissioner of the Development Fund and was succeeded by Sir E. John Russell as the Director. Since that time, the laboratory has extended considerably. The Rothamsted

Monograph "Soil Conditions and Plant Growth" by E. J. Russell, has summarised at one place, all the available information regarding the influences of the various factors and the demand for this monograph has been so great, that new editions were continuously called for, so that it has always been kept up to date. Of the multifarious problems which had been or are being tackled at Rothamsted or elsewhere, by the Rothamsted staff, may be mentioned: (1) the baking quality of wheat, (2) the effect of soil, season and manuring on the yield, composition and malting quality of barley, (3) the agricultural value of basic slag, (4) various fertiliser problems such as the respective values of the Alsatian and German potash deposits. The Imperial Bureau of Soil Science was established at Rothamsted on May 1st, 1929, with E. J. Russell as its Director.

In 1934, the Rothamsted Estate was purchased by the Experimental Station, and the experimental plots have been considerably enlarged. Rothamsted now works in several departments, *viz.*, Chemistry, Bacteriology, Physics, Botany, Entomology, Plant Pathology and Statistics. The Experimental Station is affiliated to the University of London and young graduates who wish to obtain the Ph.D. or D.Sc. degrees, can work here and obtain their degrees. The number of workers in the laboratories had increased from 28 in 1912 to 130, in 1941.

In June 1943, Rothamsted attained its Centenary. It was decided that the best way of commemorating this occasion would be to extend the laboratories, pot-culture houses and farm buildings, so as to accommodate the increased staff. The Centenary of Rothamsted has been celebrated on 21st July, 1943.

Many of the present leading scientists in various departments, all over the British Empire, have had part of their training at Rothamsted. The present booklet in which the chief aims and works of Rothamsted have been so vividly described, will prove to be a valuable handbook of information and inspiration not only to students and workers of Agricultural Science but to scientists, in general, all over the world.

S. P. R. C.

Science Lifts the Veil—By Sir William Bragg and others. Published by Longmans Green & Company. Price 1s. net.

This is the first of the new series of pamphlets being published from Great Britain with a view to popularise scientific developments in Britain in recent years. The pamphlet under review is the printed reproduction of the first series of broadcast talks on the conquest of the sub-visible universe, organised

by the British Broadcasting Corporation in collaboration with Science Committee of the British Council. The late Sir William Eragg chose the subject of the discussions and himself delivered the opening talk on "Science Lifts the Veil". Thirteen British scientists of the highest distinction have told the fascinating story of the gradual unveiling of the invisible sub-microscopic world whose knowledge, yet far from complete, has given man power to appreciate

the fundamental processes of life and the material world and control over the unseen enemies in the shape of bacteria and viruses to make life safer on this planet. The value of such a monograph containing the most up-to-date information on relevant chapters of modern physics, chemistry and biology in promoting popular interest in science need hardly be over-estimated.

S. N. S.

LETTERS TO THE EDITOR

[The editors are not responsible for the views expressed in the letters.]

ON THE LEAKAGE CURRENTS IN POGGENDORF'S POTENTIOMETERS

EVERYBODY who has ever worked with a potentiometer of this type must have experienced that when an e.m.f. is applied, there is always quite a large deflection even when the galvanometer circuit is broken. In e.m.f. measurements, the final result is decided by distinguishing a very small deflection about half a millimeter to the right from about the same deflection to the left. When such a small deflection is superposed on a large deflection sometimes amounting to several millimeters, the result becomes spurious and the experiment becomes very embarrassing. This large initial deflection is due to the leakage current which was not so far definitely localised and prevented. This leakage current is generally explained by the theory that the surface of the potentiometer board is covered by a thin coating of moisture. Moisture and dust do take part in this leakage but the potentiometer as it is generally constituted is mainly responsible for the leakage current. If certain changes are made in the body of the potentiometer, the harmful effects of dust and moisture can be easily eliminated altogether.

It is generally thought that the leakage takes place only through the upper surface of the board. The writer has found that with new potentiometers, the leakage is mainly through the upper surface whereas with old potentiometers the leakage is mainly through the lower surface. In old potentiometers, the long metal strip to which the galvanometer terminal is connected and the old card board on which the marble or the white glass plate rests short-circuit the leakage current, dust and moisture playing their part in the space between the long metal strip and the card-board flooring.

When the following changes are made, the leakage current is eliminated altogether:—

(1) The long metal strip on the potentiometer board should be done away with; (2) The galvanometer contact should be brought direct to the top of the triangular slider; (3) The card board flooring of the glass or marble plate should be replaced by rubber cloth, one or two layers; (4) The metal legs of the triangular slider should be replaced by ebonite legs; (5) The ebonite legs of the triangular slider should not slide on the board direct but on two detachable strips of ebonite placed on the board. These two strips should not be permanently fixed and should be kept apart from the board after each experiment; (6) The body of the triangular slider should be enamelled with a non-conducting paint.

The diagram (Fig. 1) given below gives the connections in a series of experiments done on the leakage current and the observations are given in the Table I to III. These Tables show that the leakage

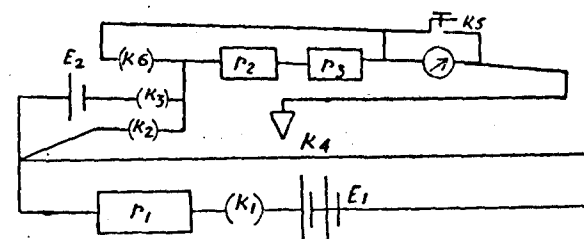


FIG. 1.

E_1 —A storage battery, 4 volts.
 E_2 —A Standard Cadmium cell.
 r_1, r_2, r_3 —Ordinary resistance boxes.
 r_4 —A megohm resistance box.

Figure of merit of the galvanometer is of the order of 10^{-7} amps.

current is eliminated altogether by the changes suggested above.

In the Tables given below, the sign $\times$ means that the key is open and the letter C means that the key is closed.

TABLE I

$K_1, K_2, K_3, K_4, K_5, K_6, r_1, r_2, r_3$	deflection in mms.	Remarks
$\times \times \times \times \times C 0 0 0$	0	Ordinary potentiometer with metal strip and metal legs.
$\times \times \times \times C C 0 0 0$	0	
$\times \times C \times \times C 0 0 0$	2	
$C \times \times \times \times C 0 0 0$	0	
$C C \times \times \times C 0 0 0$	-3	

TABLE II

$K_1, K_2, K_3, K_4, K_5, K_6, r_1, r_2, r_3$	deflection in mms.	Remarks
$\times \times \times \times \times C 0 0 0$	0	Modified potentiometer—the ebonite legs resting directly on the potentiometer board.
$\times \times \times \times C C 0 0 0$	0	
$\times \times C \times \times C 0 0 0$	1	
$C \times \times \times \times C 0 0 0$	0	
$C C \times \times \times C 0 0 0$	-0.6	

TABLE III

$K_1, K_2, K_3, K_4, K_5, K_6, r_1, r_2, r_3$	deflection in mms.	Remarks
$\times \times \times \times \times C 0 0 0$	0	Modified potentiometer—the ebonite legs sliding on ebonite strips.
$\times \times \times \times C C 0 0 0$	0	
$\times \times C \times \times C 0 0 0$	0	
$C \times \times \times \times C 0 0 0$	0	
$C C \times \times \times C 0 0 0$	0	

NARAYAN MISRA.

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 Ravenshaw College,
 Cuttack, 27-8-1943.

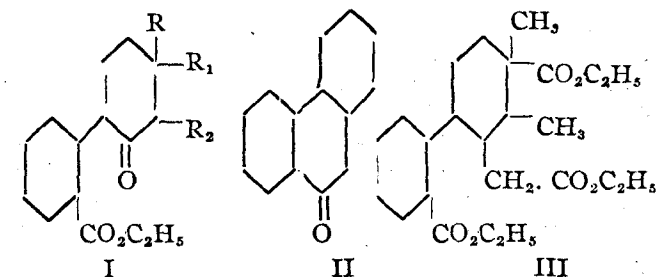
SYNTHETIC INVESTIGATIONS IN PERHYDRO-PHENANTHRENE DERIVATIVES

WITH the elucidation of the structures of sterols and bile acids, the chemistry of perhydrophenanthrenes has gained singular importance. Quite recently, Linstead *et al*¹ have undertaken investigations on the stereochemical problem of simple perhydrophenanthrene, and by carrying out a series of ingenious experiments have made considerable progress in this direction. Most of the perhydrophenanthrene derivatives, employed by Linstead for the above study, have been obtained by catalytic hydrogenation of the corresponding phenanthrenes and partially hydrogenated phenanthrenes. The only synthetic method available for the preparation of

such completely reduced phenanthrene skeleton worth mentioning is that developed by Robinson and Rapson.²

In the present communication there has been described a general method for the preparation of perhydrophenanthrene and its derivatives, which offers promise for the synthesis of perhydro-1:2-cyclopentanophenanthrene with the angular methyl groups, as present in the sterols and bile acids.

For the preparation of 2-(2'-carbethoxycyclohexyl)-cyclohexanone derivatives (I), which have been utilised as the starting materials, a method similar to that of Banerjee³ and Banerjee and Roy (private communication) for the synthesis of ketodeoxyoestrone acid and 1:2-(di-p-hydroxyphenyl)-cyclohexane respectively, has been employed.



The potassium salt of ethyl 2-carbethoxycyclohexylcyanacetate was condensed with ethyl δ -iodovalerate in boiling xylene solution, when diethyl α -cyano- α -(2-carbethoxycyclohexyl)-pimelate b.p. 179-182°/0.4mm. was obtained in moderately good yield. The above cyanoester was hydrolysed by refluxing with a mixture of sulphuric and acetic acids. The resulting crude tricarboxylic acid was esterified to yield diethyl α -(2-carbethoxycyclohexyl)-pimelate b.p. 190°/4mm., which was treated with sodium dust in benzene solution. The Dieckmann product (I, $R=R_1=H$ and $R_2=CO_2C_2H_5$), which gave a violet colouration with ferric chloride, could not be distilled without decomposition and was hydrolysed in the crude state with a hydrochloric-acetic acid mixture to give 2-(2'-carboxycyclohexyl)-cyclohexanone. The ethyl ester (I, $R=R_1=R_2=H$) b.p. 151°/4.5mm. (oxime m.p. 138-140°) was reacted on with zinc and ethyl bromoacetate in dry benzene (thiophene free) solution, when ethyl 2-hydroxy-2'-carbethoxycyclohexyl-2-acetate was obtained boiling at 140-150°/0.4mm. The Reformatsky product was dehydrated with thionyl chloride and pyridine to the corresponding unsaturated ester b.p. 180°/4mm., which on hydrolysis furnished a solid unsaturated dicarboxylic acid (m.p. 195-200° dec.). The unsaturated acid by hydrogenation over Adam's catalyst yielded a gummy acid, which has so far resisted all attempts at crystallisation. The saturated dicarboxylic acid was esterified with diazomethane.

Methyl 2-carbomethoxydicyclohexyl-2-acetate b.p. $153^{\circ}/3$ mm., thus obtained, was cyclised by means of sodium dust in benzene solution to yield perhydro-9-keto-10-carbomethoxyphenanthrene. Perhydro-9-ketophenanthrene (II) b.p. $133^{\circ}/4.5$ mm., (oxime, m.p. $217-218^{\circ}$ dec.) was obtained by the hydrolysis of the above β -ketonic ester in the usual manner. Melting point of the oxime of perhydro-9-ketophenanthrene obtained by Linstead¹ (cf. Robinson and Rapson *loc. cit.*) is $227-228^{\circ}$, so that the two compounds seem to differ in stereochemical configuration. Experiments, however, are being carried out in a manner similar to that of Linstead *et al.*⁴ in order to throw light on the configuration of our compound.

Following preliminary experiments have been carried out in order to investigate the possible extension of the above method for the preparation of perhydro 1:2-cyclopentanophenanthrene derivatives.

The sodio salt of ethyl 2-carbethoxycyclohexylcyanacetate was condensed with β -chloroethylmethylketone to yield ethyl α -cyano- α -(2-carbethoxycyclohexyl)- γ -acetylbutyrate b.p. $215^{\circ}/5$ mm. (semicarbazone m.p. 115°), which on hydrolysis and subsequent esterification furnished ethyl α -(2-carbethoxycyclohexyl)- γ -acetylbutyrate b.p. $150-155^{\circ}/2$ mm. in good yield. The above keto-ester was condensed with ethyl cyanacetate according to the modified method of Cope *et al.*⁵ and the resulting unsaturated cyano-ester b.p. $201-205^{\circ}/1.5$ mm. smoothly added on a molecule of hydrocyanic acid to give diethyl α -(2-carbethoxycyclohexyl)- α' : β' -dicyano- β' -methylpimelate, which on hydrolysis followed by esterification yielded diethyl α -(2-carbethoxycyclohexyl)- β' -methyl- β' -carbethoxypimelate boiling at $205-210^{\circ}/3$ mm. The above tetracarboxylic ester was treated with pulverised sodium in dry benzene solution. The β -ketonic ester (I, $R=CH_3$, $R_1=R_2=CO_2C_2H_5$), thus obtained, gave positive ferric chloride colouration and its sodio-derivative was methylated by means of methyl iodide in benzene solution to yield 2-(2'-carbethoxycyclohexyl)-5:6-dimethyl-5:6-dicarbethoxycyclohexanone, which boiled at $200-210^{\circ}/4.5$ mm. with slight decomposition and did not give any colouration with alcoholic ferric chloride. The above keto-ester was hydrolysed with concentrated hydrochloric acid and the resulting product was esterified, when 2-(2'-carbethoxycyclohexyl)-5:6-dimethyl-5-carbethoxycyclohexanone was obtained boiling at $185^{\circ}/3.5$ mm. The keto-ester (I, $R=R_2=CH_3$, $R_1=CO_2C_2H_5$) was refluxed with zinc, ethyl bromoacetate and benzene and the resulting crude reaction product, after separation from low boiling constituents was treated with thionyl chloride and pyridine. The unsaturated ester b.p. $200-205^{\circ}/3.5$ mm., thus obtained, was hydrogenated over Adam's catalyst in acetic acid solution to yield ethyl 2-carbethoxy-3:4-dimethyl-4-carbethoxydicyclohexyl-2-acetate (III) b.p. $205^{\circ}/4.5$ mm.

My thanks are due to Prof. P. C. Mitter for his encouragement and valuable advice and to Dr D. K. Banerjee for his generous help during the course of this investigation. My thanks are also due to Mr N. N. Ghose, M.Sc., for microanalysis of some of the compounds.

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- ¹ Linstead *et al.*, *J. C. S.*, 842, 850, 1939; *J. Am. Chem. Soc.*, 64, 1985-2022, 1942.
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SPECTROPHOTOMETRIC ESTIMATIONS OF BISMUTH

In the author's last note¹ it has been stated that bismuth can be estimated colorimetrically upto the extent of 37 both by the re-agents dimercaptobiazole and phenyldithiobiazolonthiol as the intensity of colours varies regularly according to Beer's Law when peptised by gum-acacia. It has now been observed spectrophotometrically that with dimercaptobiazole the maximum absorption occurs in the region $470m\mu$ and that with phenyldithiobiazolonthiol, the maximum absorption occurs at $460m\mu$. That the Beer's Law is followed by both the coloured systems is shown by the fact that straight lines are obtained when the logarithms of the observed transmittancies at $470m\mu$ and $460m\mu$ for seven solutions containing from $6.48 \times 10^{-5}g$ to $6.48 \times 10^{-4}g$ of bismuth, were plotted against the respective concentrations. Effects of diverse ions on the colour systems of the bismuth compounds by the re-agents as also the effects of organic solvents on the bismuth compounds have been studied.

Details will be published elsewhere.

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¹ A. K. Majumdar—*J. Ind. Chem. Soc.*, 19, 396, 1942.

THE EFFECT OF THERMAL TREATMENT ON THE CHEMICAL AND PHYSIOLOGICAL PROPERTIES OF A FEW EDIBLE OILS

In the course of investigations on the absorption and nutritive value of different edible oils used in India, it was observed that the chemical and physiological properties of oils were markedly altered by thermal treatment. The chemical properties and the absorption of a few normal and thermally treated oils determined by balance method are given in the following table. The oils were heated at the specified temperatures at the normal atmospheric pressure and the samples were procured from the market.

Oil	Temp. °C.	Saponification value	Iodine value	Acid value	Percentage of absorptions
Groundnut oil	Normal	184	83.5	9.6	99.7
	200	184	81.5	7.2	99.7
	250	186.5	83.0	5.3	99.7
	275	190	84.2	2.8	99.7
	300	192.5	76.0	2.5	99.5
Cocoanut oil	Normal	250	10	3.6	98.4
	200	246	10	3.4	98.3
	250	246	10	1.1	98.3
	275	246	7.4	0.58	96.4
	300	240	6.6	—	94.9
Mustard oil	Normal	174	100	5.4	95.5
	200	172	99.5	3.8	95.2
	250	172	92.6	3.3	95.2
	275	170	87.0	1.8	91.7
	300	166.5	78.0	—	88.7
Sesame oil	Normal	189	109	13.4	96
	200	189	107	11.2	96
	250	187	96	4.4	95
	275	189	88	1.3	94
	300	190	83	—	92.5
Linseed oil	Normal	192	187	2.6	97
	200	191	174	2.4	95.9
	250	189	144	2.2	94
	275	187	136	—	90.8
	300	187	98	—	78.3
Cow ghee*	Normal	197	56.5	1.3	99.2
	250	199	56.7	0.8	98.2
	250	196	50.8	0.5	97.0
	275	199	48	—	96.4
	300	199	42.7	—	90.6
Buffalo ghee*	Normal	195	61	2.6	98.8
	200	197.5	60.8	2.4	98.6
	250	195	56.7	1.8	97.8
	275	199	50	1.8	93.5
	300	197	46.8	—	85.8

*Adulterated sample.

The investigations on the effect of thermal treatment on hydrogenated oils and animal fats and of

addition of vitamins on the absorption of oils mentioned above are being continued.

The work is being carried out under the auspices of Lady Tata Memorial Trust.

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LUMINESCENCE OF ANTHRACENE UNDER X-RAYS

ANTHRACENE has for a long time been known to fluoresce in the ultra-violet light. The strong greenish fluorescence of this compound has been reported¹ to be due to naphthalene present in it as impurity. Anthracene also fluoresces very strongly when it is irradiated by X-rays.

Aromatic compounds consisting of a single or large number of condensed benzene nuclei, according to the quantum mechanical theories of the structure of these molecules, have got mobile electrons in their molecules. The mobile electrons are, however, free to migrate from atom to atom over the whole ring. This fact is utilised to explain the high degree of magnetic anisotropy exhibited by these molecules.

Anthracene has got the structure ,

the characteristic absorption and fluorescence of these molecules are presumably due to the transition of these mobile electrons present in the molecules.

In the modern wave-mechanical theory of the solid state, a solid is regarded as a large molecule, in which each valency electron is in a definite energy state like the electrons in an isolated single atom. They, however, occupy an energy spectrum composed of zones of energy levels in the solid state, and the observed differences in the various solids can be correlated largely with differences in the distribution and population of these zones. The spectrum of solids thus consists of broad bands instead of sharp lines as observed in isolated atoms. The investigation of the absorption and the luminiscence spectra of the substance is, therefore, expected to give us a fair idea of the energy levels of the mobile electrons of the substance as contemplated in the quantum mechanical theory.

The luminiscence of anthracene under ultra-violet excitation has been spectroscopically studied by many authors. The following table (Table I) gives the results obtained by Pringsheim.²

The spectra of anthracene in the vapour state can reasonably be assumed to give us the energy levels of the mobile electrons of the molecules. It shows that the electrons have levels at 3.428, 3.39, 3.348, 3.197, 3.028, and 2.87 volts higher than the normal configuration. The absorption spectra in

tuting carbon atoms. These electrons moving through the lattice soon lose energy by collision processes and may get trapped in some of the unfilled band. In an alternative process the electrons knock out the optical electrons from the same or some other molecules; in both the cases emission is possible.

TABLE I

WAVELENGTH OF C. G. OF BANDS OF FLUORESCENCE IN A. U.

Vapour	3600, 3640, 3685 (m)	3860 (st)	4075 (m)	4300 (v.w.)	
Soln. in benzene	3855 (m)	4065 (st)	4285 (st)	4565 (m)	4870 (v.w.)
Soln. in Naphthalene solid	3965 (m)	4140 (st)	4395 (st)	4680 (w)	
Pure crystal	4025 (m)	4220 (st)	4450 (st)	4735 (m)	5090 (v.w.)

this case should be expected at the same position. Spectra of the vapour state also show the following characteristics: the first band consists of three peaks, almost equidistant, gap between them being 0.04 volts approximately; the four main bands are also equally spaced. The spectrum as a whole undergoes a shift towards longer wavelength and becomes less sharp in the pure crystal and in solution (Table II). This effect may reasonably be attributed to the higher dielectric constant of the media and the increased mutual interaction between the molecules. The spectral shift towards longer wavelength side in the solid state shows that the energy differences between levels have decreased.

TABLE II

THE POSITION OF THE BANDS IN VOLTS

Solid state			Vapour state		
1.	3.428		1.	3.065	
	3.39	0.038	2.	2.92	0.146
	3.348	0.042	3.	2.77	0.15
2.	3.197	0.15	4.	2.60	0.17
3.	3.028	0.169	5.	2.42	0.18
4.	2.87	0.158			

The comparison between two sets of observations indicates that the energy spectrum of the mobile electrons retains much of their nature in the solid state and the crystalline field only slightly modifies its nature although it affects the absolute value of the energy bands and slightly broadens them.

The production of luminiscence by X-ray excitation is supposed to take place through the release of photoelectrons first, which then excites the electrons in the optical levels. The absorption of X-rays by anthracene crystal results in the release of electrons probably from only inner shell of the consti-

From such a consideration, we expect the emission spectra to undergo some change when excited by X-ray. It may, therefore, be of some interest to compare the results obtained by X-ray excitation with those by ultraviolet light.

Another important fact about X-ray excitation is the question of impurity. If the impurity be present in very minute traces, which is usually the case, the absorption of X-rays by this small quantity cannot account for the high intensity of emission in anthracene. If the emission is due to impurities alone, there must be assumed to be present in the crystal a highly efficient mechanism which is not yet clearly understood for carrying the excited electrons to the levels of the impurity molecules. The positions and nature of the emission bands should also be different from those in the vapour state and pure crystal.

The fluorescent spectrum of anthracene, excited by X-ray, consists of three distinct bands in the visible regions, as has been obtained with the help of a Fuess Spectrograph with glass prism (Table III).

TABLE III

BAND EXTENSION	C. G. OF THE BANDS IN VOLTS	
1. 4911—5041 (in A.U.) 251—245 (in volts)	248	0.16
2. 5232—5396 (in A.U.) 236—239 (in volts)	232	0.16
3. 5658—5763 (in A.U.) 218—214 (in volts)	216	

The centre of gravity of the bands are as before equidistant with a gap of 0.16 volts. The band system has shifted towards the longer wavelength side by an amount of 0.6 volts. Only three bands are present; perhaps other bands have shifted into the infra-red region. The frequency of the emitted light is given by $\lambda\nu = E_a - E$

Where E_a = The energy of the excited state,

and E = The energy of the state into which the excited electron falls, i.e., the energy of the ground state of mobile electrons in the unexcited molecules in the case of ultraviolet excitation.

Since the shift of the C.G. is the same for all the bands, it is probable that by X-ray excitation the energy E of the final state in the emission process has been raised by 0.6 volts in the case of anthracene crystal while the upper levels remain mostly unaffected. Most probably this is due to the fact that the transition is occurring in a molecule which has already been stripped of one or two electrons from its constituent atoms. In this connection it may be mentioned that the emission lines of K α group of the compounds of first group of elements shift to longer wavelength side of the spectra than those from pure elements. Further discussion will be taken up in a later paper.

The electronic levels in the free molecules are generally comparatively sharp at the room temperature. The effect of the lattice is to broaden the levels. The width of the band is, therefore, dependent upon the lattice influence and temperature effect.

Mott and Gurney³ have given a theoretical formula for the broadening of the discrete level due to coupling with the thermal vibration of the lattice. For strong coupling,

$$h \Delta \nu = \sqrt{h \nu_0 k T},$$

If we calculate the broadening with this formula in our case we obtain the following results:—

TABLE IV

Band	Width calculated (volts)	Width observed (volts)
1	0.24	0.06
2	0.245	0.07
3	0.25	0.04

The wide divergence between the two sets shows that the electronic levels in question for this substance are almost unperturbed by the thermal vibration of the lattice.

My thanks are due to Prof. B. B. Ray, D.Sc., Khaira Prof. of Physics, Calcutta University, for his keen interest in the work and helpful discussions.

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¹ P. Fringsheim, *Trans. Farad. Soc.*, 1939.

² *Loc. cit.*

³ Electronic processes in Ionic Crystal, Mott & Gurney.

ON THE CONSTRUCTION OF SOME NATURAL FIELDS

In this note an attempt has been made to formulate a type of 'natural' fields following the specifications of Mahalanobis¹: ρ will be positive and gradually fall off to 0 with increase of (ξ, η) ; this decrease is to be genuine, not caused simply by the boundary-effects.² From physical considerations it is apparent that such a field will have some suitable hierarchical (or multi-stage) random structure. A few simple cases have been discussed below. We start with a uni-dimensional two-stage field of length h , sub-divided into equal strips of length a . ($a \ll h$). The variate z is given by $m + \alpha + \beta$, where m is a constant, α is a random variable constant for any strip, but varying from strip to strip, and β is another independent random variable, varying from point to point within the strips. $E(\alpha) = E(\beta) = 0$, $E(\alpha^2) = \sigma_1^2$ and $E(\beta^2) = \sigma_2^2$. (E denotes the expectation value). We can now easily evaluate ρ . (ρ_1 is equal to ρ for all the fields discussed here).

$$\rho = \frac{(a - \xi) \sigma_1^2}{a (\sigma_1^2 + \sigma_2^2)}, \text{ for } 0 < \xi \leq a;$$

$$\text{and } \rho = 0, \text{ for } \xi \geq a$$

where ξ refers to its absolute value $|\xi|$.

Thus ρ tends to $\sigma_1^2 / (\sigma_1^2 + \sigma_2^2)$ as ξ tends to 0. ($\rho=1$, for ξ absolutely equal to 0, but then ξ is not an interval, which even in the limit must consist of two contiguous points). ρ falls off linearly with increasing ξ , and remains steady at 0 after reaching $\xi=a$. If $\sigma_1^2 \gg \sigma_2^2$ (within-strips variation negligible), $\rho=1$ as ξ tends to 0. Whereas, when $\sigma_2^2 \gg \sigma_1^2$ (between-strips variation negligible) the field degenerates into a simple uni-stage random one, and ρ is 0 for all values of ξ (excepting ξ equal to absolute 0).

It is easy to pass off to three (or more) stages of hierarchy. For three stages, each strip is further split up into sub-strips of length b ($b \ll a$): z is given by $m + \alpha + \beta + \gamma$, β being constant for any sub-strip

but different for different ones, and γ varying from point to point. $E(\gamma)=0$, $E(\gamma^2)=\sigma_\gamma^2$. Some typical values of ρ are shown below.

$$\rho = \frac{\sigma_1^2 + \sigma_2^2}{\sigma_1^2 + \sigma_2^2 + \sigma_3^2}, \text{ for } \xi \ll b;$$

$$\rho = \frac{\sigma_1^2}{\sigma_1^2 + \sigma_2^2 + \sigma_3^2}, \text{ for } \xi \geq b, \text{ but } \ll a;$$

and $\rho = 0$, for $\xi \geq a$.

It is also easy to pass off to fields of two or more dimensions. For a two-dimensional two-stage field sub-divided into numerous rectangular blocks of size $a \times b$, the blocks play the part of strips of the uni-dimensional field, and we get

$$\rho(\xi, \eta) = \frac{(a - \xi)(b - \eta)\sigma_1^2}{ab(\sigma_1^2 + \sigma_2^2)},$$

for $0 < \xi \leq a$, and $0 < \eta \leq b$;

and $\rho = 0$, for $\xi \geq a$, or $\eta \geq b$.

Expressing the interval (ξ, η) in the corresponding terms—say, (r', θ') —for polar co-ordinates, we

find that for a constant θ' , ρ is given by a quadratic expression in r' . It becomes linear when θ' is equal to an integral multiple of $\frac{1}{2}\pi$; these principal rectangular directions may be portrayed in nature by the edges of a rectangular agricultural plot in, say, some yield—estimating survey. The case of a statistically isotropic field is being studied. With regular hexagonal blocks (instead of rectangular ones) in a bee-hive pattern, we get a fair approximation to the isotropic field. It may be noted that z is not given by any mathematical function of x and y , but by stochastic variables; this is also to be expected in nature.

The variance function³ of a rectangular grid (i.e. dependence of variance on shape and size of grid) for the above fields has been worked out from the correlation function; some grid-perimeter effects (owing to discrete texture of field and observational errors) have also been considered. The results will be published elsewhere.

My thanks are due to Prof. P. C. Mahalanobis and S. N. Roy for their kind interest.

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Calcutta, 6-9-1943.

BIRENDRANATH GHOSH.

¹ SCIENCE AND CULTURE, 8, 424, 1942-43.

² SCIENCE AND CULTURE, 9, 46, 1943.

³ Sankhya, 4, 513.

SUPPLEMENT

SYMPOSIUM ON POST-WAR ORGANISATION OF SCIENTIFIC RESEARCH IN INDIA

A Symposium on 'Post-war organisation of Scientific Research in India' was held under the auspices of the National Institute of Sciences of India at Calcutta on the 27th and 28th September, 1943. Sir J. C. Ghosh, President of the National Institute, was in the Chair. The proceedings were opened by the Hon'ble Sir M. Azizul Haque, Commerce Member of the Government of India.

During the course of the Symposium papers were read in which the general principles underlying the planning and co-ordination of scientific research and the constitution of the organisations for the purpose as developed in the leading nations of the world were explained, an account was given of the work done by the various research institutions in India (Government departments, Universities and other unattached institutions) and attention was drawn to the problems facing post-war India. The following persons participated in the discussion:—

Sir J. C. Ghosh, Dr. K. G. Naik, Prof. M. N. Saha, Sir S. S. Bhatnagar, Dr. J. de Graaf Hunter, Dr. C. W. B. Normand, Prof. J. N. Mukherjee, Rai Bahadur S. L. Hora, Prof. S. K. Mitra, Prof. B. C. Guha, Dr. J. A. Dunn, Prof. P. C. Mahalanobis, Dr. H. K. Sen, Prof. S. P. Agharkar.

Papers for discussion were sent by Dr. J. B. Grant, Sir Cyril S. Fox, Sir John Taylor, Prof. H. J. Ehabha, Dr. D. M. Bose, Prof. V. Subrahmanyam, Lt-Col. S. S. Sokhey, and Rao Bahadur B. Viswanath.

Proposals for constituting a National Research Council were discussed and the following resolutions were adopted:—

I. The Council of the National Institute of Sciences of India be authorised to take necessary steps for the organisation of a National Research Council constituted under the statutory authority of the Government of India. The National Research Council shall be directly responsible to the Government and have the following functions:—

(a) To plan the main lines of scientific work in accordance with national needs, to formulate schemes for the above purpose, to review and modify the same

whenever necessary and to recommend ways and means for implementing the results of accomplished researches.

(b) To ensure balanced development of all branches of Science, and minimise overlapping.

(c) To advise and help relevant authorities regarding the training and supply of scientific personnel for pure and applied research.

CONSTITUTION

National Research Council

The National Research Council shall consist of scientific and technical experts not exceeding 60 in number, the majority of whom shall be elected by non-official scientific organisations, including Universities and institutions of University rank, the remaining number being nominated by the Government of India from among the scientific and technical experts. The President of the National Research Council shall be nominated by the Government of India from among the members. A Vice-President shall be elected by the National Research Council from among its members. A whole-time salaried Secretary shall be appointed by the National Research Council for carrying on its work, who will not be a member of the Council.

Governing Body of the National Research Council

There shall be a Governing Body of the National Research Council which shall consist of the following:—

The President and Vice-President of the National Research Council, and the Chairman and Vice-Chairman of each of the Boards.

Boards of Research

For the performance of its functions the National Research Council shall constitute the following Boards of Research from among its own members, each of which will be responsible, within its own

particular sphere, for giving effect to the policy of the National Research Council:

1. Board of Scientific Research,
 2. Board of Agricultural Research (Soils, Crops and Animal Husbandry),
 3. Board of Medical and Public Health Research,
 4. Board of Engineering Research,
- and such other Boards as may be considered to be necessary.

The maximum number of members of each of the Boards of Research shall be 50. The National Research Council shall appoint the Chairman and Vice-Chairman for each Board and shall co-opt eminent scientific workers in different branches in consultation with non-official scientific organisations, Universities and institutions of University rank, scientific departments of the Government and Federations of Chambers of Commerce.

Research Committees

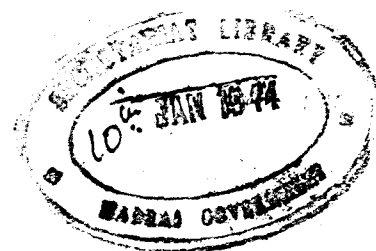
For the performance of its work, each Board will be authorised to constitute Research Committees for all important subjects, to settle the objectives of research, indicate the individuals or organisations which could undertake the several component

parts of the enquiry, receive and co-ordinate the resulting information, make it available to those who will turn it to advantage and to form a national plan into which all who are in a position to contribute information can fit the particular lines of research. Governing Bodies of National Research Laboratories, when established, shall be constituted in consultation with the relevant Research Committees.

II. The Government of India be requested to form development corporations for the performance of functions analogous to those performed by the Research Enterprises Ltd. in Canada. The National Research Council shall be represented on the Governing Bodies of the development corporations.

III. To enable effect being given to the policy of scientific development determined by the National Research Council, the Government of India should make an annual grant of five crores of rupees per annum.

It was decided that these proposals be circulated to the Government Scientific Departments, Universities, learned societies and unattached institutions for expression of their views and discussed, with a view to their being given effect to, at another Symposium meeting to be held at Delhi towards the end of the year at which representatives of the relevant organisations would be invited to be present.



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A NATIONAL RESEARCH COUNCIL FOR INDIA*

TEN years ago, the Indian Science Congress Association appointed a Committee to devise a scheme of a Central Organisation which was to effect co-ordination between scientific academies, societies, institutions, Government scientific departments and services. As a result of their devoted and painstaking work, the National Institute of Sciences was founded in 1935, with a Council consisting of a President, six Vice-Presidents, two Secretaries, a Foreign Secretary, a Treasurer and 22 ordinary members of Council. Of the six Vice-Presidents, four are nominated—one each by the Indian Academy of Sciences, the National Academy of Sciences, the Royal Asiatic Society of Bengal and the Indian Science Congress Association. Of the 22 ordinary members of the Council, four are nominated in the same manner as the Vice-Presidents.

This constitution of the Council is designed to ensure that the relationship of the Science Academies and the learned societies in India to the National Institute is one of co-operation between independent bodies. In no case has it been suggested that the relationship is one of subordination or affiliation like that existing between the French Academies and the Institute of France. The aim has always been to provide a reservoir of knowledge and experience available for application to the study of all scientific problems connected with the general welfare of the country. We have in the past tried partially to achieve this aim by regularly holding symposiums on problems of wide scientific interests. But no serious attempt has been made until recently to implement objective 2 (d) in the articles of our Association, which reads as follows:—

"To act through properly constituted National Committees, in which other learned Academies and Societies

will be associated, as the National Research Council of India, for undertaking such scientific work of national and international importance as the Council may be called upon to perform by the public and by Government."

Men of science in India have rendered whatever service they could with their limited resources in the present emergency when called upon to do so. They felt, however, that they could have rendered more effective service if a National Research Council were in existence. In England, the War Cabinet is helped by a Scientific Advisory Committee which has been set up under the Lord President of the Council, and a magnificent machinery of scientific research and development has been created both for offence and defence and for maintaining a stable base of health and welfare at home. In a broadcast from Delhi on the 5th December last, Prof. Hill observed "that the history of the present war has taught us that to neglect research is to invite calamity. The Battle of Britain depended on the courage and skill of a few brave young men in Hurricanes and Spitfires—but it depended also on the knowledge and skill of a few scientists sitting behind cathode ray tubes. The Battle of the Atlantic has depended on the courage and skill of sailors and airmen, but it has depended also on the scientists and engineers who devised and used the means of intercepting the U-boats and confounding their devices. The fact that in spite of our hardships the health and good humour of the people in Britain is at least as high as in ordinary times has depended on vigorous administrative action based on knowledge of nutrition, health and even applied psychology."

In his recent Pilgrim Trust Lecture to the Royal Society, President K. T. Compton of the Massachusetts Institute of Technology has described the war-time scientific organisation of the United States of America. First they created the National Roster of Scientific and Specialised Personnel. Do you wish

* Adapted from the presidential address by Sir J. C. Ghosh at the Annual General Meeting of the National Institute of Sciences of India, held at Delhi on the 30th Dec., 1943.

to know the names of all Americans who possess a knowledge of epidemiology and chemotherapy, who are competent in the diagnosis and control of protozoal and bacterial infections, have a knowledge of the Hindusthani language and have travelled in the tropics? To secure this information, the stops of the punch-card sorting mechanism are pushed in at the appropriate places, the cards are ground through the machine, and all those who conform to the above specifications fall out together. Next they established the Office of Scientific Research and Development with Dr Bush, President of the Carnegie Institute of Washington as Director. This office places annual contracts of the order of 100 million dollars with about 100 Research Institutions and 200 Industrial Laboratories and engages 6000 scientists and engineers for the execution of these contracts. Then they have the National Defence Research Committee, Joint Committee on New Weapons and Equipments, the National Inventors Council and finally the office of Production Research and Development of the War Production Board. In countries like Great Britain and U. S. A. which lead the scientific-cum-industrial procession of the present era, the need for mobilising scientific talent to the fullest extent is considered imperative. How much more should it be so in India where only a promising start has been made in the path of scientific exploration! Sir A. Ramaswamy Mudaliar at Bangalore the other day noted with satisfaction that the Board of Scientific and Industrial Research had done excellent work in this direction, and it is also very encouraging to learn that H. E. the Commander-in-Chief and his advisers are keenly interested in the scientific work that is in progress in the Delhi laboratories of the Board. But one cannot help feeling that much more could have been done to enlist the scientific talent of this country in aid of war-effort.

Men of science, by training and instinct, are averse to wasting their breath over might-have-beens; it is the present and future that interest them more than the past. Now that the victory of the United Nations is in sight, planning for peace has become as important as toiling for war. In the progressive countries of the world, organisation of scientific research is considered a vital element of post-war reconstruction; and such research is being planned with a crusading zeal. We have, however, not yet had any definite evidence that those who control the destiny of India share this view. If past history is any guide, we have every reason to be extremely alert. Under the stress of the last Great War, the Government of India addressed the Secretary of State as follows: "After the war, India will consider herself entitled to demand the utmost help which the Government can afford to enable her to take her proper place as a manufacturing country". It was

hoped that in accordance with the spirit of this declaration, scientific and technical research so essential for the promotion of industries would receive a great impetus. But such hopes were nipped in the bud by the Inchcape Retrenchment Committee. While in Great Britain, far-reaching steps were being taken to promote scientific and technical researches by the establishment of Research Associations in co-operation with industrial interests, and new scientific laboratories under the Department of Scientific and Industrial Research and Institutions of University rank were being planned, built and equipped on a vaster scale, the Government of India in the decade following the war attached little importance to scientific research as an agency for human betterment. Heads of the Central Scientific services found to their dismay that any suggestion for maintenance of *status quo* or for modest legitimate expansion was invariably ignored if based on claims of research. Some of the existing Research Institutes were expected to be self-supporting; and this recommendation of the Inchcape Committee was given effect to in the case of the Imperial Veterinary Research Institute at Mukteswar which was required to balance its budget by the sale of biological products. The Government of India which is ultimately responsible for the management of the Indian Institute of Science appointed a Committee in 1921, with Sir William Pope as Chairman and Sir Asutosh Mookerjee as a member, to report on the future lines of development of the Institute. The Committee recommended the addition of eight new departments to the Institute at a capital cost of twenty five lakhs of rupees and an additional annual recurring expenditure of five lakhs of rupees. No attempt whatsoever was made to implement the recommendations of this authoritative committee and the annual grant to the Institute remained stationary in the inter-war period 1920-1939.

Lord Reading is reported to have said that when he was the Viceroy, he sometimes had the idea of intensive planning for better living on a big scale, but he was too busy in day-to-day administration to get down to it; and he doubted if any Viceroy would find the time. It is no wonder therefore that when the great depression came in 1930, the Government of India had no plan but severe retrenchment to meet the situation. In America, public opinion is so thoroughly convinced of the benefits of research in industry and national life, that during the great depression, research budget was practically untouched—and in some cases the last to be cut; and in 1940, the year before U. S. A. entered the war, the annual expenditure for research amounted to 300 million dollars. In India, on the other hand, the research departments were the first to suffer and suffer grievously. Thus the Geological Survey of

India, which is the pivot on which every planning for industrial progress must rest, lost a third of its strength. The Geodetic and Trigonometrical Survey of India lost half its strength. The Zoological Survey of India fared likewise. In a country where heavy mortality has been the black spot of the administration, the annual grant of Rs. 500,000 for medical research to the Indian Research Fund Association was discontinued. There was however one silver-lining. Due to the personal interest of the ex-Viceroy, the Imperial Council of Agricultural Research was established and continued its beneficent activities with adequate financial support from the State.

In the circumstances, the Council of the National Institute of Sciences felt that the time had come when the scientific men of India should gather together and formulate a plan for post-war organisation of scientific research in India. Accordingly they arranged a symposium* on that subject which was held in Calcutta on the 27th and 28th September last.

The various proposals put forward at the symposium have been given wide publicity. Doubts have been expressed whether it is possible or even desirable to bring the whole domain of natural science within the purview of one central council. In the Soviet Union, the Academy of Science has long been an integral part of the Government in the planning of scientific and technological expansion in all its branches. There are advantages in such centralisation if the workers are imbued with real team spirit. But where such spirit is absent, the central machinery may wear away rapidly by too much friction. Then again, it has been pointed out that at the present moment several departments of the Government of India are interested in scientific research—Departments of Industries, Supply, Labour, Communications, Agriculture, Education and Health. The question has been asked that supposing the Government of India agree to the creation of a central National Research Council, what should be the relation of this Council with these important departments of Central Government? Some apprehend that such a central council may not be always wise and may not be helpful in developing that initiative in all grades of scientific workers, which is essential for success in research. The Governing Bodies of some of the existing institutions would wish to be assured that their autonomy would not be ultimately undermined by a generous policy of assisted research in their scientific laboratories. These are some of the difficulties that have been brought to our notice. They are not insurmountable; and given the good will, they may be removed by patient discussion. What is essential is that we should all feel that post-

war organisation of scientific research is a vital problem which must be lifted clear of the arena of dispute, that it will not do to pay only lip service to the principles of planning and that science must be harnessed to the task of better living in India.

It will be a great advantage if research in all branches of science and industries was made the special responsibility of a Member of the Viceroy's Cabinet; and the proposed National Research Council with its constituent Research Boards—the Board of Scientific Research, the Board of Agricultural Research, the Board of Medical and Public Health Research, the Board of Engineering Research etc., were set up under this Hon'ble Member. Each Research Board of the National Research Council should have as its counter part a Development Board in the relevant Department of the Government of India, close co-ordination between a Research Board and the corresponding Development Board being effected by a large number of common membership. The great Departments of Industries, Supply, Labour, Communications, Agriculture, Education and Health in the Central Government would thus not only remain fully cognisant of the progress of researches under the auspices of the National Research Council, but, what is more, they will be entrusted with the duty of implementing the results of the accomplished researches through the respective Development Boards functioning under them.

At the last symposium, an appeal was made that 0.1 per cent. of the national income might be set apart for research and another 0.1 per cent. for the training of research workers. This was generally accepted at the meeting and it was resolved that to enable effect being given to the policy of scientific development by the National Research Council, the Government of India should make an annual grant of five crores of rupees. The Parliamentary and Scientific Committee in Great Britain have recently made recommendations of a far reaching character. They deplore that in the period 1919-39 Great Britain began to fall behind other countries like the United States of America or Russia in the scale in which researches were carried out and applied to technological developments in many fields. During the present war, British scientists and engineers have demonstrated that their capacity and inventive genius is unsurpassed. It is now recognised that in the post-war period in Great Britain research and its application must be on a far bolder and more imaginative scale than in the period 1919-1939, and the Committee have recommended that Great Britain ought to look forward to spending ten times as much annually after the war on research and development in order to provide the necessary basis without which British industry and agriculture cannot meet the needs of the future.

* Vide SCIENCE AND CULTURE, November, 1943.

One cannot help quoting in this connection from the eloquent address of Prof. Hill: "We must insist that the cheapest and most certain method of human betterment is the improvement, in Benjamin Franklin's words, of useful knowledge. If a country's poor and undeveloped let us spend *more* on research, not less: the amount we can possibly spend is insignificant—only 1 or 2 per cent. of the national income any how—and will bring a very handsome dividend. As Herbert Agar says, this is a time for greatness—we must either be great or dead—and one important element of greatness is intelligence. Stupidity and ignorance are not compatible with greatness.

"In what ways can science help us directly in promoting human betterment? In England now we are contemplating a vast expenditure on housing, in the next 20 years £2,000 million or 2,600 crores of rupees. One per cent. of that spent on research, on design, materials, building, heating, lighting, ventilation and amenities will certainly make the new houses many times one per cent. better, healthier and more efficient. We are, in fact, already devoting whatever effort we can spare from the war to research on building. We mine 20 crores of tons of coal annually—1 per cent. of its cost spent every year on research will certainly improve the efficiency of its utilisation by many times 1 per cent. We're intending to spend half at least of that by a joint co-operative effort between Government and the industry. There are 60 million people in the Colonial Empire. The Colonial Research Committee, under the Chairmanship of Lord Hailey, is able to spend £500,000 or 6½ million rupees annually of Government money as soon as research workers are free from their war duties. Its purpose is by research to improve the welfare of the Colonial peoples. It sounds a lot but it only comes to one or two annas a head. Your Department of Scientific and Industrial Research is allowed to spend 10 lakhs of rupees per annum. It's doing very fine work for your country, as I've seen already for myself, but the cost is only 1/26th of an anna for each inhabitant of India. It could usefully spend 10 times as much. Your annual

budget now, I'm told, is 600 crores of rupees; 1 per cent. of that is 6 crores. Scientific men in India would be very happy indeed if they could look forward to anything like that. In England, £50 million a year is spent on medical treatment and to this might be added several times the amount for time and health wasted owing to preventable diseases. Medical Research in all its forms does not spend more than 1 per cent. of that. The Industrial Research Associations in England spent in 1938 about half a million pounds—a very small fraction of 1 per cent. of the annual value of British industrial production. The listeners may get the very simple idea into their heads—1 per cent. It doesn't sound very much. Let us aim at giving 1 per cent. of our national budget, 1 per cent. of the value of our industrial and agricultural production, 1 per cent. of the loss due to ill-health, 1 per cent. of the cost of our food, our transport, our houses, our water, our coal, even our broadcasting, to research—and in 10 years we shall find that we're getting back not 1 per cent. but 10 or 20 or 40 or 200 per cent. in dividends. . . .

"If those who call themselves 'Practical men' object, let us remember Francis Galton's definition of the practical man—the practical man is the man who practises the error of his forefathers. . . ."

"Perhaps in India you will be able to profit by our mistakes. One piece of advice, however, I'm confident in giving, namely, that it's worthwhile devoting a greater fraction of your national effort to scientific research and technical development: and I'd like to leave you with the three words—'one per cent.'"

We may do well to re-echo his noble words and press for an annual grant of rupees 25 crores for Scientific and Production Research, and training of research personnel. Let us hope that the Government of India will take courage and swim with the current of the modern world's enlightened opinion and not cling to cautious, wooden and anti-deluvian policies which will perpetuate ignorance, poverty and disease and ill-feeling in this land.

SCIENCE AND PHILOSOPHY

S. K. MITRA

THE scientist of the present age, with the aid of refined and powerful instruments at his disposal, can study an immense range of phenomena in space and time. At the one extreme he has the astronomical world in which times and distances are measured in millions of millions of seconds and miles respectively; at the other extreme his world is on an atomic or a sub-atomic scale in which the times and the distances involved may be only fractions of a millionth of a millionth second or centimetre. The scientist himself moves about in a man-sized world occupying a fairly central position in this scheme. The modern scientist has thus, as it were, three distinct divisions of the phenomenal world as his field of investigation.

Contrasted to this the ancients with their unaided senses had only one division—the man-sized world—as their field of investigation. They were also interested in the motions of heavenly bodies but they failed to obtain any insight into the mysteries of these motions because they worked with certain set ideas and had no science of dynamics to guide them. And, it was only when the scientists of a later age had discovered on the one hand the correct geometry of these motions (Kepler) and, on the other, had enunciated the laws of dynamics (Galileo and Newton) that they were understood. Thus arose the system of classical mechanics and mechanistic determinism with its laws or pattern of events, interpreted in terms of concepts such as space, time, force, gravitation, etc.—concepts which our minds could easily understand. The tremendous success which the system had in explaining and predicting phenomena of the man-sized world naturally led the leaders of scientific thought of the last generation to believe that its laws and concepts would be applicable not only to all the details of the astronomical world but also to those of the world of atoms and sub-atoms the study of which, after Dalton, was developing rapidly.

But in this they were mistaken. It was soon found that for the astronomical world the laws were insufficient, though, it was not at first clear whether they needed refinement or the fundamental ideas failed. And for the world of atoms and sub-atoms, the laws were found to fail totally. All these necessitated a revision of our ideas on such questions of philosophic importance as the nature of space and time, the principle of causality, the distinction between appearance and reality and the relation between the observer and the observed, in short, a complete re-formulation of the fundamental laws

of physics. The realm of science has thus been extended into that of philosophy. The border-land territories between the two are now not only contiguous, but they actually overlap. In the volume* before us Sir James Jeans in his characteristically vigorous and lucid style, has sought to discuss and also to some extent explore this interesting domain.

A book like this is always welcome to the scientist and to the philosopher alike. It enables the one to understand the view point and the difficulties of the other. The present day scientist brought up in the new ideas of physics is fully conscious of the limitations of science and its methods. He now recognises that his rôle is really that of an explorer into the secrets of Nature, and that he should never lay claim that he is in possession of the knowledge of the ultimate reality underlying the phenomenal world of perception. He therefore naturally turns to philosophy to find out if it can help him and if its methods can be of any avail. After all, though the methods of science and philosophy are different, their aims are same, namely, "to seek to obtain knowledge about the real world".

HINDRANCE TO DISCUSSION BETWEEN SCIENCE AND PHILOSOPHY

There are, however, many hindrances to a discussion between the philosopher and the scientist of the common fundamental problems. Not only there is the difference of method, but there are also differences in language and idiom. Sir James Jeans fully appreciating these difficulties has devoted one whole chapter (Chapter III) in analysing them and tracing them to their origin. The language of science, says the author, has the great merit of exactitude. "Its terms are clearly and unambiguously defined, so that each word means the same thing to every scientist, and this thing is perfectly precise". Contrasted to this philosophy has still no precise or agreed terminology. "A great number of common words as well as technical terms are used in a variety of different senses, often by the same writer". There are three principal causes for these differences of language and usage according to Sir James:

"(1) Philosophy seems to have no agreed or precise terminology because there is no agreed body of fundamental knowledge for a precise terminology to describe.

* Physics and Philosophy by Sir James Jeans. Pages 222, with preface and index; Cambridge University Press. Price 8s. 6d.

(2) The language of philosophy differs from that of science largely because philosophy tends to use in subjective, and science in objective senses.

(3) The language of philosophy further differs from that of science because philosophy tends to think in terms of facts as they are revealed by our primitive senses, while science thinks them as they are revealed by instruments of precision." (pp. 83-84).

Like Leibniz, Sir James advocates the construction of a precise technical language for philosophy. He maintains that want of this

"not only constitutes a serious hindrance to discussion between science and philosophy, but may even obscure the issue in pure philosophical problems. Many of the old problems look very different when translated into the idiom or language of science, while some vanish away in the process of translation" (p. 83).

In order that the general reader may understand the true relation between physics and philosophy Sir James has tried to trace the main chain of thoughts which runs through the history of philosophy (Chapter I). This to a certain extent is carried into Chapter II in which certain problems of epistemology—the science of knowledge—are discussed. We find in these chapters brief outlines of the philosophies of some of the foremost thinkers of the world, like Plato, Descartes, Spinoza, Hobbes, Kant, Hegel, Mill, Comte and others.

INBORN KNOWLEDGE vs. INGRAINED KNOWLEDGE

A discussion on the sources of knowledge has brought the opinion of the author into conflict with that of Sir Arthur Eddington. This conflict centres round the age old question of the existence or otherwise of *a priori* knowledge, that is, knowledge inborn in our mind. The question is important because *a priori* knowledge being independent of all experience can claim a higher degree of certainty than knowledge derived from experience. Examples of such (alleged) *a priori* knowledge of scientific interest are: Space has three dimensions (Kant); sum of the three angles of a triangle is 180° (Descartes); every thing that happens is predetermined by causes according to fixed laws (Kant). Sir James belongs to a school which does not believe in *a priori* knowledge. He maintains that all so-called *a priori* knowledge are only empirical knowledge of the man-sized world. Because, closer scrutiny reveals that they do not stand the test of *a priori* knowledge namely that *a priori* knowledge must be universal; in other words, its assertions must be true in all the three worlds now accessible to the scientist.

Now, Eddington has propounded a doctrine somewhat similar to that of Kant, namely that it is possible to build up a pure science of Nature solely

by the use of *a priori* knowledge. He believes that it is possible to have *a priori* knowledge, by epistemological reasoning alone, not only of the general fundamental laws of Nature, but also of the basic physical constants. Like Kant he also believes that "the laws of Nature which we know *a priori* are thrust on to the perceived world by a selective action of the human mind, which thus acts as a law-giver to Nature" (p. 52). This is what he calls *Selective Subjectivism*, and may be compared to the action of the mental sieves of Kant, the forms of perception (*space and time*) and the forms of understanding (*categories*). The selective action is illustrated by the following example.

"If we run a miscellaneous collection of potatoes over a sieve of one-inch mesh, we know that any potato-pattern left on the sieve will conform to at least one law—every one of its ingredients will be more than one inch in diameter. . . . It is a law thrust on to the potatoes by the selective action of the sieve and expresses a property of the sieve rather than that of the potatoes" (p. 52).

The laws deduced from *a priori* knowledge or reasoning are, therefore, not so much as laws of Nature, but are laws *imposed* on Nature by the peculiar working of our minds. The mind not recognizing its own limitations attributes these laws to the Nature itself (p. 54).

Sir James, and probably the majority of scientific men disagree with this Kantian doctrine of Eddington. He argues that the forms of perception (*space and time*) and understanding (*categories*) which act as sieves are not *inborn* in our minds, *i.e.*, are not *a priori* but are rather *ingrained* in our minds due to our inhabiting a man-sized world in which these are taken for granted. We cannot imagine anything else because we have not experienced anything else. And, if the laws of Nature were really thrust by our minds upon Nature, then the same laws as are thrust on to the man-sized world, would be thrust on equally to the astronomical and to the atomic world.

Nevertheless Sir James concedes that there "is the possibility of certain forms of thought—whether ingrained or inborn hardly matters—causing our particular type of mind to select what it does rather than something else" (p. 71) and that our minds do contribute something to the Nature they study. We would in this connection quote the following very significant remark of Dirac:

"Further progress lies in the direction of making our equations invariant under wider and still wider transformations. This state of affairs is very satisfactory from a philosophical point of view, as implying an increasing recognition of the *part played by the observer* in himself introducing the regularities that appear in his observations, and a lack of arbitrariness in the ways of Nature. . . ." (*The Principles of Quantum Mechanics*, Preface, First Edition).

PHILOSOPHIC CONSEQUENCES OF THE NEW PHYSICS

The new physics—the physics of atoms and sub-atoms and radiation—has profoundly modified our ideas on two subjects of fundamental importance both to science and to philosophy. The first is the age old philosophical problem, the principle of causality which is apparently disobeyed in elementary processes in the atomic and the sub-atomic world.

The principle received its first shock when the laws of radio-active disintegration were enunciated by Rutherford and Soddy (1903). And its overthrow—at least so far as the atomic world was concerned—was complete when Bohr (1913) and also Einstein (1917) postulated that there were spontaneous quantum jumps of atoms from states of higher to states of lower energy. Radio-active disintegration and spontaneous quantum jumps appear to be events without cause—something unheard and unthought of in the whole history of the progress of human knowledge.

The second subject on which our idea needed complete revision is the naïve belief that by the method of science we may be able to understand the ultimate reality. This is now known to be wrong. The principle of uncertainty—so ably stated by Heisenberg—says that we shall never be able to "see" the full details of any picture that we may make to represent the reality underlying the world of perception. This new principle is a logical consequence of the discovery, on the one hand, of the particle aspect of radiation and on the other of the wave aspect of matter—the so-called dual aspect of matter and radiation. [Planck's energy quanta (1899), Einstein's light arrows or photons (1905), G. P. Thomson's and Davisson and Germer's experiments (1927).]

Of these, a close scrutiny of the dual aspect of radiation alone leads, as Sir James tells us, to the following six consequences (p. 145).

- (1) So far as the phenomena are concerned, the uniformity of nature disappears.
- (2) Precise knowledge of the outer world becomes impossible for us.
- (3) The processes of nature cannot be adequately represented within a frame-work of space and time.
- (4) The division between subject and object is no longer definite or precise; complete precision can only be regained by uniting subject and object into a single whole.
- (5) So far as our knowledge is concerned causality becomes meaningless.
- (6) If we still wish to think of the happenings in the phenomenal world as governed by causal law, we must suppose that these happenings are determined in some substratum of the world which lies beyond the world of phenomena, and so also beyond our access."

The duality of matter also confirms these conclusions.

DETERMINISM AND FREE WILL

It may be asked if there is no room for causality, then how is it that science based on the assumption of the uniformity of Nature—like causes produce like effects—had such indisputable success? And further, does the break down of the principle of causality in the elementary processes of atoms and atomic nuclei give any scope to free will? The answer to the first question is that the indeterminism is confined to the world of atoms and sub-atoms and that even there, the indeterminate events are governed by statistical law. In the man-sized world, "and indeed far below—down to pieces of matter far too small to be seen by any microscope, Nature is, to all appearances, strictly deterministic; like causes produce like effects" (p. 152).

The reply to the question whether the new aspect of causality gives any scope for free will is still somewhat confused. This, in part at least, is due to the fact, that free will has not yet been properly defined. In classical physics the question of causality and free will had simple unambiguous meanings. It was simply whether the future course of a system which is entirely determined by its present state could be altered by the intervention of consciousness and human volition. But in new physics the question assumes a different aspect. According to the uncertainty principle, we can never know the present state of an elementary system with full details as are necessary for predicting its future course. The question of the possibility or otherwise of intervention of human volition therefore hardly arises in this case.

The present day opinion both of philosophers and physicists seems to be that there is no alternative to determinism. There is what may be described as unconscious determinism. The problem is not whether we have a free will, but rather, why we think we are free. Thus, as Einstein says:

"If the moon, in the act of its eternal way round the earth, were gifted with self-consciousness, it would feel thoroughly convinced that it would travel its way of its own accord on the strength of a resolution taken once for all.

"So would a being, endowed with higher insight and more perfect intelligence, watching man and his doings, smile about the illusion of his, that he is acting according to his own free will." (*The Golden Book of Tagore*, p. 12).

It is to be remembered that of the two pictures of atoms and electrons—the particle picture and the wave picture—it is in the former that causal laws fail. There are random jumps of electrons with no causal laws controlling the jumps. If we depict these phenomena by wave picture, then the waves at any instant follow uniquely, and so inevitably, from those of the preceding instant. But these waves

being the so-called probability waves—waves of knowledge—they do not control the events. They rather control our knowledge of the events (p. 215). Sir James is therefore optimistic and says:

"At least the new physics has shown that the problems of causality and free will are in need of a new formulation. The classical physics seemed to bolt and bar the door leading to any sort of freedom of will; the new physics hardly does this; it almost seems to suggest that the door may be unlocked—if only we could find the handle. The old physics showed us a universe which looked more like a prison than a dwelling place. The new physics shows us a universe which looks as though it might conceivably form a suitable dwelling place for free men, and not a mere shelter for brutes—a home in which it may at least be possible for us to mould events to our desire and live lives of endeavour and achievement" (p. 215-16).

UTILISATION OF NEW PHILOSOPHICAL PRINCIPLES

The physicist enquiring into the laws of nature is wont to think in terms of models. Thus, for a long time he imagined the atoms as hard balls; now he pictures electrons as minute particles. Models and images are no doubt useful. But they have their limitations. The physicist, however, forgetting this, not infrequently deceived himself into believing that the model—a mere mental imagery—was the reality itself. This idolatry or image worship not only stopped further progress but actually led him on to a wrong path. Thus as Sir James says:

"The history of theoretical physics is a record of the clothing of mathematical formulae which were right or nearly right, with physical interpretations which were often very badly wrong. When Newton had found laws of motion of a mechanical system which were true (apart from minor refinements of the theory of relativity), he put science on a wrong track for two centuries by interpreting them in terms of forces and absolute space and time. It was much the same with the supposed force of gravitation. Again, when the true laws of the propagation of light had been discovered, they were interpreted as applying to the propagation of waves in an ether which supposed to fill all space, and again science was started along a wrong road which it was to follow for nearly two centuries" (p. 190).

The modern physicist profiting by the past mistakes is cautious and regards models as only models; he admits that by the method of enquiry he has been following he can never hope to know the ultimate nature of reality. How then he is to make further progress? For further progress, as Sir James puts it, he must, apart from discovering the pattern of events, utilise new philosophical principles which are: *probable reasoning* and *simplification postulate*. According to the first the enquirer 'guided by probable reasoning rather than by certain deductions' introduces hypotheses about the reality about which he can never acquire certain knowledge of a positive kind. According to the second, he assumes that the simpler the hypothesis, the more

likely it is to be near the truth. As has been remarked by Einstein, the fundamental laws of Physics become more and more simplified as experimental research advances. And the simplicity observed is not due to any peculiarity in the working of our minds, but is inherent in the world of perception. To illustrate the above principles Sir James has given a beautiful illustration which reminds one of the famous parable of Plato in which the man chained in a cave tries to form mental picture of the outside world from the shadows cast on the walls of the cave—appearances of objects moving outside. We do not apologise for reproducing the illustration in some length:

"Let us imagine that in the centre of Europe there lives a peasant who has never seen or heard of sea, and cannot even read about it, but is in possession of a super-perfect radio-set which can pick up messages from every ship in the world. Suppose further that every ship is continually sending out its position in a standard form, such as 'Queen Mary', +40° 10', -72° 26', this meaning that, at the moment of speaking the ship 'Queen Mary' is in latitude 40° 10' north and longitude 72° 26' west.

At first he may merely amuse himself by listening to the various messages, but after a time he may take to recording them and if he is of an inquiring turn of mind, he may try to discover some method or order in them. He will soon notice that all latitudes lie between +90° and -90°, and all longitudes between +180° and -180°. If he then tries plotting out these numbers on squared paper, he will find that successive positions of any one ship form a continuous chain, and may begin to construct a mental picture for himself by thinking of the sender of the messages as moving objects. He will then find that each supposed object moves at an approximately uniform rate on his chart, although this law is not exact or universal. A ship may move from longitude +170° to +174° in one day, and on to +178° to the next, but the third day may take it to -178°, an apparent journey of 356°. Further, a ship may move at a regular 4° a day when its latitude is near 0°, but this daily motion will increase as the latitude increases, and may shoot up almost beyond limits if ever the latitude approaches to 90°."

Here we note that there is nothing in the observations of our inquisitive peasant which compels him to suppose that the signals are coming from moving objects. This is a mere supposition and he is guided to it by probable reasoning. However, this idea coupled with the peculiarities of the observed signals,

"may lead him to think of pasting together his +180° and -180° lines, thus transforming his plane diagram to a cylinder. This simplifies the situation enormously for it now seems most natural thing in the world that a sequence of readings equidistant in time should read 170°, 174°, 178°, -178°, etc."

This simplification shows that he is proceeding along right lines in his enquiry and is approaching the truth about the origin of the signals. There is however still the peculiarity that the supposed moving objects when in high latitudes pass over more degrees

of longitude per day. He makes further attempts to simplify the peculiarity.

"With a little ingenuity he may further think of crumpling in the two ends of his cylinder and so making the degrees of longitude smaller in higher latitudes. If he finally tries the experiment of replacing his cylinder by a sphere, he will find that his laws assume an exceedingly simple form from which all oddity has disappeared. Each ship takes the shortest course from point to point, and perform its journey at a uniform speed" (p. 182).

The inquisitive peasant is therefore justified in asserting that it is nearer the truth to say that the earth's surface is spherical than to picture it as plane.

The example illustrates beautifully the new method of enquiry to be followed in science. Like the inquisitive peasant confined in the plains of central Europe and prevented from making a direct observation of the curvature of the earth, the human mind is chained to the material body and is prevented from directly perceiving the nature of the reality. The radio signals from the moving ships represent the messages from the phenomenal world received through the sense organs. In our attempt to discover regularities in these messages, we record them against different backgrounds. And the background which makes the records the simplest reading to our mind is probably the one most near the truth.

MATERIALISM TO MENTALISM

Of the two, mind and matter, which is the more fundamental? Is mind only a by-product of matter, or, as Bishop Berkeley claimed, mind is the creator and controller of matter? On the one hand we have the doctrine of *materialism* which asserts that "space, time and the material world comprise the whole reality" and that mind is a product of matter; thought and emotion could be interpreted in terms of mechanical motion. On the other the *mentalists* (idealists) believe that the mind is of fundamental importance and that "the supposed real objects which produce our perceptions are creation either of our own or of some other mind." What has the new physics to say to this age-old problem of dualism of mind and matter? New physics has also its own dualism; it speaks of the dual aspect of matter and radiation—the particle and the wave aspect. And this is a dualism parallel to the dualism of mind and matter. When we speak of radiation and matter as particles (photon or electron) we picture them as existing in their own right and moving in space and time and they belong to the phenomenal world.

When we speak of them as waves, they have no material or real existence apart from that in our own mind. They are not waves in any material medium but are merely ingredients of a mental picture that we draw for ourselves in our efforts to understand Nature (p. 167). Thus when we change from the particle to the wave picture we proceed from the material to the mental world.

Again in the particle picture the photons and the electrons are distinct individuals in the phenomenal world. But in the wave picture, which carries us one step further towards reality, the particles lose their identity. They are "no longer independent individuals, but members of a single organisation in which their separate individualities are merged, not merely in the superficial sense in which an individual is lost in a crowd, but rather as a rain drop is lost in sea." (p. 204).

Sir James therefore says:

"It seems at least conceivable that what is true of perceived objects may also be true of perceiving minds; just as there are wave-pictures for light and electricity, so there may be a corresponding picture for consciousness. When we view ourselves in space and time, our consciousnesses are obviously the separate individuals of a particle-picture, but when we pass beyond space and time, they may perhaps form ingredients of a single continuous stream of life. As it is with light and electricity, so it may be with life; the phenomena may be individuals carrying on separate existence in space and time, while in the deeper reality beyond space and time we may all be members of one body. In brief, modern physics is not altogether antagonistic to an objective idealism like that of Hegel."

A perusal of the book makes one feel that science, even after revolutionary changes in its outlook, does not make any definite pronouncement regarding its attitude towards the many questions of philosophical significance discussed in the book. The only thing that can be said is that every thing seems to be in the melting pot. The new science does not say definitely that materialism is dead. But, at the same time, it asks if the particle picture of matter which we draw in our minds to understand nature can really give us the full attributes of matter. Similarly it does not assert that causality and determinism do not control the course of events in the phenomenal world. Yet it concedes that the case of determinism is not so strong as it used to be. Sir James therefore rightly concludes by quoting the famous words of Newton—"We are still like children gathering and playing with pebbles on the sea shore."

POWER RESOURCES IN INDIA—(ORISSA PROVINCE)

B. B. RAY

ORISSA Province and the States possess one of the richest mineral and water resources in India. Coal is also found near Talcher and Jharsuguda, but the quality of Rampur coal from Jharsuguda is rather poor.

Regarding Hydro-Electric possibilities there are a large number of possible Hydro-Electric sites in the area under survey. Of these, two major ones are both in the Koraput District and in Jeypore Estate. These are the Duduma Fall of the Machkund or Sileru River which forms the boundary line between Madras Presidency and the Orissa Province, and the Bogra Fall of the Kolab River. The natural minimum continuous flow of the Duduma Fall is about 105 cusecs and the available head is about 800 feet. With proper reservoir it is estimated that about 70,000 K.V.A. would be available from this fall.

The second site known as the Kolab River or Bogra Fall Scheme is about 14 miles from Jeypore town in Jeypore Estate. The main Kolab River would afford a development for a peak load of approximately 72,000 K.W. under a gross head of 600 feet necessitating, of course, a storage reservoir.

In addition to the two falls mentioned above, there are a large number of smaller falls scattered all over the Province. But in this paper only the Duduma and Bogra Falls Hydro-Electric Schemes and a thermal scheme from Talcher will be discussed.

Regarding thermal resources, mention has already been made of the Rampur Collieries in the Sambalpur District and Talcher Collieries. The Rampur Col-

lieries (100 million tons) are situated in the Rampur Estate near Jharsuguda. The coal is not of good quality and has a calorific value of about 8000 B.T.U. This coal is at present utilised in the Orient Paper Mills at Ib, but other industrial concerns within 100 miles of the collieries such as the Bisra Lime and Stone Quarry and the Tata's Dolomite Quarry do not use this coal. Collieries situated in Talcher State in the Eastern States Agency produce fairly good quality coal having calorific value of about 13,000 B.T.U. (200 million tons). This coal is utilised not only for several Railway Companies but is also used in the colliery power house using modern high pressure turbo-sets.

DETAILS OF HYDRO-ELECTRIC AND THERMAL SCHEMES

So far three schemes have been studied and are possible for the area under survey. These may be summarised as below

- (1) Bogra Fall Scheme of the Kolab River,
- (2) Duduma Fall Scheme of the Machkund or Sileru River, and
- (3) Thermal Scheme at the Talcher Collieries.

(1) KOLAB HYDRO-ELECTRIC SCHEME

The scheme was first surveyed by Sir Henry Howard in September, 1928 and his preliminary report was prepared in 1931. It was mentioned in his report that the Machkund River Scheme is of the

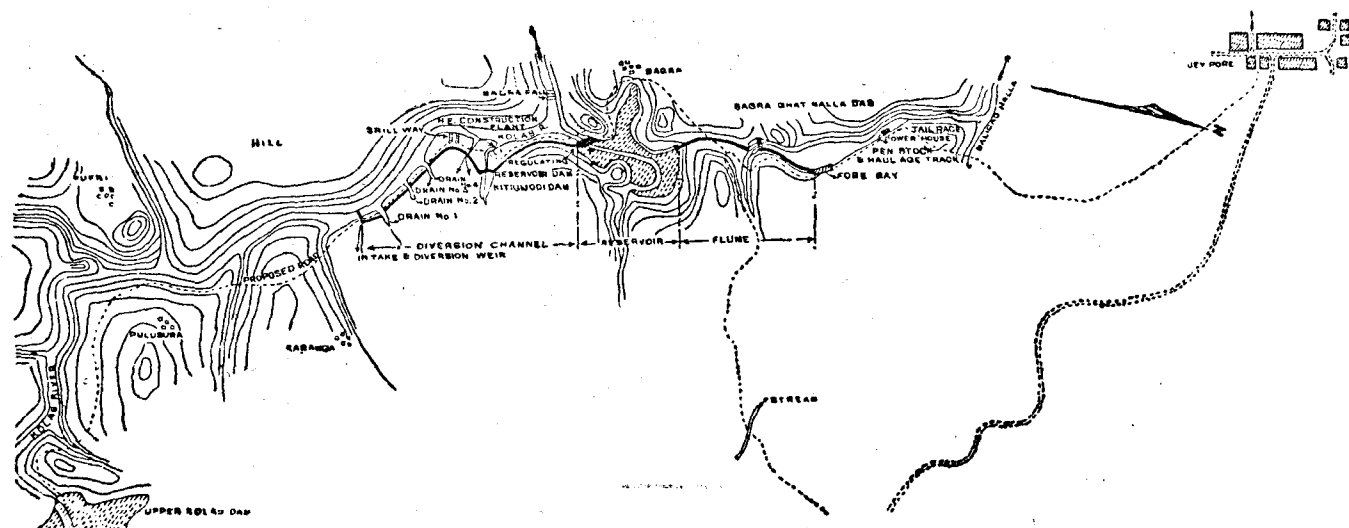


FIG. 1. Kolab Hydro-Electric Scheme.

same order as the Kolab and a reconnaissance was made in May, 1929, the report of which showed that there were no material advantages over the Kolab and owing to great inacceptability his main report was concentrated on the Kolab. A very short resumé of the Kolab Hydro-Electric Scheme may be summarised as under.

The report on the Kolab Hydro-Electric Project is an introductory report and before any work could be started, it will be necessary to have further detailed investigation. Notes on the Kolab Hydro-Electric Project prepared by Sir Henry Howard in 1939 suggest certain modifications to the original scheme. However, it must be emphasised that both schemes are based on the assumption that a starting load of at least 6,000 K.W. is available within economic distance from the power house, and it has been decided that a maximum distance of 200 miles can be taken as the economic distance of transmission.

A Resume of Kolab Hydro-Electric Scheme

The main scheme consists of a dam storing about 2.2 thousand million cubic feet of water, a canal for a combined flow of approximately 900 cusecs, a regulating reservoir, a forebay and penstock designed for a continuous load of 36,000 K.W. The approximate cost excluding the transmission line will be 350 lakhs on an average basis of cost per effective K.W. at Rs. 1,000. Sir Henry Howard recommended to work the original scheme in stages as the load demand increases, and the scheme could only be possible when a preliminary load of at least 6,000 K.W. is available.

The main scheme as ultimately visualised cannot be generally improved upon, except in detail. It consists of:—

- (a) a dam storing about 22000 m.c. ft. of water ;
- (b) a tunnel and canal to the regulating reservoir designed for a combined flow of 900 cusecs ;
- (c) a regulating reservoir in the Ravinjode Nala of about 30 m.c. ft. capacity ;
- (d) a tunnel and/or open canal for 1,800 cusecs to a forebay for diurnal storage ; and
- (e) penstocks and machinery for a peak load of 72,000 K.W. and a continuous load of 36,000 K.W. under a gross head of 611 ft.

Items (d) and (e) might have to be split up into two independent installations on account of the large quantity of water to be dealt with and topographical limitations.

The whole scheme would have a total maximum effective capacity exceeding 80,000 K.W. at 50 per cent load factor and would cost approximately

360 lakhs excluding transmission lines and sub-stations.

The cost is well within the economic limit for power development, and if ever the construction could be justified it should prove a valuable asset to the Province. The development must, if possible, be carried out in stages without prejudice to the final scheme.

The first stage might not include the upper Kolab Dam, but would depend upon thermal power to make up for the shortage of water during the dry months and also take advantage of seasonal power. A diversion dam and inlet would be constructed and the water led by an open channel to the regulating reservoir ; later this would be supplemented by a tunnel as in the original scheme. The works from the regulating reservoir to the forebay would have been constructed for their ultimate capacity unless an alternative line for future use could be located. As the capacity of such works would have to allow for a speak demand of 900 cusecs, at 50 per cent load factor, i.e., 1,800 cusecs the problem may be difficult, and it might be necessary to take a second channel or tunnel from the regulating reservoir to another penstock line and power house site.

The first stage of the scheme might be assumed to consist of an open canal to the regulating basin for 400 to 500 cusecs with a tunnel for a later stage. There would be two penstock lines and three generating units—one spare—of 7,250 K.W. each. As explained later for scheme (b), part of this generating capacity might be utilised for secondary or ten month power. The estimated cost of the civil works and power station, as described above, is Rs. 88 lakhs or nearly Rs. 1,100 per effective K.W. without making allowance for the secondary power supply. The second stage would include the Upper Kolab Dam with one 14,500 K.W. generating unit and penstock line. The third stage would consist of the addition of a second 14,500 K.W. unit and penstock line. The fourth stage would include the construction of the large dam for storing 22,000 m.c. ft. of water, a tunnel to the regulating reservoir, a second aqueduct to the forebay, and two other 14,500 K.W. generating units and penstock pipes at the power house. The fifth stage would consist of the construction of an auxiliary power house at the main dam with $3 \times 4,500$ K.W. units.

The estimated cost of the civil work and power station upto the second stage is Rs. 128 lakhs or Rs. 465 per effective K.W. at 50 per cent load factor ; for the fourth stage Rs. 330 lakhs or Rs. 455 per effective K.W. The power house and the Dam would cost about Rs. 30 lakhs. The above rough estimates bring out the increasing economic value of the scheme as development proceeds.

The following possibilities were examined but require confirmation in the field:—

(a) A diversion dam 41' high constructed at the head of the fall and giving a storage of 14 m.c. ft. The water to be led through a tunnel approximately 6,000 feet long in the hill side on the right bank and down a penstock pipe to the plant under a head of about 420'. This site could be developed for 100 cusecs continuous, equal to 2,800 K.W. or 5,600 K.W. at 50 per cent load factor.

If the whole of the power output could be utilised in the neighbourhood of Jeypore at an average rate of 9 pies per unit at 11,000 volts it might be possible to prepare a workable scheme.

The scheme will not be further discussed as (b) appears more favourable.

(b) This scheme is similar to (a) but a head approximately 100 feet higher appears possible by increasing the length of the tunnel to 7,250 feet. In this case 7,000 K.W. at 50 per cent load factor could be developed at a rough cost of Rs. 64 lakhs giving an unit cost of Rs. 914 excluding transmission system.

(c) By raising the dam contemplated in schemes (a) and (b) to a height of 91 feet above the river bed, the water could be backed up into the regulating reservoir included in the original scheme. The scheme does not appear worth further consideration.

Taking the most favourable of the schemes already described, viz., (b) and making allowance for secondary power, the estimated cost would have to be increased to Rs. 72 lakhs but the total effective capacity at 50 per cent load factor would now be 12,000 K.W. instead of 7,000 K.W. This will be termed scheme (d).

Scheme (d) previously described may be adopted if on examination in the field it proves to be feasible and within the estimated cost per effective K.W.

To ensure the commercial success of the scheme an initial demand for electricity must be created and a certain progress maintained. Furthermore the tariffs must be economic both to the supplier and the consumer.

For the purpose in view allowance has been made for an average annual revenue of Rs. 150/- per effective K.W. at the power house which is about the same as that in the Pykara Lower System. There should be no difficulty in obtaining that revenue.

Allowing a diversity factor of 1.25 between H.T. consumers and an average over all transmission loss of 7.5 per cent the revenue per H.T. consumer should be about Rs. 130/- per K.W. of demand per annum. This is equivalent to 0.70 anna per unit at 34 per cent load factor. These H.T. rates are satisfactory

for motive power in medium size industrial establishments and afford a margin for sales of low tension energy at higher rates.

As regards the load, an initial local demand of 2,000 K.W. rising to 7,000 K.W. in 10 years is necessary.

Scheme D

3 units of 6,000 K.W. each (one spare)
2 penstock pipes for 175 cusecs each.
Continuous flow 100 cusecs } Minimum water
10 months flow 175 cusecs. } condition.
Storage about 14 m.c. ft. at weir site.
Gross head 520 feet.
Cost of civil works penstock and Power House—Rs. 72 lakhs.
Local transmission system costs down to 11 K.V. bulk supply points—Rs. 11 lakhs rising to Rs. 23 lakhs in the tenth year.

A LAND AND REVENUE FORECAST (Lakhs of rupees)

Year	Capital expenditure	Interest at 5 per cent	Operation and maintenance	Depreciation	K.W. Demand	Gross Revenue	Surplus
1	2	3	4	5	6	7	8
1	83	4.15	2.00	—	2,000	3.00	-3.15
5	87	4.35	2.40	1.74	9,500	10.45	1.96
10	95	4.75	2.90	1.90	12,000	13.25	3.70

Net Return 8.9 per cent.

(2) DUDUMA HYDRO-ELECTRIC SCHEME

The Sileru or Machkund River rises in the Vizagapattam District, not far from Ganga-Raju-Madugulu at a height of 3,400 feet above sea level and flows northwards forming the boundary line between Madras Presidency and Orissa Province and near the site of the Duduma Falls which is situated in Jeypore Estate in the Orissa Province, the river changes its course southwards flowing through Jeypore Estate into the Sabari River (Kolab), a tributary of the Godavari.

The writer carried out preliminary observations in 1941. The flow of the river was measured as approximately 150 cusecs and the height of the fall was estimated slightly over 800 feet, from the possible site of the forebay down to the power house level. About 6 to 7 miles up stream the bed of the river is rocky and the erection of a dam is possible. The main forebay can be erected about half a mile above the fall.

Both the left and right banks of the river were investigated and although it appears that the scheme

on the left bank of the river would be slightly easier as no elaborate tunnelling is necessary, the scheme on the right bank side i.e., on the Orissa border is possible and would be more profitable in the long run.

flume from the weir up to a point due north of Makkiput village when it will be necessary to build a tunnel through the rock before feeding into the pipe line, the power house being situated at an approximately mean level of 1,750 feet above sea

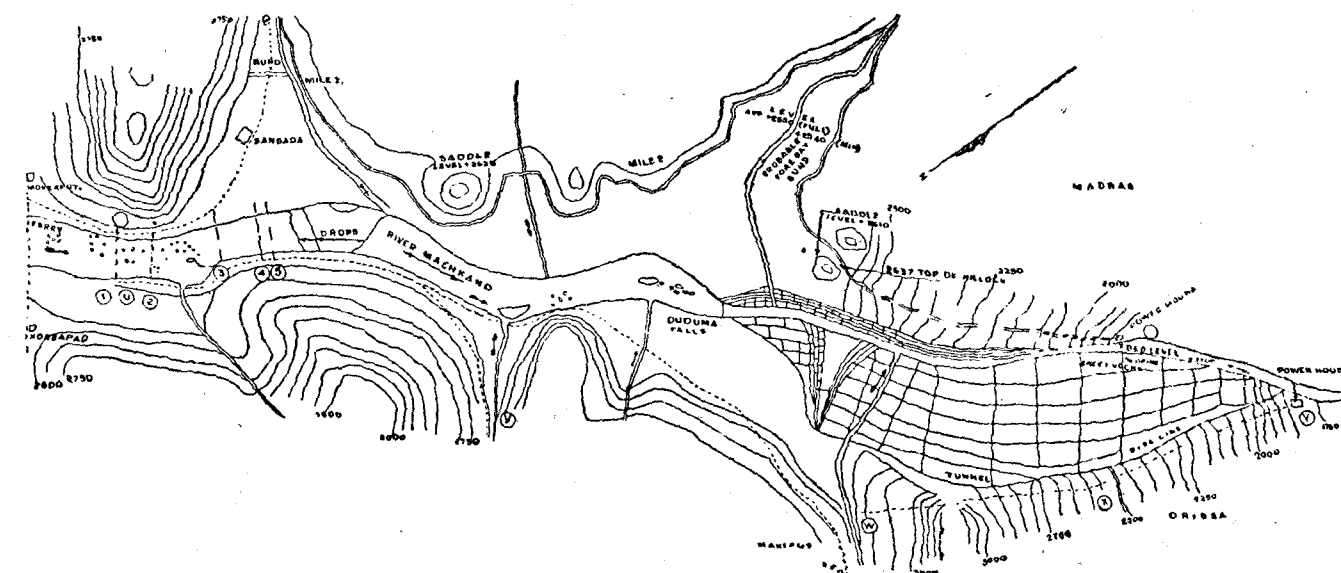


FIG. 2. Machkund Hydro-Electric Scheme.

The Duduma Scheme is essentially a medium head Hydro-Electric Scheme utilising the falls with storage reservoir. The minimum flow is about 105 cusecs and the maximum flow possible with a storage reservoir is 700 cusecs.

It is proposed to build up the scheme in stages and in the initial scheme a small storage for 29 to 30 million cubic feet of water is proposed. As no reliable rain fall data are available for the site of the fall, calculations are based on the mean annual rainfall which may be taken as about 50 to 52 inches per annum.

During the first stage of the scheme the following works may be suggested. At about one mile above the Duduma Fall where the bed is rocky it is proposed to build a masonry weir about 30 feet high and 600 feet wide to divert the water into a flume channel. It is assumed that with this arrangement a continuous flow of about 125 cusecs will be available and during the flood season about 15 feet of water is expected to flow over the weir. The length of the weir would be about 300 feet. The forebay bund would be about 300 feet long and about 60 feet high. If the power house is built on the Madras side of the river a 1000 feet of low pressure tunnelling will be necessary feeding a surge tank before leading into the pipe line. If the power house is built on the

Orissa side, it will be necessary to have an open level. From the preliminary observations it appears that there would be very little difference in cost between the left and right bank schemes. It is proposed in the initial scheme to instal three 7,000 K.V.A. generating sets. About 12,000 K.V.A. would be available after the first stages of development, the third set being a spare. In the final stage of development it is proposed that as load increases the flow will be increased gradually to 700 cusecs and it will be necessary to have an ultimate storage reservoir of 25,000 million cubic feet and this storage reservoir will be located at a place 7 miles up stream near the village Sindiput as mentioned above. Of course, it is necessary to have a separate surge tank pipe line and necessary penstock etc. The additional plant capacity would be 4 units of about 14,500 K.V.A. each. Then the total maximum capacity of the scheme would be roughly 70,000 K.V.A. as compared to 76,000 K.V.A. in the Kolab Hydro-Electric Scheme. The gross cost per K.V.A. for complete scheme would be approximately Rs. 950/- for initial stage and about Rs. 520/- for the final stage. The initial scheme would cost approximately 175 lakhs and the final scheme about 400 lakhs including major transmission lines. For high tension transmission and distribution in Orissa Province and States a further sum of Rs. 50 lakhs will be required.

TABLE I
COMPARATIVE STATEMENT

Name of Hydro-Electric Scheme	Stages of development	Units	Total Rating		Cost in lakhs of Rupees		Rate per K.V.A. in Rupees			
			Gross K.V.A.	Effective K.V.A.	Civil Works & Power Station only	Complete scheme including transmission line and sub-stations	For Civil Works & power station only		Complete scheme including transmission lines and sub-stations	
							Gross	Effective	Gross	Effective
1	2	3	4	5	6	7	8	9	10	11
Machkund	First	3 of 6250 K.V.A. of which one is spare.	18,750	12,500	86.00	174.00	459	688	928	1392
	Final	3 of 6250 K.V.A. of which one is spare plus 4 of 14,400 K.V.A.	76,350	70,100	259.00	392.00	339	369	513	559
Pykara	First	3 of 7810 K.V.A.	23,430	15,620A	71.90	107.38	307	460	459	688
	Present	3 of 7810 K.V.A. plus 2 of 12,500 K.V.A.	48,430	40,620	107.08	177.25	221	263	366	436
Mettur	First	3 of 12,500 K.V.A.	37,500	25,000	51.25	125.66	137	205	337	506
	Final				Satisfactory figures not available.					
Papanasam	First	3 of 6250 K.V.A.	18,750	12,500	128.41	179.00	685	1028	955	1432
	Final	5 of 6250 K.V.A.	31,250	25,000	181.66	258.17	582	727	826	1033
Kolab	First	2 of 12,800 K.V.A.	25,600	12,800	140.00	224.00	563	1125	875	1750
	Final	4 of 12,800 K.V.A.	51,200	38,400	182.00	284.00	356	474	555	740

The scheme appears to be fairly satisfactory. The sufficient catchment area, continuity of water supply and the head available are suitable for power development but since the preliminary data prepared are tentative and as rain fall and the flow of the river have not been observed over a period of several years, it is imperative that before any definite scheme could be drawn up, it would be necessary to have a preliminary survey for at least 3 years for taking measurement and observations. It is anticipated that a minimum of 50,000 rupees will be required for taking these observations.

(3) THERMAL SCHEME AT TALCHER

For North Orissa it is possible to have a thermal station since good quality and cheap coal will be available at Talcher within 60 miles of load centre. A medium size power station with steam pressure of 275 to 300 pounds square inch, using modern turbo alternator sets of about 1,000 K.W. capacity each will be suitable and a very economical scheme may be worked out.

The scheme may be outlined as under. The coal at Talcher is of fairly good quality having calorific value of approximately 13,000 B.T.U. Pulverised coal will be available at the power house sidings at the rate of Rs. 2/- per ton; this compares very favourably with the Bihar Electrification Scheme where the cost of coal per ton works out at Rs. 3/8/- per ton.

Sets of about 1,000 K.W. at the suggested pressure of 300 pounds per square inch at approximately 40 per cent load factor should average 1 K.W. hour per 2 pounds of coal and with coal at Rs. 2/- per ton, the fuel cost per K.W. hour is '085 anna.

With a 1,000 K.W. set at 30 per cent load factor units generated would be 26,10,000. The cost per K.W. installed may be taken at the rate of Rs. 500/- so that 2,000 K.W. plant would cost approximately 10 lakhs. Interest and depreciation on this figure at 5 per cent is Rs. 50,000/- plus cost per unit due to capital expenditure is '302 anna and total cost for generation per unit '387 anna. In the initial scheme three automatic fed boilers, including coal and ash handling plant and water softener, two turbo sets for 300 pounds per square inch pressure of about 1000 K.V.A. each, may be provided. Only minimum quantity of auxiliary plant would be necessary as emergency power may be obtained from the M.S.M.

Collieries power station at Talcher. The cost will be as under

Items.	Cost.
Boiler Auxiliary plant including coal and ash handling and water softner ...	4.5 lakhs.
Turbo alternator and auxiliary plant including spray pond ...	3.7 lakhs.
Electrical switch-gear and transformer including supervision and spares ...	1.0 lakhs.
	9.2 lakhs.
Miscellaneous expenditure 1/3% ...	.046 lakhs.
Engineering and supervision 2 1/2% ...	.23 lakhs.
Contingencies 2 1/2%	.23 lakhs.
	9.706 lakhs.
or Say, Rs.	9.75 lakhs.
Transmission line ...	3 lakhs.

The capital cost, however, may be reduced further if arrangement is made with the existing power house to instal a third set of about 1000 K.W. capacity to meet the extra load. The river Brahmani flows through the mining area and there is ample water for cooling purposes. With a thermal electric scheme at Talcher, it would be possible to supply power within a radius of 60 miles of power house at bulk rate of '75 anna per unit so that power for industrial development would be available for 1 anna per unit. Thus, not only Cuttuck the capital of Orissa but the adjoining States will be benefited by this scheme. The scheme appears to be very favourable and it is opined that a thermal electric scheme for North Orissa is economically possible. The scheme mentioned above is based on present day practice and is only tentative giving an approximate idea of cost.

CONCLUSION

The figures given in the paper are based on pre-war rates and prices. Most of the investigations were carried out before the commencement of the war. A scheme of this nature is only possible if load develops and investigations were carried out to find out load conditions. It is not possible to enter into details, but it will suffice to say that an initial load demand of 4,500 K.W. rising to 9,500 K.W. after 5 years, within economic distances of transmission, is anticipated. Vizagapattam is within economic distance of transmission from the site of the Falls.

The Hydro-Electric Scheme can be taken up as a major post-war development for this part of India.*

* The author expresses his thanks to the Government of Orissa for giving permission to publish the paper. A detailed paper on the subject will be published in the *Electrician*.

RECONSTRUCTION OF EDUCATION ON A SCIENTIFIC BASIS

RANG BAHADUR MATHUR

WE live in changing times. Our lives are being transformed very rapidly and in many ways. The impact of science and western civilization on our way of life, of about a century ago, has been so great that it has thrown us almost completely out of gear. Outwardly we are making partial efforts to adopt modern customs, manners of life and occupations, use of machines, rapid transportation, scientific knowledge and scientific appliances, but inwardly we are still out of tune with the changing times.

The fact is we are being dragged unwillingly over a path we have not deliberately chosen for ourselves. Industrialisation, commercialization and other such factors, have come to our land too, to stay and progress, while our leaders of thought and our masses are unwilling and unprepared to have them. There is a clash of opinion about the direction of the way of life our country should take. There is a tug of war between the East and the West in India. And so we have not mentally adjusted ourselves to science and the changes brought about by science. We have not developed a scientific attitude of mind, so to say.

But there are some movements that are world movements. They come to all countries of the world sooner or later, and nothing can ever stop them.

The changing times have been making ever increasing demands of greater and newer knowledge, skills, capacities and qualities in man. A person entering upon the threshold of life is expected to have a different and greater preparation today than was expected of him fifty or even twenty years ago. This preparation for life a nation gives to her people in her schools. But from the beginning of the present system of education in India till today, never have the schools been able to catch up with the changing Indian life. In all this time the schools have kept largely aloof from the people and their needs, and have never adequately done their duty of preparing people for the need of the day.

The schools have not multiplied enough to give education to all who are hungry for it, nor has the curriculum of the existing schools kept pace with the adult society. The gap between the two is ever widening.

But still the number of schools and of students attending the schools has been steadily increasing all over the country, so much so that officers of the education department, headmasters and others connected with education, have all this time been busy in attending to the rising number of students, school

buildings, training teachers, and finance. They have been concentrating and attending only to school administration, to the sad neglect of the real problems of education. The curriculum has been made into a patch work of school subjects ill adjusted and uncorrelated, all jumbled together without any consideration of their value or importance. Thus reading, writing, arithmetic, history, geography, mathematics, English, Hindi, Urdu, Bengali, Persian Sanskrit, Arabic, science, drawing, with a smattering of manual training, hand-work, art, music or some such subjects, have been incorporated without any consideration of utility or co-ordination.

While the persons directly concerned with and interested in schools have been solely busy with school administration, the work of laying down the syllabus and writing text-books has been left to the professors of universities and colleges. They are primarily interested in their own special subjects and their logical development. They never come into contact with children and know nothing of the child mind, their needs and capacities. Hence they write books which are logical, abstract, narrow in outlook, and useless for the children for whom they are written. They write only the facts that have been universally accepted in the past, and never touch the topics that are current and perhaps of vital interest to the children. The agony of teaching such text books to the students is like that of forcing stones through the throats of hungry persons.

The professors also become examiners for the School Leaving examinations and demand of the students not what they have learnt but what they have remembered of the innumerable unrelated facts which they have been able to memorise with much effort and less thought. This, then, is the reason for the ever widening gap between school education and the present need of the people.

Is it a wonder then that the layman accuses education of being thoroughly bad and ill conceived, and that he laughs at a modern educated person? Because his training has been superficial and not thorough, the grasp over the subjects is weak and not firm, his confidence and convictions weak, initiative nil, thinking muddy, and dissatisfaction great.

It is distressing to note that there is no fundamental principle, aim, or purpose of our education. We have not developed any philosophy of education, any theory to support the practices we should follow in schools. There is no goal to give direction to our efforts. We have but a narrow outlook and an uncertain future.

What aim our education should have and how the philosophy of our education can be built up are big problems. What we are concerned with at present is how we can get out of our present muddle.

There have been efforts at reform of our educational system, but those are mostly superficial reorganisation of the existing machinery. They may be called supervisory make-shifts, and not fundamental reconstruction of education, viz., the transference of intermediate classes to schools, or adding only one year to the school life. Making primary education and study of the mother tongue compulsory, allowing the study of certain subjects in different vernaculars, including art, music, carpentry, book-keeping, typewriting etc., as regular subjects for the Matriculation examination, stress on physical training, games, sports and extra curricular activities, are certainly all reforms of great value. But these are external makeshifts that permit the structure of the school to stay as it is. There has been no re-orientation of outlook, reconstruction of the entire school system, or the whole fabric of education.

The thing most needed is the scientific study of education i.e., the application of scientific technique to education along with the advocacy of child freedom, activity, and initiative. We must seriously analyse our thoughts on education and determine what ought to be taught, why it should be taught, when it can be taught, and how it can best be taught. There does not seem to be any other way of improvement, except by clarifying our thoughts and coming to some definite conclusions.

Important work of this kind has been carried on by many American schools and educational organisations for a number of years. Most outstanding of them and incorporating all the essential factors of this movement is the one known as the Winnetka plan or technique. It has been developed by Dr Carleton Washburne and his faculty members in the Public Schools of Winnetka, a suburb of Chicago, over a period of about twenty four years now. It has evolved out of 'educational experiments and research carried on by teachers in actual classrooms in an attempt to find solutions to the many problems of curriculum, method, class promotions, and administration, which confront every teacher who tries to do his work in the light of at least some scientific knowledge.'

Lewis M. Terman says, "The essential features of the Winnetka plan are to be sought rather in its points of view than in the detailed procedures". And so it would be better to present first, the principles or the philosophy of the Winnetka technique, as given by Washburne himself, in the preface of his well known book 'Adjusting the School to the Child'.

"We recognise the right of the individual to a happy, satisfying, well adjusted life both as a child and as an adult. We recognise that both from the stand point of the welfare of the individual himself and from that of the progress of society, freedom of self expression and the right of the individual to vary from his fellows are essential. And we recognise that the individual is a part of a large social organism; he needs, on the one hand, certain knowledges and skills in common with his fellows—ability to speak and read and write the same language, ability to use the same system of number, and the possession of enough rudiments of common knowledge to serve as points of reference for later learnings—and, on the other hand, a realization of the integral interdependence existing between him and his fellows".

The method employed in achieving these aims, as already mentioned is of experimentation, and scientific educational research. The Winnetka schools have not contented themselves in accepting the ordinary construction of the common school subject. Along with other workers in this field, they have also tried to determine by research what out of the increasing content of these subjects are the minimum and most essential facts which every normal child must learn, what he has to master, if he is to live a happy and satisfying life,—facts without which he can not work and think satisfactorily. They have carried on this analysis of sorting out the essentials from the unessential in each school subject in trying to find answers to the questions, such as what knowledge shall be given to the children, and why it should be given.

Take for instance, Arithmetic. It is perhaps the most important of all school subjects with respect to the time and trouble spent by children over it. There is a good deal of muddled thinking about the purpose of teaching it. Whether it is (a) formal discipline, trying to train the children's mind; (b) utility, trying to give children useful and practical skill; (c) keeping up old traditions, that is, teaching a thing because it has long been taught, or (d) vocation, trying to prepare children for a variety of possible vocational pursuits. Washburne in his article 'Why is Arithmetic a Bugbear' in 'The New Era', January 1934, analysed the causes of the inefficiency in the teaching of arithmetic in schools and wrote, "Each of these purposes seemingly justifies the inclusion of some subject matter; all gets thrown into the hopper, and out it comes in a nicely organised, quite logical, and utterly unchildlike and unreal course of study. It serves none of its purposes well, because it tries to serve too many". "The solution to this difficulty is to select one goal and steer straight toward it". Which is, 'those phases of arithmetic which will in all probability be used, by the great majority of the children'.

Now this is a very important and startling conclusion to arrive at, because it throws into bold belief the fact that the sole criterion for building up the curriculum of even a subject like arithmetic has

become 'the need of the growing child'—an important tenet of progressive education.

A group of principals and superintendents of schools in Illinois had organised a 'Committee of Seven' under the chairmanship of Washburne to undertake a careful experimental examination of the problem of organising the arithmetic curriculum. It made certain revelations that there is a mental age when children acquire mental readiness for learning each arithmetic topic efficiently. It was found that formal work in simple addition cannot be learnt efficiently before a mental age of six and a half years, column addition before 8 years 3 months, multiplication before 10 years, long division before 12½ years of mental age. "There is little gain in postponing beyond these ages the teaching of the particular topic; and that there is steadily increasing gain by postponing until it is reached".

The chart shows some of the topics needed by a child, and the mental age at which he will be able to learn them efficiently.

Topic	Minimum Effective Mental Age	Optimum Mental Age
Addition Facts—Sums 10 and under ...	6-5	7-4
Subtraction Facts—Easier fifty ...	6-7	8-11
Addition Facts—Sums over 10 ...	7-4	7-11
Subtraction Facts—Harder fifty ...	7-8	8-11
Simple Column Addition (columns not over three digits high and wide) ...	8-3	10-1
Subtraction (not over three digits in subtrahend and minuend) ...	8-9	9-1
Meaning of Fractions ...	9-0	9-10
Addition and Subtraction of Fractions and Mixed Numbers with Common Denominators (no borrowing) ...	9-10	11-1
Multiplication Facts ...	10-2	10-2
Simple Multiplication (one-place multiplier, not more than four places in multiplicand) ...	10-2	10-8
Meaning of Decimals ...	10-5	10-5
Multiplication of Decimals (easy examples in simple and compound multiplication) ...	10-6	13-6
Simple Bar Graphs ...	10-5	
Simple Division of Decimals (division of integer or decimal by one-digit integer) ...	11-4	12-2
Simple Case I Percentage (involving only simple division of decimals) ...	11-4	12-6
Memorisation of Fractional and Decimal Equivalents ($\frac{1}{2}=5$, $\frac{25}{100}=\frac{1}{4}$) ...	11-6	13-10
Multiplication of Fractions ...	12-3	13-2
Division of Fractions ...	12-3	14-4
Case I Percentage ...	12-4	13-11
Long Division—Complete ...	10-9	12-7
Division of Decimals—Complete ...	13-0	13-11
Case II Percentage—Complete ...	13-0	13-11

In trying to find an answer to the question how to teach a subject, the Winnetka schools have evolved

perhaps the most unique and revolutionary technique in the world—the technique of individual instruction.

Those of us who have any experience of teaching know it from experience that all children are not alike in their intelligence or grasp of the subject and diligence or ability for work. We all try in our little ways to help the weak and hold back the good ones and also to assist the slow to keep pace with the faster ones. Whatever we do, it is a haphazard and sorry attempt to keep to the same lesson-lock step children of different abilities. Winnetka schools have found out from the results of standardised tests that there is a very wide range of abilities among the children in any classroom, as much as of four to five years. That is, say in the fourth class, there will be found children of second, third, fourth, fifth and sixth class ability in any subject that one may wish to test. "To treat these children as if they were alike, giving them all the same lesson, and the same time to learn it in, and then to mark them all by a common standard is simply preposterous".

Washburne also takes account of the finer differences in the studying of a subject. There are some subjects or parts of a subject which must be mastered equally well by all the children, e.g., skill in common computation, reading, writing, spelling, memorising important facts of history and geography etc. And there are some subjects, parts of a subject or aspects of it, in which the children may legitimately differ from others; and these are the appreciation of literature, the reading done by individual children and creative work of all kinds. These need not be mastered in the same degree or in the same manner by all children.

As already mentioned, research has determined what exactly every student is expected to master in each subject. In order to allow children of widely different abilities to master thoroughly or attain a common standard in these common school subjects there is no other effective way, says Washburne, than to 'individualize them'.

This means breaking up a subject into small pieces or units and re-writing it in such a manner that we can place in children's hands material by which they can to a considerable extent teach themselves. If the teachers permit children to progress at their own individual speech with such material, they will be at different levels every time. The teacher will find it difficult to correct the children's work, help them and follow their progress. Complete diagnostic tests have been made to cover all the different topics and points which it has been decided the child must master. The purpose of these tests is not to mark the children, but to find out where each child needs help. On the basis of these tests the self-instructive

material has also been made self-corrective, such that children can correct their own daily work.

The idea is "that each child may learn each new step for himself with a minimum of help from the teacher. Hence each step is introduced by simple, clear, childlike explanations with plenty of worked out examples. Ample practice is given so that the child may master one step perfectly before going on to the next, with provision at the same time for short cuts for the child who can master the step easily. As a means of developing the child's own sense of responsibility and of relieving the teacher self-correction of the daily practice work is provided, so that the child can himself tell whether his practice exercises have been worked out satisfactorily. Self testing is also provided, followed by complete diagnostic tests given by the teacher".

Like Arithmetic, the teaching of English has also been individualized in Winnetka. For English is another subject in which great amount of confusion of thought and purposes exist. Under its head are included different items with different purposes, such as spelling and grammar, punctuation and handwriting, dictation and original composition, ability to speak, and ability to express well.

The Winnetka schools have studied the motives behind teaching of the different aspects of English and decided on the policy of giving specific training in spelling, punctuation, handwriting and grammar. Side by side with this specific training, they afford many opportunities to the children for original compositions in which the different elements of the subject can be suitably integrated. The course of study in English has also been based on a combination of research and experience.

History and Geography are other allied subjects whose teaching has been completely overhauled by the American educators. Very little thought had been given so far to the purpose of teaching these subjects and the means by which this purpose was being attained.

In attacking this problem these educators first tried to make a distinction between the definite things a child should know of and the desirable things he might learn from this course. They had to decide upon the criterion by which to judge what things to include and what things to exclude from the course. They decided upon two aims. "One is that children shall be familiar with those persons, places, and events—with those facts, in a word—to which allusion is so commonly made in literature and conversation that the child would be unable to read and talk intelligently if he knew nothing of them; and second, that a child shall attain knowledge of those facts which will shed direct light upon the

problems which he will probably have to face as a citizen".

Washburne and the Winnetka teachers carried out an investigation to determine scientifically what persons, places and events are so commonly referred to that every one needs to have some familiarity with them. Harold Rugg and his associates at the Lincoln School of Teachers College, Columbia University, made a study of the outstanding problems confronting the American people and of what facts, historical movements, meanings, and principles do young people need to study together to understand the modern world. Winnetka Social Studies Text Books and Ruggs' Social Science Course (in six volumes) contain the results of these investigations carried over a period of about ten years. Winnetka books are meant for children of the primary and the Rugg's books for children of the middle and high classes.

While these books allow individual instruction so far as the study of facts are concerned, they also give children many opportunities for carrying out group and creative activities i.e., projects, dramas, debates etc. They afford a nucleus for the training in corporate and social life. A whole science of society has been built up round these studies, and is well worth knowing by one interested in the training of youth for the world of today.

A collection of about 2000 questions asked by children forms the foundation on which the book "Common Science by Washburne" (World Book Co.) is built. This is also a book like others built on educational research. But unlike the science text books of our experience, it explains the scientific principles in a dramatic manner and conversational style, just to suit the intelligence of the children of that age. With the help of this book science can also be taught like other subjects by the individual method to the children.

Thus Winnetka schools have individualized the school subjects or phases of them which require mastery of facts and in which students are examined for promotion. By so doing they have found a definite saving in time and freedom from the fear of failure for a child, for now he can progress at his own natural speed in the school subjects.

But the studying of these formal school subjects is not all the education a child needs for a good preparation for life. There are other traits and characters we want very much a child to develop—his originality, creative impulses, initiative, emotional adjustment, a sense of responsibility for his own welfare and that of his group, his nation, and of humanity. Far more people fail in life, at home, in business, or in community, because they lack these than because they lack in the three 'Rs'.

The Winnetka schools pay the greatest importance to this side of school life, and are one of the foremost in putting Dewey's ideal of education into actual practice. 'Education is a process of living and not a preparation for future living'. The schools offer continuous opportunities for developing children's individuality and self expression, as well as the spirit of co-operation and social harmony through group and creative activities *i.e.*, projects arising out of social studies, work in art, in music, in handicrafts, in creative writing, in their electives or hobbies, as well as in their student government, playground etc. Persistently the schools aim at developing the inner life of the child and harmonising it with the life of his social group and accordingly devote as much time of the day to these activities as to formal studies.

Towards the end of developing each child's personality and emotional balances, the schools have organized a Department of Educational Counsel. This influences all school work and makes detailed studies, on individual basis, of children who are not making satisfactory adjustment to school or to life. This department makes much use of the principles and techniques of Freud and Adler and consists of a psychiatrist, a psychologist, two pediatricians, school principals, and Washburne himself. A great deal of use is made of intelligence and other kinds of tests. From these a chart is drawn for each child which can predict his mental maturity at any date, and his academic progress in relation to his mental growth.

Thus science and scientific technique is remodeling educational thought and procedure in Winnetka. And what is true of Winnetka is to some extent also true of the progressive schools of America and perhaps England, Russia, and some other countries too.

Generally educational reform is brought about by (i) changes in administration, and (ii) scientific study of education or (iii) revolutionary ideas of some great persons. Just changes in administration are at the best very weak and imperfect attempts at reform. There is no change in view and the system is kept as it is. Real revolutionaries like Rousseau, Dewey, Pestalozzi Frobel, or our Tagore and Gandhi, cut straight through the superficial details of administration and visualize the school in a totally new orientation. The ideas and ideals of such persons have the greatest and most far reaching effects on the educational system of any country. But even these must be supported by continuous study of education on a scientific basis. This is the aspect of the problem. I feel, our educators must pay more attention to, now and in the future.

As it is constituted our educational system has become somewhat old and stubborn. But the new, the progressive, and the unfettered schools that are coming up in our country now, and the Wardha Scheme, or what has remained of it, may, because they are young and elastic pay greater attention to the really scientific study of our educational problems. And thus strive to give our children, real, good, and thorough education they need today.

ANTOINE-LAURENT LAVOISIER (1743-1794)

FOUNDER OF CHEMISTRY AND PHYSIOLOGY

IN the December, 1943 issue of this journal Professor P. Ray in an able article has brought out the fundamental contributions of Lavoisier as a chemist but his physiological contributions have not been mentioned. Lavoisier's claim as the founder of physiology has been brought out in the following lines.

The modern era of the science of nutrition was opened by Lavoisier in 1780. He was the first to apply the balance and the thermometer to the investigation of the phenomena of life, and he declared "La vie est une fonction chimique." The work of today is but the continuation of that done a century

and more ago. Lavoisier and Laplace made experiments on animal heat and respiration. The great German chemist Liebig received his early training in Paris, residing there in 1822. Liebig's conception of the processes of nutrition fired the genius of Voit to the painstaking researches which laid the foundation of his Munich school. These have been repeated and extended by his pupils, of whom Rubner is the chief, and by others all the world over. Thus the knowledge often transmitted personally from the master to the pupil, to be in turn elaborated, had its seed in the intellect of Lavoisier. It was he who first discovered the true importance of oxygen gas,

to which he gave its present name. He declared that life processes were those of oxidation, with the resulting elimination of heat. He believed that oxygen was the cause of the decomposition of a fluid brought to the lungs, and that hydrogen and carbon were produced in this fluid and then united with oxygen to form water and carbon dioxide. He said that perspiration regulated the quantity of heat lost from the body and that digestion replenished the blood with the materials eliminated through respiration and perspiration. It was he who first made respiration experiments on man, the results of which are briefly described in a letter to Monsieur Terray¹, written in Paris and dated November 19, 1790. There is no existing record of the apparatus with which Lavoisier worked and early obtained the following results. Lavoisier sums up the more important conclusions as follows:

1. The quantity of oxygen absorbed by a resting man at a temperature of 26°C. is 1200 pounces de France² hourly.
2. The quantity of oxygen required at a temperature of 12°C. rises to 1400 pounces.
3. During the digestion of food the quantity of oxygen amounts to from 1800 to 1900 pounces.
4. During exercise 4000 pounces and over may be the quantity of oxygen absorbed.

These remarkable results are in strict accord with the knowledge of our own day. We know more details, but the fundamental fact that the quantity of oxygen absorbed and of carbon dioxide excreted depends primarily on (1) food, (2) work and (3) tem-

perature was established by Lavoisier within a few years after his discovery that oxygen supported combustion. Writing in 1849 Regnault and Reiset say, "Les recherches modernes ont confirmé ces vues profondes de L'illustre savant."

Lavoisier³ was the first to recognize that animal heat was derived from the oxidation of the body's substance and to compare animal heat to that produced by a candle. To prove this he burnt a known quantity of carbon in an ice chamber and noted the amount of ice melted. He then calculated the amount of heat produced from a unit of carbon. He and Laplace put a guinea-pig in an ice chamber and noted the amount of ice which melted during ten hours and calculated the heat given off from the animal. They then determined how much carbon dioxide the guinea-pig gave off. The animal yielded 31.82 calories to the ice chamber, while a calculation from the respiratory analysis showed that 25.408 calories could have been derived by the burning of enough carbon to yield the same amount of carbon dioxide as was eliminated by the animal.

Lavoisier realized several of the errors in his work. For example, the calorimetric determination on the animal was made at a different temperature from that of the respiratory experiment, and Lavoisier knew that cold would raise the carbon dioxide output. Also cold reduced the heat in the animal itself, and, further, the water of respiration was added to that of the melting ice. But Lavoisier concluded that the source of the heat lay in the oxidation of the body, and that is why he is acknowledged as the founder of physiology.

N. R. Dhar.

¹ Report of the British Association for the Advancement of Science, Edinburgh, p. 189, 1871.

² 1 cubic pounce = 0.0198 litre.

³ Lavoisier and Laplace; *Academic des Sciences*, p. 379, 1780.

DR. C. W. B. NORMAND

RECIPIENT OF SYMONS MEDAL

DR C. W. B. NORMAND, M.A., D.Sc., C.I.E., Director General of Observatories, India, has been awarded the Symons Gold Medal for 1944 by the Royal Meteorological Society (London).

The Symons Medal was instituted in 1900 by the Royal Meteorological Society for award bien-

nially "irrespective of sex or nationality for distinguished work done in connection with meteorological science". This has come to be regarded by meteorologists the world over as amongst the highest honours which a meteorologist can aspire to.

Dr Normand is a distinguished student of Edin-

burgh University where he specialised in mathematical physics and chemistry. He joined the Indian Meteorological Service in 1913 and has been for the last 17 years the head of the India Meteorological Department. Under his guidance, these years have seen a rapid and phenomenal increase in the activities of the department in all aspects. To see this, one has only to turn over the pages of the annual administration reports of the Department. A brief reference will be made here of some of the important developments which have taken place during this period.

Foremost among them has been the Meteorological Organisation created to meet the increasing demands of aviation. Briefing (or Auxiliary) Centres have been opened. The number of surface and pilot balloon observatories rose from 211 and 11 in 1927 to 326 and 35 respectively in 1940. Since then there has been a further increase in the number of observatories due to war requirements. The staff also has similarly increased in all its cadres and in particular the strength of the gazetted staff (exclusive of developments due to war) has trebled itself.

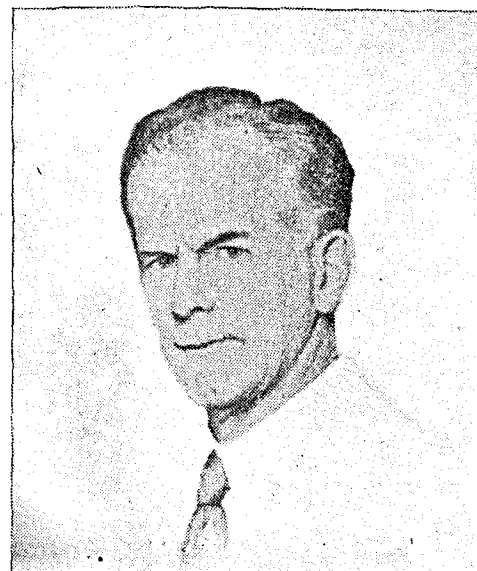
Dr Normand's great interest in Upper Air problems is not merely reflected in the increase in the number of Pilot Balloon Observatories and observations but also in the steadily increasing number of soundings of the upper atmosphere with Dines Meteorographs. This has provided valuable Upper Air data which are of the utmost importance to aviation and to a better understanding of the structure of the atmosphere. Special studies of particular weather phenomena, like Nor'westers of Bengal, depressions etc., by means of intensive soundings of the atmosphere have also been made. Recently the department has developed a special Radio-Sonde suitable for use in India.

As India is a predominantly agricultural country a special branch in Agricultural Meteorology was created in 1932. The department's seismological work received fresh impetus by the appointment of a special officer for seismological research.

Dr Normand has been India's representative in the International Meteorological Conferences for many years. He is the Vice-President of the International Aerological Commission for Region D which comprises India, East Indies and the Far East.

In addition to the organisational activities referred to above Dr Normand has stimulated meteorological research in India as can be seen from the large number of original papers published by the members of the Indian Meteorological Department. He has himself made outstanding contributions to

meteorology, particularly to the theory of Wet-Bulb temperature and its applications to the thermodynamics of the atmosphere which have won universal recognition. His theory of Wet-Bulb temperature was first published in its complete form in 1921; but he had conceived his principal ideas on the subject much earlier as is evident from his writings on the effect of high temperature on the human body during his three years war service in Mesopotamia in the last war.



DR C. W. B. NORMAND

One of the fundamental problems of the upper air has been the determination of a function of pressure, temperature and humidity which is an invariant in the adiabatic processes in the atmosphere. This problem had attracted the attention of such distinguished meteorologists as Hann, Margules, Knoche and others but Dr Normand was the first to introduce the concept of Wet-Bulb potential temperature which is practically an invariant in adiabatic processes in the atmosphere¹. In the same paper, he introduced another quantity, 'Equivalent potential temperature' which is a single-valued function of Wet-bulb potential temperature and hence an invariant in adiabatic processes. With the passage of time and the growing volume of upper air data these two quantities have proved most useful in the analysis of weather. In this paper he also gave a

¹ *Memoirs of Indian Meteorological Department*, Vol. XXIII, Part I, 1921. Wet-bulb Temperature and the Thermodynamics of the Air by Dr C. W. B. Normand.

construction for obtaining the Wet-bulb temperature for any values of pressure, temperature and humidity, from thermodynamical diagrams. No ready tables to obtain Wet-bulb temperatures for values of pressure, other than the standard value (pressure=1000 mb.) are available and the construction suggested is ingenious, simple and full of physical significance. It displays a very deep and thorough understanding of thermodynamical problems. This construction is contained in *Normand's Theorem* which is as follows: If T , T' and T_a are simultaneous readings of Dry-bulb, Wet-bulb and Dew point temperatures respectively, then the unsaturated adiabat through T , the saturated adiabat through T' and Dew point curve (or isohyric) through T_a all meet in a point. He derived several other important results, a few of which are (a) Wet-bulb temperature is a measure of the heat content of air and (b) Wet-bulb temperature is a measure of the entropy of the atmospheric air. Again, in 1931, he introduced the idea of Latent Instability in connection with the discussion of stability and instability of the atmosphere. Particularly in Indian latitudes, where lapse-rates (of temperature) ordinarily exceed the moist adiabatic rate (i.e., for saturated air) a finer distinction in the classification of stability criteria is needed to reveal those cases which are associated with disturbed weather. The

idea of latent instability introduced for this purpose has proved a very useful and practical criterion for forecasting thunderstorms and duststorms of the convective type. Some of his other published papers deal with the influence of water vapour on problems of energy. Here again, he has been the first to point out the modifications necessary in the old conclusions due to the presence of latent instability.

Those who are in close contact with him know the great amount of thought and hard work that Dr Normand has brought to bear on his favourite problems for many years although he has not yet made available all the results of his investigations. But the quality of his hitherto published work is undoubtedly what has earned him the high honour that the Royal Meteorological Society has conferred upon him.

Dr Normand had the unique distinction of being elected twice president of the Mathematics and Physics Sections of the Indian Science Congress.

Among the previous recipients of the Symons Medal are such distinguished names as Hann, Sir Napier Shaw, Hildbrandson, W. H. Dines, Sir G. C. Simpson, Sir G. T. Walker, Schmidt, Vand J. Bjerknes and Lt.-Col. Gold.

Notes and News

SUBSTITUTE MATERIALS IN WAR AND PEACE

ACCORDING to a report in *Nature*, the Royal Institute of International Affairs (Oxford University Press) has recently issued a brochure bearing the above title. Within its necessarily short compass Dr C. H. Desch, the author of the brochure, has given a good account of some of the important synthetic materials which have largely substituted such natural products as petrol, rubber, fibres, metals etc. Curiously enough a large number of people, including many among the intelligentsia, still entertain a doubtful attitude regarding the equal merits of substitute products. This little monograph containing useful information as to the significant role being played by substitute materials in this war will

considerably help to dispel such unfounded impression about a substitute.

In 1941, as Dr Desch revealed, Germany used producer gas in place of petrol in driving some 150,000 lorries and about 20,000 new agricultural tractors and has since considerably increased its use in running ever greater number of locomotives. Since 1939, the same country has been using an artificial fibre synthesised from coal, limestone and chlorine for protective clothing, fishing nets and chemical fitters. In the same year, some 10,000 tons of 'fodder yeast' were produced at Regensburg. The Axis countries have now largely replaced nickel by chromium and molybdenum for use in the air-craft industry, and this, so far as the information goes,

has not led to any deterioration of the quality of the Axis planes. Synthetic resins proved so effective a substitute for aluminium in the United States that they have become scarcer than even aluminium. Great Britain has reduced the number of steel specifications from 2,000-3,000 to 85. Copper and 'stainless' steel for the manufacture of resistant chemical plants have been greatly substituted by mild steel with a surface layer of the more valuable metal. The United States has planned to produce annually 800,000 tons of synthetic rubber from petrol and 200,000 tons from grain alcohol, and plants are now under construction. Japan is reported to be actively engaged in producing petrol from her abundant resource of natural rubber. These brisk developments about substitute materials only herald the beginning of a new age in which the substitute materials will eventually take the lead and replace the mineral resources whose supply is dwindling slowly but surely.

FIFTH ANNUAL GENERAL MEETING OF THE INDIAN CHEMICAL MANUFACTURERS' ASSOCIATION

At the Fifth Annual General Meeting of the Indian Chemical Manufacturers' Association, held at Bombay on November 6, 1943, Dr H. Ghosh, in course of his presidential address, referred to some of the outstanding difficulties impeding the progress of chemical and pharmaceutical industry in this country. Speaking of India's basic chemical industries, he said that this country has to depend on foreign supply for 95 per cent of her requirements of basic chemicals. Attempts to develop basic chemical industries, such as coal distillation products, production of ammonium sulphate, alkali products, acetic, citric, tartaric, phosphoric and cheap sulphuric acids, starch products and alcohol, have been meagre despite the immense possibilities of these industries in this country. It is indeed regrettable that India having unlimited supply of cheap coal could not yet develop the coal distillation which is the source of supply of basic chemicals for dye stuff industry, solvents, bakelite industry, chemico-therapeutic and pharmaceutical products and reagents. The immense scope for the manufacture of basic chemicals in India has been clearly shown in all the reports and recommendations of various committees and conferences which have discussed this problem since the beginning of the war, but no organised effort has so far been made by the Government to implement the same. He referred to the examples of Australia and South Africa, both agricultural countries and suppliers of raw materials like India, which have, under the stimulus of the war, experienced unprecedented development of basic chemical industries.

Dr Ghosh then discussed the problem of fertilisers on whose satisfactory solution depends the success of the much advertised 'Grow More Food' campaign. The Food Grains Policy Committee set up recently by the Government estimated India's annual requirements of fertilisers at about 3,50,000 tons. Non-official expert opinion is that India would require annually about one million tons of fertilisers to meet her growing requirements of all crops including rubber, sugar and coffee. Before the war India used to consume about 1,00,000 tons of fertilisers of which only 20 to 25 thousand tons were produced in this country. There is at present only one synthetic ammonia plant with a small output, and the Government are now seriously considering schemes for the production of more fertilisers.

Referring to the quinine problem which has assumed serious proportions, Dr Ghosh attributed its cause to the faulty quinine policy of the Government of India and the Provincial Governments. Quinine salts which used to be sold at Rs. 18/- a pound before the war is now selling at Rs. 350/- a pound, and even then it is scarcely available or often adulterated. India manufactures only 70,000 pounds of quinine out of her total estimated requirement of 600,000, i.e., less than 12 per cent. In normal times the deficit used to be supplied from the Dutch East Indies. The Japanese occupation of Dutch East Indies has exposed millions of people to the scourge of malaria which has now joined hands with famine to depopulate Bengal at an alarming rate. India possesses large tracts of suitable land for cultivation of cinchona, but the Government has so far refused to take any step in spite of the repeated requests and recommendations of the Indian medical practitioners and public to extend the cultivation of cinchona.

Dr Ghosh stressed the need of industrial research which has now become the recognised practice in all leading industrial countries. The importance of the industrial research has received in Europe and America is reflected from the fact that one concern in Germany spent 31 million marks for experiments in the liquifaction of coal. In the United Kingdom the coal industry with the assistance of the D.S.I.R. spent 200,000 pounds a year on coal utilisation researches. The Fuel Research Board in addition spends 100,000 pounds a year on the survey of coal researches, and the Gas Industry spends about 400,000 pounds a year in research. American Petroleum Industry's contribution is no less than 600,000 pounds on research. He referred to the limited scope of research afforded by the Board of Scientific and Industrial Research and advocated better co-operation of the Board with the existing industries. He further suggested the establishment of an independent institution of industrial research under the con-

trol of a Board appointed by the Chemical Manufacturers' Association, for which funds should be made available by the leading industrial concerns of the country.

NEED FOR CO-OPERATIVE RESEARCH IN INDIAN CHEMICAL INDUSTRY

THIS formed the subject of the Presidential Address by Sir Shanti Swarup Bhatnagar, Director, Board of Scientific and Industrial Research, India, at the conference of manufacturers of chemical and pharmaceutical products and representatives of universities and research institutes, held at Bombay on November 6, 1943. Sir Shanti Swarup emphasised the need for co-operative research in Indian chemical industry and recommended the creation of research associations in India after the model of the research association of the United Kingdom. To convey an impression as to the present state of chemical industry in India he quoted some figures relating primarily to heavy chemicals. India now manufactures or shortly will manufacture sulphuric acid, about 80,000 tons, caustic soda about 4,500 tons, soda ash about 56,000 tons, chlorine about 2,600 tons, chlorosulphonic acid about 15 tons and formaldehyde about 60 tons a year. The production of coal tar has risen to 80,000 of which nearly 40,000 tons a year are distilled, and such constituents as naphthalene, anthracene, benzene, toluene and phenol are being recovered. Other chemicals, such as potassium chloride, potassium chlorate, barium chloride, bromine, sodium sulphate, sodium sulphide, sodium and potassium dichromate, etc., are now manufactured in fair quantities. These figures, though encouraging on first thought, are not, however, very inspiring when compared with those of other countries, and much more would have been done and the opportunities created had the Industry and the Government been alive to co-operative research at an earlier date.

Sir Shanti Swarup then briefly dwelt on the co-operative research in England and the activities of the research associations established under the aegis of the Department of Scientific and Industrial Research. These associations, at present numbering twenty three, collectively hold a very important position in British industry and spent in 1938 over half a million pound on administration and research, one-third of which was provided from the D.S.I.R. funds and the balance by the industries. The results which these associations have achieved during such a short time are indeed admirable. For instance, the British Scientific Instruments Research Association designed the object glass of the huge 100 inch telescope at Mount Wilson, besides introducing a number of optical glasses. The British Electrical and Allied Industries Research Association met with consider-

able success in the prevention of telephone and broadcasting interferences. A very good heat resisting alloy 'silal' was introduced by the British Cast Iron Research Association as a result of the fundamental work on influences of different ingredients on properties of cast iron alloys.

Indian industry can derive similar benefits through the creation of research associations. The Council of Scientific and Industrial Research has not so far financed any research association or suggested the formation of any. Sir Shanti Swarup explained that this was due to the paucity of funds at the disposal of the Board. Barring a munificent grant of Rs. 8,30,000 from the Tatas and a donation of Rs. 1,00,000 from the Indian Wire and Steel Products, Tata Nagar, not many donations have been received from industry. The Government grant of Rs. 10 lakhs a year is hardly adequate for the programme which the Council has before it. Large funds are needed to bring into being the proposed National Chemical Laboratories, the National Metallurgical Laboratories, the Fuel Research Station, the National Physical Laboratories of the Central Glass and Silicate Research Institute. The activities of the Council have therefore so far been limited to running their own laboratories and financing a number of research schemes at various university centres and technical institutions. Accordingly, he suggested that the group of chemical manufacturers who constitute the All-India Chemical and Pharmaceutical Manufacturers' Association should join and set up a research association. Sir Shanti Swarup, as Director of the Board of Scientific and Industrial Research, assured that the Council will recognise it and help it with the best of their ability. In the event of the establishment of such a research association it may not be necessary to have a separate laboratory building from the very outset, and he suggested that work can be started without delay in the already established laboratories. For example, a centre of industrial research in connection with chemical industry could be started in the Calcutta University. A grant could be made by a group of manufacturers jointly in consultation with the Council of Scientific and Industrial Research, to the University for space and facilities. The staff could be provided from the funds of the association concerned and the work could be started satisfactorily almost immediately and without waiting till the association could collect sufficient funds for a separate up-to-date laboratory.

THE CENTRAL BOARD OF IRRIGATION JOURNAL

THE appearance of the new quarterly journal of the Central Board of Irrigation has at last removed the long-felt need of a periodical entirely devoted to

irrigation and allied problems to keep the majority of irrigation engineers interested and informed in irrigation matters. The journal represents an extension of activities of the Information Bureau of the Board which has already been doing a very useful service by publishing technical papers, monthly abstracts of current literature received in the Bureau and annual reports containing summary reports of research stations, papers contributed to the Research Committee and discussions thereon. The technical nature of these publications designed mainly for the specialists and research officers has necessarily a limited interest, and as such there was clearly a need for a periodical of this type to record in a more or less general way the advancement of the science of irrigation and the progress of irrigation research in various Provinces and States in India. The Executive Committee of the Central Board of Irrigation, therefore, decided to publish a quarterly journal under the editorship of A. R. Thomas, Secretary of the Board. While it is expected that the journal will prove highly useful to irrigation engineers working on different fields, for whom it is primarily intended, the general reading public interested in the irrigation problems of the country will also find it a very useful source of information.

PROPOSED NEW BARRAGE AT DELHI

THE Central Board of Irrigation Journal reports that at a conference in New Delhi in which the representatives of U. P., the Punjab and the Central Government and the Chief Commissioner of Delhi attended the proposed new barrage at Delhi met with general approval, and it was agreed that a weir was necessary to ensure adequate water supplies to Delhi during the next and subsequent hot weathers, for the electric power house and for unfiltered water. The scheme originated with the shortage of water in Delhi this summer. It was felt that a weir across the Jumna should be constructed to ensure adequate levels and to store adequate supplies for the power house and pumps. At the same time, the Punjab Government was considering a scheme for irrigating the district of Gurgaon by an extension of the Western Jumna Canal through a tunnel under the Delhi ridge. Then the idea of combining the two schemes suggested itself. In consequence it was proposed to construct a barrage at Indrapat (the Purana Qila) to head up supplies to R.L. 672, and to take off from above this barrage a canal flowing southwards to the Gurgaon district.

The amalgamated scheme would give Delhi a lake about 6 miles long and about three quarters of a mile wide which would ensure an abundant water supply throughout the year. With the construction

of the barrage, it would be necessary for both banks of the Jumna to be strengthened. These latter would be used for boulevards on either side of the river. It is proposed to construct a road bridge across the barrage about 50 ft. wide with ample side-walks. The lake with boulevard on either side connected by the road bridge would open up possibilities of such amenities as a boating club, swimming club etc., and of the establishment of a satellite town on the left side of Delhi. The scheme is estimated to cost about a crore of rupees.

INDIA'S MINERAL INDUSTRIES

THE present position and future scope for expansion of India's mineral industries formed the topic of the presidential address of Mr B. Rama Rao, Director of Geology in Mysore, to the 19th Annual General Meeting of the Geological, Mining and Metallurgical Society of India, which was held on the 29th November, at Calcutta. In his address, Mr Rama Rao gave an interesting and detailed account of the mineral wealth of India and its geographic distribution, the various mineral industries existing in different provinces and the scope for their future expansion and the ways in which the Government can help to foster the rapid growth of these industries.

Mr Rama Rao stated that the estimated value of India's annual production of ores, minerals and metals has been ranging now from 30 to 35 crores of rupees, which, when compared with the value of minerals, metals and mineral fuels produced annually in the United Kingdom, South Africa, Canada and Australia, stands lowest. The progress of mineral industries in India during the last 50 years, though not altogether negligible, cannot be considered to be commensurate with the country's extent and of its total population. Several causes are attributed to this tardy growth of India's mineral industries, amongst which he instanced the lack of enterprise and initiative of the Indian capitalists in venturing on the mining and metallurgical fields which, to them, have become unfamiliar and unattractive, want of effective State-guidance and help, and the country's general ignorance of its available mineral resources and their uses.

India's present imports of various mineral products, mineral fertilisers and chemicals, etc., amount to several crores of rupees every year. Most of these, like refined kaolin, dressed emery, graded asbestos, and industrial chemicals like the dichromates, which are absolutely necessary for some of the local industries, can be easily prepared in India out of the raw minerals available in the country.

Mr Rama Rao said that India has deposits of more than a hundred varieties of useful minerals which could serve as raw materials for several indus-

tries, but these are, however, irregularly distributed in the country. After giving a succinct account of the provincial distribution of minerals and the mineral industries now existing therein, he examined in detail the scope for expansion of the metallurgical industries like iron and steel smelting, production of ferro-alloys, extraction of gold, lead and copper, etc., and also the scope for developing various non-metal industries—like the manufacture of abrasive products, ceramic, refractory, and glass industries, mineral paints and pigments, and production of mineral fertilisers and chemicals and several other miscellaneous mineral industries in each of those provinces.

However, to formulate simultaneous workable plans for the systematic and progressive development of the several possible mineral industries in the different provinces, Mr Rama Rao stated that reliable information on the accurate extent and quality of most of the deposits in several areas is lacking, and this has to be obtained by an intensive mineral survey in each of the provinces by careful, modern methods of prospecting. The absolute inadequacy of the geological service available now for such purposes was strongly stressed. In indicating the State's function to foster the rapid growth of the country's mineral industries, Mr Rama Rao strongly urged the immediate organisation by Government of well equipped, mineral survey departments in each of the provinces for an intensive exploration and the constitution at the Centre, of a "National Mineral Utilisation Board", with several advisory committees in respect of different groups of industrial minerals. He discussed the relative functions of such central and provincial organisations for their harmonious working and for their production of maximum benefit to the country. The address concluded with a strong plea for the prevention of wasteful methods of mining specially noticeable in the case of mica, coal and a few other minerals; for the conservation of the country's essential minerals by their scientific utilisation and intelligent and discriminate use; and for the immediate formulation of workable plans for the development of possible mineral industries in the country so as to correctly assess the actual extent of its needs, of the essential minerals it has and of others it has not.

SOMETHING MORE IMPORTANT THAN WAR

ONE of the delegates from Great Britain was Sir Ernest Rutherford who had been collaborating closely with the French physicist, Paul Langevin, in the development of underwater supersonic devices. The day before the conference, when the British and American delegations came over from London, Rutherford was not present but he sent me a letter, delivered by Professor Bumstead, stating that some

very recent experiments which he and his research assistant had been carrying on in the Cavendish Laboratory had apparently indicated success in disintegrating the nucleus of the hydrogen atom. 'If this is true', Rutherford wrote, 'it is a fact of far greater importance than the war.' He went on to say that he was in the midst of a second experiment to check these startling findings and that he would be delayed a couple of days pending the termination of this experiment. Then Rutherford added as a postscript: 'Tell nobody about this because I may be mistaken.' Later it developed that what Rutherford had actually done had not been to disintegrate the hydrogen nucleus, but rather to disintegrate the nuclei of nitrogen atoms. So far as I know Rutherford's letter to me was the first written indication of success in the long, long struggle to produce by artificial means a transmutation of one chemical element into another. I wish I had kept that letter and had turned it over to Professor Eve at the time when he was writing his interesting biography of Ernest Rutherford. (From the Pilgrim Trust Lecture by Prof. K. T. Compton).

INDIAN SCIENCE CONGRESS ASSOCIATION

THE ensuing Science Congress was to have been held in the first week of January, 1944 at Trivandrum under the auspices of the University of Travancore. Owing to the peculiar geographical location of the city it was feared that many members would find it extremely difficult to reach Trivandrum in these days of transport difficulties. The University of Delhi having kindly extended the invitation, the Executive Committee of the Association has decided that the 31st Session of the Science Congress will be held at Delhi instead of at Trivandrum.

The Session will open on Monday, January 3, 1944, and close on Thursday, January 6, 1944. Professor S. N. Bose, F.N.I., Head of the Department of Physics, University of Dacca, will preside.

The Local Secretaries at Delhi are:

Sir Shanti Swarup Bhatnagar, Kt., F.R.S., Professor of Chemistry, University of Delhi and Director of Scientific and Industrial Research, Government of India, Delhi.

Prof. D. S. Kothari, Ph.D., F.N.I., Professor of Physics, University of Delhi, Delhi.

Sir Maurice Gwyer, Vice-Chancellor of Delhi University is the Chairman of the Reception Committee.

The following are the Presidents of the respective sections:

Mathematics and Statistics.—B. M. Sen, Esq., M.A. (Cantab.), I.E.S., F.N.I., Late Principal,

Presidency College, Calcutta. *Physics*.—Prof. D. S. Kothari, M.Sc., Ph.D., Professor of Physics and Head of the Department, University of Delhi, Delhi. *Chemistry*.—Prof. R. C. Ray, D.Sc., F.I.C., F.L.I.Sc., Professor of Chemistry and Head of the Department, Science College, Patna. *Geology and Geography*.—Dr A. S. Kalapesi, B.Sc. (Bom.), Ph.D., D.I.C., F.G.S. (Lond.), St. Xavier's College, Cruickshank Road, Bombay. *Botany*.—Dr T. S. Sabnis, D.Sc., F.A.Sc., I.A.S., Principal, Cawnpore Agricultural College and Economic Botanist to the Government of U. P., Cawnpore. *Zoology and Entomology*.—Prof. Vishma Nath, M.Sc., Ph.D. (Cantab.), F.N.I., Professor of Zoology, Government College, Lahore. *Anthropology and Archaeology*.—Verrier Elwin, Esq., M.A. (Oxon.), F.R.A.I., Patangarh P.O., Dindori Tahsil, Mandla District, (C. P.). *Medical and Veterinary Sciences*.—Prof. K. V. Krishnan, M.B.B.S., M.R.C.P., D.B., D.Sc., F.N.I., Professor of Microbiology, All-India Institute of Hygiene and Public Health, 110, Chittaranjan Avenue, Calcutta. *Agricultural Sciences*.—Rao Bahadur D. V. Bal, M.Sc., (Agri.) Hons., Ph.D., A.I.C., F.C.S., Agricultural Chemist to the Government of Central Provinces and Berar, Nagpur (C.P.). *Physiology*.—Prof. S. N. Mathur, M.B., B.Sc., Ph.D. (Lond.), Professor of Physiology, Medical College, Agra. *Psychology and Educational Science*.—John Sargent, Esq., M.A., C.I.E., Educational Adviser to the Government of India, Imperial Secretariat, New

Delhi/Simla. *Engineering and Metallurgy*.—J. J. Ghandy, Esq., C.I.E., B.Sc., M.I.E., F. Inst. F., M.I.S.I., General Manager, Tata Iron and Steel Co., Ltd., Jamshedpur.

ANNOUNCEMENTS

At the 19th annual General Meeting of the GEOLOGICAL, MINING AND METALLURGICAL SOCIETY OF INDIA held at Calcutta on 29-11-1943 the following were elected to the Executive Council for 1943-44.

President—Sir Cyril S. Fox. *Vice-Presidents*—Prof. L. Rama Rao, Prof. N. N. Sen. *Joint-Secretaries*—Prof. N. N. Chatterjee, Prof. S. K. Bose. *Treasurer*—Prof. B. N. Maitra. *Librarian*—Prof. S. Ray. *Other Members of the Council*—Prof. M. Chatterjee, Dr A. K. Dey, Prof. T. N. Muthuswamy, Mr P. S. Narayana, Mr N. H. Ojha, Mr N. L. Sharma, Prof. Daya Swarup, Prof. K. P. Rode.

It is proposed to hold a REUNION OF THE PAST AND PRESENT STUDENTS OF THE PURE PHYSICS DEPARTMENT of the University of Calcutta. The Reunion is expected to be inaugurated some time in February after the completion of preliminary arrangements. Further details may be available from Dr H. Rakshit, Secretary of the Reunion for 1944. All past physics students are hereby requested to send in their names, the years of passing, present occupations and addresses, both present and permanent, to the Secretary.

SCIENCE IN INDUSTRY

PARACON—THE NEW SYNTHETIC RUBBER

'PARACON' is the name given to a new speciality rubber recently synthesised by Drs C. S. Fuller and B. S. Biggs, of the Bell Laboratories and their associates. The new synthetic product has more or less all the properties of natural rubber and in certain respects appears to be superior to it. For instance, it offers better resistance to heat, light and oxidation and is damaged by oil or petrol only with difficulty. In its raw state, 'Paracon' is highly plastic and can be easily moulded into intricate shapes and used in the preparation of rubberized fabrics. But the effect of steam, acids and alkalis proves more serious on the synthetic product than on natural rubber.

Details of manufacture of the new synthetic rubber are at present lacking for obvious reasons. It is, however, reported that the chief materials re-

quired for its synthesis are derived from coal and agricultural products, or from coal and petroleum sources. The chemical processes and the plant equipments, involved in its manufacture, are different from those required in other important branches of synthetic rubber now in production on a large scale. The new synthetic rubber, besides offering a fresh outlet for agricultural and coal products, will significantly contribute to the total production of synthetic rubber in U. S. A. For a fuller detail, the reader is referred to the following publication of the Bell Laboratories: *Bell Lab. Rec.*, 20, No. 9; May 1943.

A NEW METHOD OF FOOD DEHYDRATION

The problem of food dehydration has received renewed interest in these days of shipping shortage.

We have from time to time recorded in these columns the various methods of drying vegetables and other food-stuffs, developed notably in U. S. A. *Science* has recently reported a new method of food dehydration, working on an entirely different principle, which is claimed to have succeeded for the first time in effecting a removal of 99 per cent of the moisture content from a compressed vegetable block. Developed by Vernon W. Sherman, of the Federal Telephone and Radio Corporation, the new process, it is interesting to note, employs radio-frequency energy for the purpose of dehydration.

Food dehydrated by ordinary methods using hot air contains as much as 5 per cent of moisture which often becomes the cause of spoilage, especially in the tropics. Further reduction of the moisture content by warm air generally makes the skin of the vegetables tough and also causes an undesirable blackening called 'case hardening'. Dehydration by radio-frequency energy which easily reduces the moisture content to one per cent only does not, however, affect the skin in this way if suitable wave-lengths are employed.

In the method developed, 80 per cent of the moisture content of vegetables to be dried is first removed by conventional hot air method. The food-stuffs are then compressed into blocks and placed in the magnetic field of the drying unit in which the energy of the radio-frequency is made use of. The drying operation is completed in about an hour. It is stated that during dehydration the temperature remains remarkably uniform throughout the mass of the food-stuff, which is not experienced in any other method. The speed of the process contributes largely to the high retention of vitamins in the dried foods. The foods dehydrated by the electronic method also keep well for a longer period of time, about one to two years, even in hot and humid climate. The method is also economic, as less than one kilowatt hour of energy, costing about one cent (nearly half anna) is required for the removal of one pound of water.

The method has so far been tried only on a laboratory scale. The construction of a 50 kilowatt electronic food drier which would turn out 6 tons of dried food a day, equivalent to about 60 tons of fresh food, is at present under consideration.

ALCOHOL FROM WHEAT

Dr A. K. Balls and Irvin W. Tucker, of the United States Department of Agriculture, have recently developed a process of obtaining alcohol from wheat at a considerably smaller cost, according to a report of the *Scientific American*. Besides the economic factor, the new process is significant inas-

much as it leads to the recovery of protein as by-product of alcohol distillation.

Malted barley is now generally used in the production of grain alcohol because of its concentration of diastase. It is well-known that the enzyme diastase converts the starch of the cereal grains to sugar to feed the yeast cells. The advantage of malted barley in its high concentration of diastase is, however, limited by the high cost of this cereal. Attention was, therefore, focussed on wheat and other grains available at a much lower price; but these cereals did not at first appear suitable for the purpose owing to the loss of their natural diastase during the cooking operation prior to distillation.

It is with the object of extracting diastase from wheat before cooking that research was started at the U. S. Department of Agriculture. It has been found that this extraction can be conveniently effected by a solution of sodium sulphite available in large quantities as a waste product in several industries, such as pulp and paper, ore roasting and coke making. Sodium sulphite not only extracts the diastase, but also sets free the protein content of the wheat, which rises to the surface as a thick, yellow froth. Protein can be easily separated and the solution containing diastase can be employed to convert the starch into sugar after cooking. The extraction of diastase and protein does not require much additional equipment and is a simple affair. Moreover, the separation of protein at the beginning of the operation reduces the bulk of the cereal to be handled during the subsequent stages of alcohol production.

It is stated that the replacement of expensive barley malt by wheat and the recovery of protein as a by-product will henceforward considerably reduce the cost of alcohol production. It has been estimated that the new process will make possible a recovery of one billion pounds of protein a year in a practically pure form, which can be used as a supplement to livestock feed, for protein enrichment of white flour for bread and cereals, and for processing into a number of essential chemical products, including casein.

GAS TREATMENT YIELDS BETTER CATHODES

It is well-known that oxide-coated cathodes emit electrons more readily than cathodes of pure metal. But the use of oxide-coated cathodes is not generally possible in high voltage tubes owing to the tearing effect of the strong electric field. The oxide-coating consisting of a paste baked on to the metal is actually torn off from the surface of the cathode when placed in a strong field. Experiments performed in the laboratories of the Lamp Division of the Westinghouse Electric and Manufacturing Company have recently shown that a copious supply of electrons is

made possible by dissolving gases like oxygen, nitrogen or hydrogen into the metal. According to a report of the *Scientific American*, July 1943, Dr Harvey C. Rentschler first observed, in 1935, that a small amount of oxygen dissolved in such metals as thorium, uranium and barium increased the emission of electrons from these metals. Similar effect was not, however, at first observed in commoner metals, such as iron, nickel, copper, zirconium, titanium and others when the gases were dissolved in them. Later on investigations were carried on with pure form of zirconium, titanium and hafnium, and an increased emission of the electrons was found. These metals in the pure state were mounted on a core of tungsten and heated in an atmosphere of oxygen, hydrogen or nitrogen, first at a low temperature and then at a higher temperature, after which the gas was pumped out. The metals become brittle

and hard and can withstand temperatures as high as 2700°F. The gas dissolves uniformly in the metal to give rise to a 'solid solution' and is not liberated on heating, as no pressure increase in the vacuum tube is recorded. Thus treated the metals serve as excellent cathodes.

It has been suggested that during the process the atoms of oxygen, hydrogen or nitrogen actually penetrate into the crystalline structure of these metals and set free the electrons in the structure causing them to be emitted from the metal more readily when heat or light is applied.

This new method of treating metals in an atmosphere of gas bids fair to produce better and longer-lasting cathodes for high voltage electronic tubes. It is also stated that the use of such cathodes would require less power to operate the tubes.

GLASS INDUSTRY

S. DATTA,

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, DELHI

(Continued from the last issue)

CAPITAL AND LABOUR

Capital is far from shy as far as glass industry in India is concerned. The tempting Indian market has always attracted Indian capitalists in spite of the many and quick failures of factories in the past. Judged by past indications there is little doubt that fresh capital should be forthcoming in the future provided there is a reasonable guarantee of efficient organization. Indian glass industry enjoys certain advantages in regard to labour also. In U. P. where there has been the largest concentration of the industry, labour is available in abundance at a very cheap rate. There is no dearth of skilled labour so far as the bangle industry is concerned. The 'Shishgars' of Ferozabad possess much hereditary skill and have shown themselves capable of adopting modern methods successfully. In other branches of the industry also, Indian workers have acquired the knowledge of the present methods from Japanese and Austrians, who have now practically disappeared from Indian glass factories. Today there is no European or Japanese labour either on the machinery or on the manipulation of glass in any Indian factory. The Indian Tariff Board (1932) expressed the definite opinion that the skill of the Indian glass blower and artisan is not such as to constitute a handicap to the industry. The inferior quality of the Indian products in many cases is not due to lack of

skill but due to Indian producers attaching far too little importance to the quality of their products.

SELECTION OF SITE FOR GLASS WORKS IN INDIA

The glass industry in India at present is largely concentrated in U. P. Next comes Bengal and then Punjab and Bombay (see Table 13). The suitability of a site is to be determined mainly by the nearness of the market where the variety of glassware produced will be in great demand. The chief raw materials used in large quantities in glass industry are silica, lime, soda and coal, of which soda at present is imported. The price of soda is lowest at Bombay and Calcutta, but the position may be changed if soda is manufactured in Northern India from indigenous crude alkalies. Price of coal is lowest in places near the Bengal and Bihar coal fields. Sand, suitable for glass making, is available practically in every province of India, though in some cases the sands may have to be previously washed and treated. Considering the nearness of market, transport facilities and prices of chief raw materials, glass factories for the manufacture of any kind of glassware imported from abroad, if established somewhere near Calcutta, will have the greatest advantage against imported goods. U. P. enjoys certain advantages, as good quality sand and lime are available in large quantities near at hand, and labour is

much cheaper than at Calcutta. The traditional skill of Ferozabad workers is also a great asset to the bangle industry. Moreover the large North Indian market is much nearer to the Northern U. P. factories than Calcutta or Bombay which are the distributing centres of imported glassware. Factories in the Punjab also enjoy this advantage. Bombay in spite of a large market, has at present a great handicap as it has to pay a much higher freight charge for coal. Gas fired furnaces run on liquid fuels if introduced in the glass factories in Bombay, may to some extent remove this handicap.

STATISTICS REGARDING IMPORTS, EXPORTS, PRODUCTION AND TOTAL CONSUMPTION

In discussing the statistics regarding imports, exports and production of glassware, it must be emphasised that these have been profoundly affected by the war. It would be more reasonable to tabulate the pre-war figures up to 1939 and then discuss separately the subsequent changes and developments that have taken place after the war started.

The value of the glassware imported into India in each of the years during 1926-27 to 1938-39[†] is shown in Table 8. There are two kinds of glassware

figures including the value of metal fittings as well as the glass in the bulbs. After the last great war (1914) there was a sharp increase in the value of imports and in 1920-21 it reached the record figure of Rs. 337.62 lakhs. This somewhat decreased in subsequent years and remained almost stationary at about Rs. 2.5 crores. There was little variation between the year 1926-27 and 1929-30 in the total value or that of the various kinds of glass imported. The figures for 1930-31 and immediately succeeding years reflect partly the effects of general trade depression. In the case of several items, however, there has been systematic and considerable decrease in the value of imports. The most remarkable decrease is in the case of glass bangles, the value for 1938-39 being 24.2 lakhs which is less than 1/3 of the value of import ten years earlier. This is of course due to large increase in indigenous manufacture which seems to have well withstood foreign competition. Beads and false pearls show significant decrease and so also lampware and tableware. Indian glass factories have begun to produce on a large scale lampware and cheaper tableware and the indigenous products are meeting in a large measure the demands of the market. 1938-39 figures for bottles and phials and sheet and plate glass show some decrease as com-

TABLE 8

VALUE AND QUANTITY OF GLASSWARE IMPORTED INTO INDIA†
(Value in Thousands of Rupees and Quantity in Thousands)

	1926-27	1927-28	1928-29	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39
Bangles	84.86	89.52	76.76	85.23	49.90	34.51	39.89	27.13	31.07	27.19	28.02	29.26	24.20
Beads and false pearls	30.95	26.62	30.42	30.61	15.72	9.43	12.40	13.43	13.10	15.30	12.15	18.86	13.38
Do. Cwt.	...	...	...	37	19	15	22	21	21	22	19	22	19
Bottles and Phials	39.04	33.01	36.19	39.49	29.94	24.09	24.40	21.10	24.82	30.23	23.56	29.32	27.95
Do. Gross	...	...	...	703	616	461	810	786	830	1039	846	1186	982
Lampware	19.37	22.20	19.58	21.08	12.26	7.50	6.67	5.05	5.72	5.98	6.06	6.90	5.17
Scientific Glassware	2.32	1.73	1.66	1.34	1.43	1.19	1.38	1.16	92	72	1.51	1.94	1.93
Sheet and Plates	31.66	29.86	29.68	30.97	23.88	19.72	23.11	21.24	23.68	24.33	21.34	25.42	23.70
Do. sq. ft.	...	...	...	22,195	19,804	15,747	18,620	19,540	24,764	30,918	27,332	21,014	27,065
Tableware	9.15	9.40	10.94	13.29	9.46	5.91	5.40	5.26	5.54	4.57	4.52	5.97	5.90
Other glassware*	35.54	36.06	32.26	29.92	22.19	19.62	29.21	27.72	27.70	31.08	30.76	34.21	22.90
Total	252.89	248.40	237.49	251.93	164.78	121.97	142.46	122.14	132.56	139.40	127.92	151.38	125.12
Electric bulb**	...	...	...	...	...	35.37	35.99	34.29	38.04	39.87	33.02	89.76	28.01

† Figures for Burma are not included.

* Electric Lamp Bulbs are not included.

** Figures available from 1931-32. The cost of the glass bulb is of course only a fraction of the electric bulbs.

which are not included under this head: electric light bulbs and glass tiles, the latter being included under building materials and not shown separately in the Trade Returns. The value of the imports of electric bulb has been recorded separately since 1931, the

pared to figures for 1929-30 or earlier, but an examination of the quantity of goods imported shows that there has been rather an increase than decrease as suggested by a study of the values alone. Nor is there any reason to expect a real decrease, as India

is not producing any appreciable portion of her requirements of bottleware or glass plates and sheets, though naturally the demand for these things are gradually growing.

Table 9 gives the percentages of value of each kind of glassware imported from different countries

future also Indian manufacturers will have to contend with Japan as their biggest competitor.

EXPORT

There has been for a long time export of glass from India though the volume of the trade has not

TABLE 9

PERCENTAGE OF VALUE OF EACH KIND OF GLASSWARE IMPORTED FROM DIFFERENT COUNTRIES INTO INDIA IN 1929-30 AND 1938-39.

	Czechoslovakia		Japan		Italy		Germany		British Empire		U. S. A.		Austria		Belgium		Others	
	1929-30	1938-39	1929-30	1938-39	1929-30	1938-39	1929-30	1938-39	1929-30	1938-39	1929-30	1938-39	1929-30	1938-39	1929-30	1938-39	1929-30	1938-39
Bangles	65.4	39.1	29.3	54.1	...	...	2.0	1.8	...	2.1	...	...	...	...	...	...	2.4	2.9
Beads and false pearls	37.1	32.8	30.5	36.3	18.2	20.1	5.7	6.7	...	...	...	...	5.1	2.1	...	...	3.4	2.0
Bottles—																		
Sodawater bottles	...	...	...	64.4	...	...	46.8	20.7	46.3	18.0	...	...	...	...	...	...	6.9	9.9
Other bottles and phials	...	...	5.1	55.8	...	...	20.4	20.3	16.1	6.6	...	...	...	...	...	...	7.7	4.0
Lampware	5.6	15.5	11.2	13.7	...	...	44.8	48.9	...	8.1	21.3	4.5	8.4	7.4	6.5	...	2.2	1.9
Scientific glassware	...	...	...	20.7	...	...	56.6	57.0	25.9	18.6	...	...	...	...	...	...	8.3	3.7
Sheet and plate	6.2	2.9	5.4	30.2	...	...	5.0	12.3	16.2	12.2	...	...	...	...	60.5	40.6	6.7	1.8
Tableware	2.1	5.8	68.0	72.2	...	...	8.7	6.8	7.0	10.3	...	...	...	...	11.4	...	2.8	4.9
Other kinds	...	...	4.8	43.4	52.1	...	19.1	10.9	18.1	16.0	...	...	...	...	6.6	...	12.8	...
All sorts	28.4	14.3	29.4	48.0	2.2	3.5	13.6	13.4	9.5	8.0	1.8	2	1.6	5	9.4	7.7	4.1	4.4

into India in 1929-30 to 1938-39, and shows the position of the principal exporting countries *vis a vis* the Indian market. Considering all kinds of glassware, immediately before the present war, Japan was by far the largest exporter, nearly half the total import coming from that country. In ten years Japan's quota has risen from 29.4 to 48 per cent and for every kind of glassware, there has been an increase of import from Japan, the most remarkable increase being in the case of bangles, bottleware, scientific glassware and sheet and plate glass. The next important exporting countries were Czechoslovakia and Germany. The latter retained her quota steady at nearly 13 per cent while Czechoslovakia's quota came down from 28.4 to 14.3 per cent, this being mainly due to the reduction in her export of bangles. The only other exporting countries worth mentioning are Great Britain and Belgium both of which show a little decrease in their quota. Belgium was the principal exporter of sheet and plate glass before 1930 but lately she was almost equalled by Japan. Great Britain registers appreciable decrease in the export of bottleware and scientific glassware, Japan having partly ousted the British products from the Indian market. It is obvious that before the present war (1939) Japan had an almost unrivalled command over India's glass market, and probably in

been large. In the table on the next page (Table 10) are shown the values of Indian glassware exported during the years 1929-30—1940-41.²⁶ The values of glassware re-exported from India are also shown separately. Exports by land to Persia, Afghanistan and Tibet have been reported but no figures indicating the extent of the trade are available.

This export trade shows that there are markets round the Indian ocean sea-board and with the development of Indian glass industry India would be in a position to export much larger quantities of glassware to these markets.

INDIAN MANUFACTURES

It is difficult to form an accurate estimate of the total production of glassware in India as no statistics of production are compiled or published, and in many cases manufacturers are not willing or able to give precise information regarding their production. Estimates made from time to time cannot be taken, as anything more than approximations. Sir Alfred Chatterton wrote in 1919: "The value of outturn of glassware by organised factories in India is, at the

²⁶ Annual statements of the Sea-borne Trade of British India, published by the Dept. of Commercial Intelligence and Statistics.

TABLE 10

VALUE OF GLASSWARE (MANUFACTURED IN INDIA) EXPORTED FROM INDIA

	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40	1940-41
Aden and Dependencies	3,310	3,339	4,015	5,138	2,702	1,800	2,366	5,136	4,999	1,785	4,592	13,475
Bahrain Islands	2,105	1,130	1,650	1,471	6,761	1,541	1,010	7,999	16,625	12,230	7,783	8,384
Ceylon (excluding Maldives)	15,441	10,434	6,150	14,525	6,330	9,045	7,302	8,274	16,185	9,662	15,647	87,375
Burma	...	...	...	...	...	...	...	...	54,115	57,297	85,264	195,046
Federated Malay States	5,345	4,421	1,693	1,504	660	3,649	1,950	513	7,465	6,795	3,805	5,205
Other British possessions	29,254	28,213	21,862	8,532	8,999	11,102	6,688	7,050	11,022	8,384	20,369	78,303
Native States in Arabia	8,320	3,065	2,663	2,170	3,390	3,146	2,336	14,880	4,550	5,325	12,460	20,148
Iran	2,358	3,853	1,505	1,325	380	4,625	3,468	2,102	6,922	7,618	6,997	16,054
Other foreign countries	16,330	6,737	6,462	8,035	16,670	7,912	4,480	3,262	7,707	6,124	12,574	159,785
TOTAL	1,03,463	61,192	46,000	44,700	45,892	42,892	29,600	49,216	1,29,590	1,15,220	168,991	583,774

VALUE OF GLASSWARE (FOREIGN MERCHANDISE) RE-EXPORTED FROM INDIA

TOTAL	3,88,786	2,36,989	1,75,196	1,63,245	1,85,473	1,81,442	1,42,565	1,33,276	198,077	1,97,371	205,064	205,513
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present time, not far short of 20 lakhs of rupees a year, and, if to this we add the value already arrived at of the bangle glass trade at Ferozabad, we arrive at a minimum of 40 lakhs a year.²⁷ During the years following the last Great War (1914) the production gradually increased.²⁸ The Indian Tariff Board gave the following estimate of the value of glassware manufactured in India in 1932:

Bangles	Rs. 115.00 lakhs.
Bottleware	6.50 "
Lampware	16.00 "
Sheet	2.50 "

Total ... Rs. 140.00 "

Of these, the figure for the major item *viz.*, bangle was supplied by Glass and Bangles Industrial Association of Ferozabad while the figures for the others were collected mainly from the manufacturers.

Dixon²⁹ in his survey of Indian Glass Industry in India estimates the value of blown glassware produced in India in 1935 as 36.57 lakhs of rupees, which shows an appreciable increase over the figures collected by the Indian Tariff Board in 1932. As for bangles, Dixon admits that as there are a large number of cottage workers producing the ware, no accurate estimate of the value is possible. From personal enquiries made at Ferozabad he estimates that the value of the bangles made in factories together with the value of the glass made for supply to cottages is about 30 lakhs of rupees, which

²⁷ Indian Munitions Board Industrial Handbook, p. 268, 1919.

²⁸ *Ibid.*, p. 49.

²⁹ *Ibid.*, p. 25.

appears to be a gross under-estimate when compared with the figure accepted by the Indian Tariff Board. Dr A. A. Nadel, Glass Technologist to the Govt. of U. P. estimated that before the present war (1939) the value of India's production of glass and glassware reached 120 lakhs of which 80 lakhs were to be attributed to the bangle industry. The different estimates show considerable discrepancies particularly in the case of bangle production. This, as has been pointed out by Dixon, is due to the large number of cottage workers engaged in the industry, from whom correct trade returns can scarcely be collected.

An approximate estimate of the total Indian market can be made by taking the value of the goods imported together with that of the Indian manufactures.

TABLE 11

TOTAL CONSUMPTION OF GLASS AND GLASSWARE IN INDIA...

	Value of Imports (1938-39) (Lakhs of Rupees)	Value of Indian Manufactures*
Bangles	24.20	80
Other Glassware (including Blownware, Sheet Glass, etc.)	100.92	40
Total	125.12	120

* Pre-war figure estimated by Dr A. A. Nadel.

If Dr Nadel's estimates are reasonably correct the Indian industry was supplying nearly half of the Indian market before the present war. Nearly 80 per cent of the total consumption of bangles was being made in India. But if bangles are omitted, the pre-

war relation 50 : 50 between Indian made and imported glassware would be radically changed. Of the other goods less than 30 per cent of total consumption was made in India and the rest imported. These figures are full of implications for the present and prospective manufacturers of glassware in India. Even in the case of bangles, which is the only branch of glass industry adequately developed in India, there is still scope for extension. India is practically the only market in the world for glass bangles, and there is no reason why the Indian factories should not produce all the qualities and varieties of bangles in sufficient quantity to meet the full demand of the Indian market. The position with respect to production of bottlere is far from satisfactory and there is ample scope for the establishment of new works and introduction of machinery to increase output in the existing factories. As regards lampware and other kinds of cheap blownware like tableware some progress has been achieved and the industry is meeting the country's demands. Considerable headway has still to be made with regard to sheet and plate glass and pressed glass and tableware of the more expensive varieties. The Indian industry should capture a considerable part of the local market for these wares, for which there is a demand sufficient not only to absorb the whole of the products of the factories now in existence, but also to encourage the establishment of new factories. Moreover, in India at present, comparatively much less glass is used than in other countries and a rapid increase in demand of glassware is to be reasonably expected. These considerations lead to the inevitable conclusion that there is a market waiting to absorb as much glassware as the industry in India can produce at present or in the near future.

REVIEW OF THE TRADE AND PRODUCTION DURING THE WAR PERIOD

The value of the imports of glass and glassware considerably receded after the war started in 1939. The value of import for 1940-41 was Rs. 86.26 lakhs as compared to the average value of Rs. 136.08 lakhs for the four years preceding the war (see Table 12). The actual quantity of glassware imported must have declined more than in the proportion of the values of imports as there has been a rise in price due to war conditions. Imports of glass bangles and beads etc., came down considerably. Glass sheet and plate import was reduced to nearly half though the decline in value of import was not so remarkable owing to the rise in price. Import from European countries except Great Britain virtually stopped due to war conditions and the Indian Trade in 1940-41 was distributed as follows: Japan 59 per cent, United Kingdom 20 per cent, China (a new source

TABLE 12
VALUE OF GLASSWARE IMPORTED INTO INDIA

	1935-36 to 1938-39 (Average)	1939-40	1940-41
Bangles ...	27.17	18.40	6.86
Beads and false pearls ...	14.92	8.50	3.45
Bottles and Phials ...	27.76	20.59	24.77
Lampware ...	6.3	3.78	2.02
Scientific Glassware ...	1.52	...	...
Sheet and plate glass ...	23.7	19.94	17.53
Tableware ...	5.24	...	...
Other glassware ...	29.74	30.56	31.63
Total ...	136.08	101.77	86.26
Electric bulbs ...	35.16	26.33	21.57

of supply of bottles and phials) 6 per cent and Belgium 5 per cent. Later figures are not available though it may be presumed that the value of import has considerably declined since Japan's entry into the war, as she was responsible for more than half the total imports in 1940-41.

War has caused a remarkable increase in the export trade (see Table 10). In 1938-39 the value of export of Indian glassware was Rs. 1.15 lakhs. This figure jumped up to Rs. 5.84 lakhs in 1940-41. The value of foreign glass re-exported from India however remained practically stationary.

There has been remarkable increase in the production of glass and glassware in India during the few years of the war. As mentioned before figures relating to production of glass and glassware in India are not collected or published. In the following table (Table 13) are shown the number of glass factories and average number of daily workers employed in the glass industry in British India and the Indian States during 1938-41.

The table shows that after the war started in 1939 there has been a great expansion of the industry in India. Assuming Dr Nadel's estimate for pre-war Indian production (120 lakhs) to be fairly accurate (it seems to be a cautious and conservative estimate) and in the absence of any other better method of estimation, assuming that production is directly proportional to the number of workers engaged in the industry, an approximate estimate of the total production in 1941 would be in the neighbourhood of 270 lakhs. Thus from an analysis of the total workers engaged in the industry it appears that during the first two years of the war production has more than doubled. Later figures are not available and it seems reasonable to presume that this trend has continued.

TABLE 13
NO. OF FACTORIES AND AVERAGE NO. OF DAILY WORKERS EMPLOYED IN GLASS INDUSTRY IN INDIA

Province	Number of Factories					Average No. of workers employed daily				
	1937	1938	1939	1940	1941	1937	1938	1939	1940	1941
Madras ...	...	1	1	2	3	...	95	100	354	821
Bombay ...	...	6	4	5	5	...	700	1025	1414	1724
Bengal ...	...	12	12	14	17	...	2110	2280	3406	4649
U. P. ...	...	47	49	60	79	...	4219	4733	5821	8038
Punjab ...	...	3	3	4	5	...	134	204	148	345
Bihar ...	...	...	1	1	2	...	...	10	30	777
Orissa ...	...	1	1	1	1	...	163	203	340	243
C. P. ...	...	3	3	3	4	...	344	375	535	706
Total British India ...	60	73	74	90	116	7156	7765	8930	12048	16703
Hyderabad ...	...	2	2	2	2	...	304	351	551	533
Mysore ...	...	...	1	1	1	...	...	295	244	386
Central India States ...	...	1	1	1	1	...	100	102	50	90
U. P. States ...	...	...	...	...	1	...	...	...	...	390
Bombay States ...	...	1	1	1	1	...	333	333	1100	245
Western India States ...	...	1	1	1	1	...	150	150	200	200
Grand Total ...	60	78	80	96	123	7156	8652	9165	14193	19547

GLASSWARE MANUFACTURED IN INDIA

Until recently the Indian glass factories mainly produced the following articles: (1) Bangles, on cottage scale and factory scale, (2) Hollowware consisting of lampware and tableware, (3) Bottles and phials, (4) Sheet glass, (5) Fancy goods and (6) Pressed ware.

BANGLES

The bangle industry is the only adequate developed branch of the indigenous glass industry. Even before the present war (1939) over 80 per cent of the total consumption in the Indian market was being manufactured in India, and the most serious competitor Japan, had been almost driven out of the market (see Table 8). The only competitor before the present war was Czechoslovakia, and the import was limited to a few expensive varieties. The bangle industry is concentrated in Ferozabad, a small town in the United Provinces, where the entire population of nearly 40,000 is directly or indirectly connected with the glass bangle trade. Glass bangles are made on a small scale in other places in Bombay and Madras Presidencies, but nowhere do they approach the large scale of manufacture as at Ferozabad.

The art of glass bangle making entirely by hand as practised by the "Shishgars", as these cottage workers are called, has reached a state of perfection through its century old traditions. The skill and speed of these workers still allow them to hold their own against the factory made bangle. There are several hundreds of cottage shops in Ferozabad

where these workers remelt in primitive furnaces glass purchased from factories and shape them by hand into bangles. Bangle factories at Ferozabad are of comparatively recent origin. These factories produce their own glass and draw it first into spirals which are cut into open rings. Each ring is separately joined and this has become an ancillary trade. Decorative operations, like cutting, painting, enamelling, setting of facets and mirrors are done in large number of little shops and factories. "The Ferozabad bangles are characterized by a wide range of colours, a silky finish and a certain harmonious refinement in the use of gold and silver, applied more often indirectly than on the outer surface. There is indisputably, innate beauty of material in these glasses not to be found in bangles made of plastics or other substitutes for glass".³⁰ After the war started (1939) in spite of increase in cost of chemicals and labour, the industry has been working on a very satisfactory margin of profits. In 1939 there were 27 bangle factories at Ferozabad producing on a large scale. In 1941 the number of factories increased to 45 and in addition there were 5 factories engaged solely in the production of block glass for use by bangle makers. A central gas plant for Ferozabad is under erection and the replacement of kerosene lamps by gas for joining bangles will lead to further development of the industry there. The bangle makers of Bombay and Madras make their bangles by similar methods. They work on a much smaller

³⁰ Science and Industry, issued by the Commercial Museum, Calcutta, p. 1, 1941.

scale and were never serious competitors of the Ferozabad "Shishgars".

HOLLOWWARE

The type of glassware like tumblers, lamp-globes etc., described in trade under the name of 'hollowware' is now being manufactured in India on a fairly large scale and a remarkable expansion has taken place in this branch of the glass industry. The war has severely curtailed imports and the Indian factories are facing growing demand for tumblers, chimneys etc. A number of Indian factories producing these wares on a large scale are changing over from old fashioned pot furnaces to tank furnaces or improved type pot furnaces. The working process adopted in all the factories are similar and are mostly manual. This has been described in detail by Dixon.³¹ Some factories have introduced jar making machines and finishing machines. The Bhajoi (U. P.) hollowware plant is one of the oldest establishments of its kind in India and produces wide range of articles, including excellent lighting articles of opal glass. One factory in Bombay has introduced some very ingenious and efficient semi-automatic suction and blow machines for making good quality lamp globes.

BOTTLES

Bottle manufacture in India is much less developed than other branches of glass industry and the indigenous products in the past had great difficulty in competing with imported bottles. They were not much in demand by distilleries and pharmaceutical concerns, owing to irregular capacity, poor finish and in some cases insufficient chemical and mechanical resistance. There are O'Neil and Lynch automatic bottle blowing machines fitted with miller feeders at the Allahabad glass works, Naini and a Roirante machine at the Bombay Glass Works, Matunga. Their complicated working requires expert handling and composition and temperature of glass has to be very carefully controlled if they are to operate successfully. The Allahabad factory had been closed for some years, but since the outbreak of the war most of its departments have started working. Due to the war, imports of bottles from Europe and Japan have practically stopped and there has been an acute shortage. Starting of adequately equipped bottle factories appears to be an imperative necessity. Two new bottle factories, one at Benares (equipped with tank furnace and semi-automatic machines) and the other at Ghaziabad near Delhi were erected in 1941. When working in full capacity these will produce 3,500 and 1,800 tons of bottles annually. One glass factory in Bengal (Sodepur Glass Factory) is producing sodawater bottles.

³¹ Dixon, E. *Ibid.*, p. 115.

Bottles are still made in western U. P. in Bijnor on a cottage industry scale. Glassblocks imported from Ferozabad are remelted in home made furnaces and small bottles are produced which are sold at a low price.

SHEET GLASS

Plane sheet glass was, until recently, manufactured by only one factory—The United Provinces Glass Works at Bhajoi. Here window panes are produced by a modern direct drawing process. Fourcault sheet drawing machines are fed from a large tank furnace and molten glass is continuously drawn day and night through a special fireclay slotted block or die by a series of asbestos rollers. The U. P. glass works has the only plant of this kind in the whole of Asia and at present working up to its maximum capacity it is producing nearly 5,500 tons of window glass per year. Another factory, the Sodepur Glass Works in Bengal, has also started production of sheet and plate glass. There is scope for expanding indigenous production of sheet glass, as nearly double the quantity produced in India was still being imported from abroad before the present war.

In the Allahabad Glass Works, Naini, there is equipment for the manufacture of figured or ribbed sheets. The melted glass is cabled by hand into the machine where it is passed between rollers by which the patterns are impressed on it. It comes out in the form of a sheet and is transferred automatically to the annealing lehr.

FANCY GOODS

Fancy goods such as glass buttons, pendants, animal figures and a crude variety of beads known as cattle-beads, are produced on cottage industry scale in some town of northern U. P. Fine beads as used for necklaces and false pearls were not made in India until 1940, when a trading centre was established at Benares by the Glass Technology section of the Department of Industries, U. P. and a number of workers were instructed in the manufacture of fine beads according to improved methods. Some of these trainees have set up independent working units as cottage artisans. The introduction of the manufacture of beads and glass pearls necessitated the production of special glasses in the form of rods, the material for bead making. Such rods are being produced in some factories on a commercial scale according to formulae evolved by the Glass Technology Laboratory at Benares.

PRESSED WARE

A small amount of pressed ware, consisting chiefly of tiles, small dishes and jars, ink-stands

and paper-weights etc., is also produced in India by means of hand presses. As the pressing operation spoils the brilliancy, these articles are fire-polished by methods similar to fire edge finishing.

SOME RECENT DEVELOPMENTS

Though most of the Indian glass factories are engaged in the production of cheaper articles, some factories have now specialised in good quality glassware. Recently manufacture of electric bulbs, glass rods and tubes, and good quality scientific and heat resistant glass has been undertaken by a number of factories in U. P. and Bengal. A number of electric lamp manufacturing companies in Calcutta are manufacturing electric bulbs in their own factories. Two glass factories in U. P. also are manufacturing electric bulbs. Glass rods and glass tubes for the manufacture of ampoules, test and specimen tubes and syringes etc., are being produced in a number of factories in Bengal and U. P. Laboratory ware from neutral and heat resistant glass is manufactured by the Ganga Glass Works and the Scientific Indian Glass Co. of Calcutta. China glass, a variety of densely opaque glass, used for decorative purposes, is at present manufactured in Ferozabad. In addition to the above the Indian glass industry is now manufacturing and supplying the Defence and Supply Departments of the Government of India with many of their requirements in various types of glass, particularly surgical and laboratory requirements of glass products.

One general complaint against ordinary Indian glassware is that they are not properly annealed. In Indian factories annealing is done usually in an enclosed firebrick chamber heated by a small open fire in one corner. The chamber is raised to a temperature of nearly 500°C, the articles are stacked inside, the doors are closed and the fire is allowed to die out so that glassware gradually cools to about room temperature in about 48 hours. In this old fashioned method of annealing, the glass is not evenly heated. Some Indian glass manufacturers use a better method which consists in stacking the articles in iron trucks and passing these down a long oven heated to the proper annealing temperature by a fire near the feed end so that there is a gradual fall of temperature towards the delivery end. Better type of annealing lehrs, as are in use in other countries, which consist of endless chain belt running continuously down a long muffle furnace, may with advantage be employed in Indian factories.

In recent years the Indian glass industry has made some progress in the methods of production, in the kinds of ware manufactured, and also in the manufacture of crucibles and furnace blocks from Indian refractory materials. But the industry will

have to adopt more progressive methods and practices and extend the use of machinery in the manufacture of different kinds of ware, if it is to meet the country's needs in glassware. To mention one particular instance, the Indian Tariff Board estimated that if hand labour were replaced by automatic machinery in the manufacture of bottles, the labour cost would be reduced to about one-fourth of the labour cost on hand manufacture. At present the price realised by the Indian manufacturer is often considerably less than the price of imported articles due to inferior quality of the local products. Up to date mechanical methods of production will go a long way towards removing this disability.

The Indian Tariff Board expressed the view that particularly in the case of bottle and phial manufacture, unless hand labour is replaced by automatic machinery and cost of production largely reduced, the future of the industry in India will remain precarious in face of foreign competition. The Board also drew attention to the economy which would result from the use of recuperative furnaces. A reduction of fuel consumption by at least 33% may be obtained. At the same time the average life of the crucible would be much longer. More important however, would be the improvement in quality and appearance of the glass. Glass made in open pots in a direct fired furnace tends to be dirty and spotted, whereas a recuperative furnace working on gas which is a much cleaner fuel, produces glass of better appearance.

OPTICAL GLASS

Attention has recently been directed to exploring the possibilities of manufacturing optical glass in India. The manufacture of optical glass is an important section of the glass industry and presents some of the most difficult problems with which the glass maker has to deal. The presence of striae, seeds or stresses within the structure of the glass makes it useless for optical purposes. To avoid the slightest internal stress, in annealing optical glass, the various temperatures and time periods are delicately adjusted and controlled. The annealing is often extended to several days and the glass is usually allowed to cool down within the pots so that the latter can be used only once. The temperature of the furnace has to be regulated very carefully as excessive temperature causes the clay of the pot to dissolve in glass and low temperature causes difficulty in freeing the glass from seeds and fixing it properly. The raw materials used must be purest possible and the melting pots are to be of the purest fireclay. The batches have to be finely ground and well mixed before melting. The melting pots are heated equally all round and the melted glass continually agitated in

order to mix the components and keep the composition of the glass as uniform as possible.

Before the last war (1914) optical glass manufacture was confined largely to Germany and even England was dependent upon continental supplies. After the war however, the British Government gave effective assistance to manufacturers to perfect this branch of the glass industry and now Britain is much better prepared and equipped to produce all the optical glass requirement of her army and navy than she was at the time of the last war (1914). Immediately after the commencement of the present conflict (1939) the need for the manufacture of optical glass in India for military purposes was stressed and several schemes of research on optical glass were undertaken under the auspices of the Board of Scientific and Industrial Research.²² Samples of optical glass have been prepared, which were cut and tested at the Mathematical Instrument Office and found to have required dispersion in optical instruments. Further researches are being pursued to effect improvements. The raw materials used in the manufacture of optical glass are: soda ash, potash, lime, barium carbonate, red lead, nitre, arsenic, manganese, and sand. There is no considerable difficulty in obtaining local supplies of all these materials. Difficulties regarding the standardisation of compositions, methods of manipulation, high-temperature furnace technique, heat resistant glass melting pots, repressing, annealing, grinding, polishing and testing have been solved. This branch of the glass industry, however will not be able to stand on its own legs in India without effective government assistance and scientific aid to manufacturers who will have to stand specialized competition from abroad after the cessation of the war.

TECHNOLOGICAL RESEARCH

The glass industry is highly technical and requires for its development both scientific and mechanical equipment as well as a large degree of skill. In India hitherto there has been no adequate provision for the investigation of scientific problems connected with the glass industry or for training of technical personnel possessing the requisite knowledge of technology and modern methods of manufacture. The Indian Industrial Commission (1916-18) and the Indian Tariff Board (1932) expressed the view that any protection to the glass industry would prove ineffective and would not secure further development and ultimate success of the industry unless the Government offers assistance of a more direct kind by providing arrangements for research and training in

glass technology. In recent years some useful research work on glass and glass-making materials has been done in the Department of Glass Technology, Benares Hindu University, the Glass Technology section of the Industries Dept., U. P., the Forman Christian College, Lahore and the Laboratories of the Industrial Research Bureau which later merged into the Department of Scientific and Industrial Research. Creation of a Central Glass Research Institute devoted to research on a large scale on glass and to the introduction of new industrial processes in the glass industry, is under contemplation of the Government. Such an institute will be of great assistance to the industry both in supplying technical personnel with necessary specialized training in the modern methods of manufacture and giving aid to the manufacturers by undertaking research problems facing the industry.

PROTECTION TO GLASS INDUSTRY

The Glass Industry in India has, since the cessation of the last war, (1914), laboured under great difficulties mainly from the effects of foreign competition, particularly Japanese. Indian glass manufacturers had for sometime been clamouring for some form of protection as a result of which in 1931 the Government of India referred the question to the Indian Tariff Board. After an elaborate enquiry and survey of the Glass Industry in India the Indian Tariff Board came to the conclusion that the Indian Glass Industry's claim for protection was justified. Their conclusion, as summarised in their Report, will bear quotation.

"Our examination of the various factories which constitute the natural advantages postulated by the Fiscal Commission in an industry which advances a claim for protection (*viz.* 1. The industry must be one possessing natural advantages, such as an abundant supply of raw materials, cheap power, a sufficient supply of labour or a large home market; 2. The industry must be one which without the help of protection either is not likely to develop at all or is not likely to develop so rapidly as is desirable in the interest of the country; 3. The industry must be one which will eventually be able to face world competition without protection) has satisfied us that the glass industry substantially complies with this condition. Of the raw materials, sand is the bulkiest and this is present in abundance, and there is good reason to think that by suitable treatment much of the Indian sand might be rendered fit for the manufacture of the best glass. Soda ash is not at present obtainable in the country but this disadvantage is balanced by the other natural advantages possessed by the industry. The manufacture of soda ash has been achieved successfully in India; and there is good reason for expecting an early resumption of its manufacture when supplies will at once become available in the country. Lime is available in unlimited quantity. Of other raw materials such small quantities are required that in their case the question of advantage hardly arises; but some of them, *e.g.*, saltpetre, borax and manganese dioxide are readily obtainable. The presence of suitable refractory materials and the quantity of the coal available in the country constitute definite advantages. The disadvantages ascribed to Indian labour at early surveys of the industry have now largely disappeared and certainly do not outweigh the advantages of its abund-

ance and its adaptability. And finally the existence of a great market throughout the country, which may be expected to expand even more rapidly than in other countries, and the opportunities for export both by sea and land constitute a further advantage. We are therefore satisfied that on the balance the glass industry does possess such natural advantages as to justify its claim for protection."²³

The Tariff Board accordingly proposed protective duties of 25 per cent *ad valorem* on sheet and plate glass and 50 per cent *ad valorem* on bottles and phials, lampware, tableware etc. The Board also recommended a long period of protection, *viz.*, 10 years, in order that the industry might get itself

²³ *Ibid.*, p. 51.

In addition to the above references, information has been collected by direct correspondence with the Director-General, Commercial Intelligence and Statistics, the Director of Industries, Bengal and the Glass Technologist to Government, U. P. and several specialists engaged in glass manufacture and technological research.

sufficiently reorganized as regards methods of production, equipment and financial resources to successfully withstand foreign competition. The Government of India, however, did not give effect to the recommendations of the Tariff Board and no protective duty on glassware has since been imposed. The only relief accorded was a rebate of Customs duty (Commerce Department Resolution No. 458T 14, dated 22nd June, 1935) on soda ash used in the manufacture of glass. After the cessation of the present war it is likely that the Indian market will again be flooded with foreign glassware and the Indian industry will again be hard hit by specialized foreign competition. Judging from present conditions of the glass industry in India it is difficult to see how without a protective duty the Indian industry would be able to withstand a severe foreign competition.

MEDICINE AND PUBLIC HEALTH

ACOUSTIC STETHOSCOPE

A NEW acoustic stethoscope capable of detecting sounds within the body which could not be hitherto heard with the ordinary stethoscope in use has been developed by the R.C.A. Laboratories in U.S.A., according to a report of the *Scientific American*. Sounds of the body generally range from 40 to 4000 cycles. The ordinary stethoscope makes audible only a very limited range of frequency from 200 to 1500 cycles. The new stethoscope has for the first time succeeded in covering the full range from 40 to 4000 cycles and transmitting them without attenuation or discrimination. The beat of the heart, normal or abnormal, respiratory rattles, peristaltic squeaks, murmurs, and groans are considerably amplified by the acoustic stethoscope which has now made diagnosis based on the structure of the sound much more reliable. The new stethoscope derives its advantage from the fact that it couples the ears of the diagnostician more closely to the human body through the employment of a reversed taper tube, which results in greatly improved matching of the acoustic elements.

As the meaning of the several new sounds heard through the new instrument is not yet known, the

use of a suitable filter has been advised. By this device the range of the audible body sounds can be limited at will. Investigations as to the proper interpretation of the new sounds are now being carried on, and when their results will be available the acoustic stethoscope may prove an invaluable instrument at the disposal of diagnosticians.

AN IMPROVED INSULIN TREATMENT

AN improved and simplified insulin treatment for diabetes has been reported in a recent issue of the *Science News Letter*. The use of slow-acting protamine zinc insulin for prolonged action is well-known. This requires less number of injections and has therefore an advantage over ordinary insulin. But it has been found that moderate and severe cases of diabetes, receiving injections of protamine zinc insulin, suffer from inadequate control of blood sugar level after meals when the need for insulin is greatest. This is due to the fact that insulin is slowly released from the protamine zinc compound at a steady rate throughout the day and night. In such cases, physicians have recommended an additional injection of regular insulin along with the use of protamine zinc insulin. Thus the rise of blood sugar after meals

²² Report on the Technical work of the Board of Scientific and Industrial Research for 1941-42.

can be controlled, while the protamine zinc compound will ensure protection against rise of blood sugar at night.

The combined treatment has the disadvantage that it requires more injections and involves a possibility of error arising from the use of two varieties of insulin with two different doses. This led to the suggestion of using a mixture of two insulins in one single injection. Drs Cyril M. MacBryde and Harold K. Roberts of St. Louis used a mixture of three parts of fast-acting insulin with one part of the protamine zinc form and tried it on 62 patients with significant results. The insulins were mixed and adjusted to a slight alkalinity about the same as that found in body tissue. The mixture not only controlled blood sugar as satisfactorily as the previous combination treatment but effected better regulation in most cases. In mild cases the response was even much better.

In another series of investigation, Drs Arther R. Colwell and Joseph L. Izzo used a different mixture containing two parts of regular and one part of protamine zinc insulin. Their studies on 60 patients reveal that a single injection of this mixture also gives better control than that obtained with standard insulins injected more often. It is further stated that the dosage is about 10 per cent less than with ordinary methods because of improved efficiency.

WHEN TO PICK VEGETABLES

"To get the most vitamins out of vegetables, pick them in late afternoon and eat them before dark

the same day. Such is the advice to Victory Gardeners given by Dr Mary Elizabeth Reid, of the U. S. Public Health Service and National Institute of Health, in the *Journal of The New York Botanical Garden*. Tests show that even on the vine vegetables may lose as much as 25 per cent of their vitamins after the sun goes down.

Department of Agriculture experts have lately made some special studies of this subject and learned that 'light has a remarkable effect upon the accumulation of vitamin C'. Some of their findings are:

Vegetables lose part of their vitamin C content not only at night but on cloudy days. Greenhouse plants grown during the months of May and June have twice as much vitamin C as those grown in December and January. Fruit on the shaded side of a tree has less vitamin C than that on the sunny side.

Besides vitamins, shaded plants apparently also lose some starches, sugars, proteins and minerals.

Silkworms grow fatter on mulberry leaves picked at dusk. Cattle do better if pastured in late afternoon rather than in the morning.

Concludes Dr Reid: For good vitamin C values the harvesting of vegetables should not be done before mid-forenoon, say 10 o'clock, after a spell of clear weather; after a cloudy spell, not till late in the day."—(*Times*, August 16, 1943).

SOME HINTS FOR THE DISPOSAL OF EXCRETA IN RURAL AND SMALL URBAN AREAS IN BENGAL

"RUSTIC"

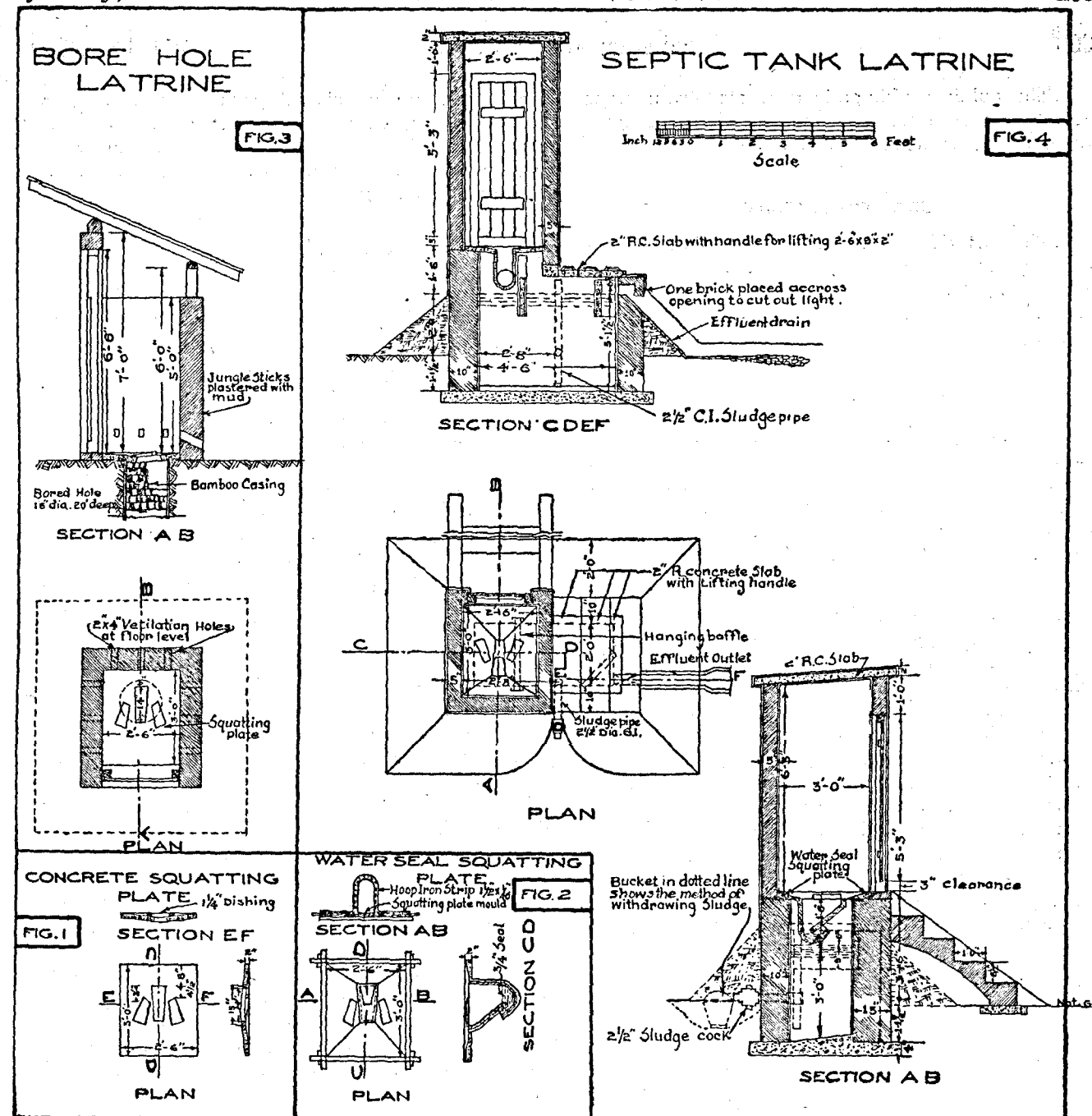
INTRODUCTION

ONE of the grave sanitary defects of village life in India is the absence of latrines in houses; and the consequent promiscuous pollution of the soil, tanks, canals and rivers. The effects of improper disposal of human excreta in small unsewered towns and rural areas are felt in—(1) increased prevalence of ankylostomiasis and ascariasis on account of soil pollution, (2) increased prevalence of water-borne diseases on account of pollution of sources of water-supply, and (3) increased prevalence of fly-borne diseases, due to pollution of food by flies which breed in large numbers and have access to excreta.

This is indicated to some extent in the death rates quoted below for bowel diseases.

DEATH RATES PER 1,000 IN THE YEAR 1938

	British India		Bengal	
	Rural	Urban	Rural	Urban
Dysentery and diarrhoea	.9	2.4	1.2	2.7
Cholera	.9	0.5	1.4	1.0
Typhoid	Separate figures		not available	
Total mortality ..	24.3		25.00	



PLANS OF DIFFERENT TYPES OF SANITARY LATRINES

Notes on Septic Tank Latrine: The design is on the assumption that the family consists of 6 members, that the average annual temperature is 25°C, and that digested sludge will be withdrawn at least once a year, through the sludge valve provided, at the rate of 14 to 15 cft. per year.

Essential features of Public Health significance

Tank capacity 27 cft. net, with water-tight walls and floor, sludge pipe for withdrawal of sludge 2 ft. below water line, baffle at outlet, effluent outlet, and removable roof.

Latrine seat of concrete essential; water closet type of seat recommended to render the tank contents inaccessible to flies. Light trap at outlet for discouraging fly-breeding.

Building the latrine over the tank saves collection and transport of excreta, also saves separate foundation for latrine.

The level of the latrine is to be above ground to facilitate withdrawal of sludge at ground level.

The tank must be sited so that the effluent will not pollute any drinking source.

Non-essential features

The nature of the super structure for the latrine is immaterial so long as it affords privacy to users.

The steps leading to the latrine may be of any kind of material. An earthen ramp may do.

The roof may be omitted if necessary.

The latrine may adjoin a room in the house.

Disposal

Disposal of effluent—by ground absorption, or garden irrigation, or discharge into a drain.

Disposal of digested sludge—by burial in garden, or as manure in garden.

(Continued at the bottom of the next page)

The public health problem created by improper excreta disposal in rural areas is very large in magnitude, and calls for urgent solution.

NEED FOR LATRINES

The first thing to be done is to discourage promiscuous defaecation and soil pollution, by building clean family latrines, and localising the places for defaecation. A clean and cheap latrine will gradually create public opinion in favour of the use of latrines.

SANITARY LATRINE SEATS

A sanitary latrine must have a floor on which the eggs of ankylostoma will not hatch. All solid and liquid excreta must be collected at one spot and must not be accessible to flies, pigs etc. The place must be suitable for washing, easy to keep clean and sheltered to afford privacy. Shelter from sun and rain is desirable but not essential.

These requirements are met by a well designed concrete squatting plate as shown in Fig. 1, surrounded by an enclosure of bamboo matting or a more substantial wall of brick or other material, and a roof, if desired. The nature of the superstructure may be varied according to the means of the family, and may cost anything from Rs. 4/- to Rs. 35/-, but the concrete squatting plate is an essential part of standard design. This design was evolved in Ceylon when Dr Jacocks was directing the Ankylostomiasis campaign, and has been found successful after many years of experience. The cost of such a plate is about Rs. 3/- at prewar rates, excluding the cost of the mould. It is desirable that the Government

Health Department should manufacture this latrine plate and distribute it at cost price or free in deserving cases, in all rural areas. The machinery for manufacture and distribution of these plates requires considerable enlargement.

THE DISPOSAL PROBLEM

In most villages in India there is no scavenging service. The latrines have to be self-contained, in the sense that the disposal of excreta must also be carried out near the latrines. Where scavenging service is available, the excreta may be collected in a bucket placed under the squatting plate. But this type of latrine is not quite satisfactory, as the volume of nightsoil, urine and ablution water produced by a large family in a day is too much for a single bucket, and may overflow. Further, it is not easy to keep the bucket clean. The excreta are accessible to flies in the "Fly season". The transport of excreta through the streets is often unsatisfactory, and leakage from the carts may propagate hookworm.

BOREHOLE LATRINES

The "Borehole latrine", which has been popularised in Ceylon and some parts of India through Health Units, (Fig. 3) is a self-contained hygienic latrine for the rural family. It consists of a hole 14" to 16" in diameter dug in fairly soft and porous soil by a special auger to a depth of about 20 feet, or about 3 feet below the watertable. Four to five men can easily put down such a hole in half a day. The concrete squatting plate mentioned above is installed over the hole, and an enclosure is built around it for privacy. Excreta and ablution water fall into the borehole and undergo anaerobic digestion, which is facilitated if there is subsoil water. The narrowness of the hole makes it dark and unsuitable for fly breeding. In very loose soil, the upper part of the hole has to be lined with some stiff material, such as bamboo matting, or a short length of pipe or oil drum, to prevent caving in.

The borehole gets gradually filled with digested sludge. When it gets filled to within 3 feet from the ground, it is closed with earth, a new hole is dug, and the squatting plate and enclosure are re-erected at the new hole. Although it would be unwise to put up a borehole latrine too close to a well or other source of drinking water, the risk of pollution of the subsoil water by a borehole latrine is now known to be not as great as was once believed. The risk cannot be stated in general terms, as likely to extend to 50 feet, or 100 feet, around a borehole. This is indicated by the studies of Dyer on soil pollution, which are about to be published shortly.

Bill of Quantities.

	For Septic Tank	For Water-seal latrine
1. Earth work (excavation, filling etc.) ...	70 cft.	15 cft.
2. C. Concrete 1:3:6 ...	11 cft.	— cft.
3. Reinforced C. Concrete 1:2:4 (baffles, roof etc.) ...	2 cft.	2.3 cft.
4. Brick-in-surki or lime mortar ...	67 cft.	27 cft.
5. Cement rendering 1/4" thick ...	165 sft.	18 sft.
6. Lime plastering 1/4" thick ...	10 sft.	132 sft.
7. Water-seal squatting plate ...	One	One
8. 2 1/2" C.I. dip pipe & cock ...	One	One
9. Door 5'-3" x 2'-0" including frame and fittings ...	One	10.5 sq. ft.
10. Effluent channel 4" wide ...	4 ft.	—
11. Cutting grooves, forming outlet weir etc. ...	6.5 ft.	—
12. Turfing ...	100 sft.	—
13. Stairs to latrine ...	—	4 Nos.
14. Lifting handles for covering slabs ...	6 Nos.	—

Sludge accumulation in borehole latrines.—In the anaerobic digestion of excreta a certain residuum of digested sludge is left. This is colloidal in structure, with 85 to 87 per cent. of bound water, which cannot ordinarily be separated, but may be reduced by the addition of chemical conditioners, vacuum filtration, and elutriation. These special methods are not available in rural excreta disposal. The amount of such sludge can be computed mathematically, and is estimated to amount to 2.1 to 7.3 cft. per 1000 users, according to whether night soil alone, or all personal excreta are included. The filling up of the borehole with sludge is the limitation to its life. No field experiments appear to have been carried out on the volume of sludge produced per capita in a borehole latrine. Enthusiasts under-estimate the volume, and say that boreholes last for 4 years or more. However, such views are not based upon experiments under controlled conditions. Experiments on this point should be carried out in important Government and municipal departments.

In many Bengal villages the subsoil water is high, and the soil is loose. It is often difficult to put down a borehole deeper than 8 to 10 feet, as the sand keeps falling when the auger has gone 2 to 3 feet below the water-table. In such a borehole, the effective column available for filling with digested sludge is only about 9.7 cft. (7 ft. depth x 16"). If the mathematical estimate of sludge may be relied upon in the absence of experimental verification, such a hole will be filled by 1320 users, i.e., by a family of six depositing all excreta in 220 days. It would be a handicap to the promotion of rural sanitation if a new borehole had to be dug for each small family so frequently. On the other hand it is more likely that only night soil may be deposited in the borehole by a rural family. If so, the hole will be filled by 4620 users, or by a family of six in the course of about two years.

From the foregoing considerations, it appears that the borehole latrine is a good family latrine; and not so suitable for common use by a number of families or in a public place. The limitation to its utility arises from the accumulation of digested sludge.

PIT LATRINES

A pit latrine can be dug so as to have a large volume, where owing to a hard soil, or a loose soil with high water table, it is not possible to dig a deep borehole of large volume. If the pit is roofed over at top, the excreta can be made inaccessible to flies. This is often neglected, or considered impracticable, in public latrines for *melas*, camps etc., and excreta

are expected to be covered with earth by the user or the attendant. However, a covered pit is quite practicable for a family latrine. A pit 5 ft. long, 2 1/2 ft. wide, and 5 ft. deep may last for 2 1/4 to 8 years under use by a family of six. At the end of that period it may be filled to 2 ft. below ground with sludge. It must then be filled with earth up to ground level, and a new pit must be dug.

If flood water gets into an unlined pit latrine, or the subsoil water rises high, conditions may become offensive. In a dry region a pit latrine will be quite suitable, provided the pit is roofed, and flood water is excluded. A pit latrine has one advantage over the borehole. No special auger is required to dig a pit. Both must be located so as not to pollute any well or other source of drinking water.

COST OF BOREHOLES AND PITS FOR LATRINES

The cost of digging a borehole is about Rs. 2/- to Rs. 3/- at prewar rates for labour, assuming that the auger is available. The cost of digging a pit 6' x 2 1/2' x 5' and covering it with a concrete roof is about Rs. 10/- or Rs. 10/8/-, but the roof valued at Rs. 9/8/- to Rs. 10/- may be reused when a new hole is dug. When a new pit is put down and the old one is closed, an expense of Rs. 1/8/- may have to be incurred.

A DESIGN FOR A SEPTIC TANK LATRINE

In many respects, a septic tank latrine is an improvement on the borehole and the pit latrines. A design suitable for a family of six is shown in Fig. 4.

It consists of a tank 4 1/2' x 2' x 3' deep below water line, with water-tight floor and walls, and two hanging baffles dipping 9" into the water and projecting 6" above it. There is a 4" diameter outlet for the effluent, with a light trap to discourage fly breeding, and a leadaway channel. As the functioning of the tank will be adversely affected by excessive accumulation of sludge, it is essential that the sludge from the bottom of the tank must be withdrawn at least once a year. A dip pipe and sludge valve are provided for this purpose. To withdraw sludge at ground level, the tank has to be built in cut and cover, 1 1/2 ft. into the ground and 2 1/2 ft. above. The walls may be built of brick in lime or surki mortar, plastered with cement inside, and protected by a bank of earth outside. The tank is designed for an average annual temperature of 25°C, a load of six users, and at least annual withdrawal of

sludge to the extent of about 15 cft. per annum. 7½ cft. may be withdrawn once in six months if possible. The tank will be roofed over as shown.

It is not likely that there will be any sewers in a rural house. Hence the level of the septic tank need not be limited by sewer levels, and need not be below ground. If the tank has to be built entirely below ground, sludge withdrawal becomes slightly complicated. The sludge must be raised to ground level from a depth of 3 ft. or more. If the tank is built in cut and cover as shown in the figure, sewers cannot be connected, but the withdrawal of digested sludge is easy.

The latrine may be built just above the tank, and may adjoin a house if necessary. The standard squatting plate may be used, but some inconvenience due to splashing is possible. To overcome this, a water-seal squatting plate may be used (Fig. 2). This is a concrete plate developed in Ceylon and found successful there. It has a seal of ¾" unlike the standard closet pan which has a seal of 2½" or 3". The ablution water used ordinarily is sufficient to flush the plate and eject the excreta. This plate would cost Rs. 5/- to Rs. 6/- at prewar rates, excluding the cost of the mould. Some plates of this type are under experimentation, in some research institutes. If found successful, as expected, this plate will avoid splashing and render the excreta inaccessible to flies.

The ablution water will be sufficient for anaerobic digestion of excreta. The tank being impervious to water, soil pollution is not possible, and hookworm and ascariasis are controlled. The digested sludge is inoffensive and innocuous, and regular withdrawal at the designed rates and intervals gives a long life to the tank, without affecting the clarity of the effluent. The digested sludge may be buried or used in the garden. Bathrooms are not expected to be connected, although there is no insuperable objection to connecting one if desired. The volume of effluent will normally be small, and may conveniently be disposed of by absorption in the surface soil, garden irrigation, or discharge into a drain.

The design of a septic tank is not a simple and straightforward matter under all conditions. Various experiments have been made in tropical countries to devise a satisfactory design. The design in Fig. 3 is based upon the given conditions of load, temperature, and desludging. Under the same conditions, if the family consists of 10 members instead of six, the size of the tank may be increased to 6' x 2½' x 3' deep below water line.

COST

The cost of building a septic tank latrine for 6 according to Fig. 4 estimated at pre-war rates is as follows :

	Rate	Septic tank		Latrine	
		Qty.	Rs. AS. P.	Qty.	Rs. AS. P.
Earthwork ..	6/-	.07 unit	0 7 0	.015	0 1 6
C. Concrete ..	60/-	.11 unit	6 10 0		
R. Concrete ..	2/-	2 cft.	4 0 0	2.3	4 10 0
Brick in lime	25/-	.67 unit	16 11 0	.27	6 12 0
C. rendering ..	6/-	1.65 sqs.	10 0 0	.18	1 1 0
L. plastering	3/8/-	.1 sqs.	0 6 0	1.32	4 10 0
Water-seal plate ..	6/-			One	6 0 0
Dip pipe assembly ..	10/-	One			
Door ..	-/12/-	sft.	10 0 0	12.5	7 14 0
Effluent channel ..	-/6/-	4 ft.	1 8 0		
Cutting grooves, etc.	Lump sum		0 8 0		
Turfing ..	2/-	1 sq.	2 0 0		
Stairs ..	-/12/-	each		4	3 0 0
Lifting handles for covering slabs ..	-/2/-	4 nos.	0 8 0		
Contingencies			2 6 0		1 15 6
		Total	55 0 0		36 0 0

A septic tank for Rs. 55/- and a water carriage latrine for Rs. 36/- will no doubt appear expensive for the rural family. However there may be families willing to pay for a really satisfactory amenity like this. It is not essential that the latrine must be built with a brick superstructure and concrete roof. If an enclosure of bamboo matting is put up around the water seal plate the cost of the latrine may be brought down to Rs. 10/-. It may be possible to effect a few economies in the cost of the tank and bring it down to Rs. 50/-. In laterite regions the substitution of laterite blocks for bricks will bring the cost down to Rs. 45/- or even less than this.

DISCUSSION

Three types of self contained latrines are suggested for the disposal of excreta in rural areas and small unsewered towns. Their limitations of life, cost, and suitability are discussed. The borehole latrine and the pit latrine are cheap family latrines, suitable for rural areas. Their life is limited by the accumulation of digested sludge; and renewal expenses must be incurred periodically. For this reason, expensive superstructures need not be put up for these latrines.

The septic tank latrine is more expensive, but has a very long life if desludged periodically at regular intervals. The design suggested is suitable for a family of six, and contains a water-carriage latrine and means for easy desludging.

In municipal towns which cannot afford to have underground sewers, a byelaw insisting that all house-owners must build proper septic tanks will go far in improving environmental hygiene. The provision of septic tanks may be made a condition pre-

cedent to the sanctioning of building plans in such municipalities.

The expenditure on septic tanks will amount to Rs. 8/- to Rs. 10/- per capita, perhaps more if carried out by Government or municipalities. However, if a sum of Rs. 12 to 15/- per capita can be pooled, many municipalities will be able to instal underground sewers, which are rather more satisfactory.

BOOK REVIEWS

A Text Book of Heat (for junior students) —By M. N. Saha and B. N. Srivastava. Third Edition. Published by the Indian Press, Ltd., Allahabad. Price Rs. 6/8/-.

We welcome the appearance of the third edition of Professor Saha and Dr Srivastava's deservedly popular text-book on "Heat". Neither the authors nor their admirable work which, first published in 1933, is now running its third edition require any introduction to science teachers and students of Indian as well as foreign universities. Written on entirely modern principles and on a novel plan, the book represents a significant departure from the old and boringly elaborate method of dealing with a classical subject, such as heat. In these days of modern physics when the student's attention is naturally more and more detracted from classical subjects and focussed on modern subjects, it is an extremely difficult task to write a text on "Heat", which will maintain a lively and real interest in the subject,—so essential for a balanced knowledge of a growing and dynamic science like physics.

In the new edition the book has been thoroughly revised and some of the discussions brought more up-to-date. The new additions include 'principles of air-conditioning' and 'thermodynamics of the atmosphere'. A concise but informative discussion on the fundamental principles of air-conditioning and some air-conditioning machines has been in keeping with the growing importance of air-conditioning in industry. The war has brought to the fore the importance of meteorology in India, and there are evidences that in the after math of the war the meteorological studies will be undertaken in this country on a vaster scale. The addition of a separate chapter on 'Thermodynamics of the Atmosphere' will help the students

to be equipped with an elementary knowledge of the atmospheric conditions, which so far received little attention in many Indian Universities. The usefulness of the book as a text has further been increased by the incorporation of numerous worked out illustrative examples in every chapter. We, however, regret to note that the book has failed to maintain its peace-time characteristics of fine get-up, printing and clear diagrams due probably to the stringency of paper and other difficulties connected with war-time publication.

S. N. S.

Science for the Prosecution—By JULIUS GRANT, M.Sc., Ph.D., F.I.C. Published by Chapman & Hall Ltd. (London); pages 295.+index; Illustrated. Price 15 shillings.

Science now plays a very important rôle in our daily lives and the book under review, dealing with the various applications of scientific methods and principles to the detection of criminological mysteries, reveals another very important aspect of science.

In discussing the scientific methods adopted in countering the efforts of criminals the author has lucidly explained the theoretical principles underlying each of them and has fully described by the aid of diagrams and drawings the apparatus and technique employed. Appropriate court cases are also cited as further illustrations.

There are 10 chapters in the book. The captions of these chapters, stated below, indicate the subjects discussed :—

- (1) Scientific approach to crime.
- (2) Optical methods (general).
- (3) Ultra-violet Rays.
- (4) Infra-

red Rays. (5) Spectroscopy. (6) X-rays. (7) The Microscope and the Camera. (8) Chemical methods. (9) Blood group test and serum analysis. (10) Psychology and crime.

The spectacular contribution of optical methods namely, the utilisation of fluorescence analysis in ultra-violet light, the infra-red photography of invisible objects, the absorption spectra, etc., in solving the dark mysteries of crime such as the detection of obliterated writings, writings in invisible inks, identification of counterfeit coins, finger prints and blood stains and in the investigation of cases involving forgery, fire-arms and poisons, has been exhaustively treated. Other similarly interesting topics dealt with are blood group tests for establishing paternity of children, biological and serum methods for the identification of different types of blood and the application of some modern methods in analytical chemistry, namely, micro-analysis, colorimetry, nephelometry and conductometric analysis, in ascertaining drunkenness, identifying poisons, and in the investigation of other medicolegal cases.

The function of psychology in the fight against crime is discussed very ably in the last chapter. Details are given regarding methods for investigating and suppressing criminal instincts and also for detecting crimes by the aid of such instruments as Polygraph or Pathometer.

Crimes can hardly be stopped so long as the criminals get a chance of escaping for want of sufficient evidence but it is expected that by harnessing science in the interest of justice criminal mysteries will be solved with greater efficiency in future and escape from the hands of justice will become more difficult. A time may thus come when the ordinary criminals, as distinguished from those of the abnormal and truly aberrated type, will be impressed that "crime does not pay". With this end in view, Institutions have been established in Europe and America for the fundamental study of forensic medicine, criminological science and psychological examination of juvenile delinquents.

It is interesting to note that though the subject is treated with strict scientific accuracy the popular appeal has not been sacrificed. The book is concluded with a classified reading list of different branches of the subject.

This is very well got-up and well-written book and would adequately serve the purpose for which

it is intended. The author deserves congratulations for the success of his effort.

B. K. M.

Organic Chemistry—By P. B. Sarkar, D.Sc. and P. C. Rakshit, M.Sc., Ph.D. Revised and enlarged Second Edition. Pp. 576+VI. Published by K. Sarkar. To be had at H. Chatterjee & Co. Ltd., 19, Shyama Charan De St., Calcutta.

The book has been thoroughly revised and modern topics e.g., a short account of the electronic theory of valency, resonance structure, optical activity of organic compounds having no asymmetric carbon atom, etc. have been incorporated adding to the usefulness of the book.

The book will be very helpful to undergraduate students, as the subject matter is explained with lucidity and most of the important reactions have been illustrated by laboratory experiments. A critical comparison of the available methods for the preparation of the same compound has been made in some cases, but it may be pointed out that some of the methods of preparations described are rather uncommon. The important feature of the book, as has been mentioned by the authors in the Introduction, lies in dealing with the commercial preparation of organic compounds and the authors have spared no pains to give a clear and concise account of important industrial preparations that come within the sphere of this elementary book.

The authors have paid particular attention to the classification of the organic compounds and the important properties of the substances, specially the points of similarity and difference of various functional groups have been elaborately discussed so that the beginners might follow the subject with interest.

Though the get-up and the printing of the book leave nothing to be desired, the book is not free from misprints. The authors would be advised to omit unnecessary details in the future edition, so that the book may be presented to the students in a more condensed form without affecting its usefulness.

There are some mistakes, which have escaped the attention of the authors even in this second edition e.g., 'invertase' on p. 106. Glucose cyanhydrin on hydrolysis gives normal heptylic acid (p. 321).

D. C.

LETTERS TO THE EDITOR

[The editors are not responsible for the views expressed in the letters.]

PHARMACOGNOSTIC STUDY OF *EUPHORBIA PILULIFERA* LINN.

Euphorbia pilulifera Linn. (= *Euphorbia hirta* Linn.) is an annual herb growing wild in the hotter parts of India, and in most tropical countries. It belongs to the Euphorbiaceae family, characterised by three-seeded fruits and unisexual flowers. The plant is collected during the flowering and fruiting stage. The entire plant is used in the preparation of drug.

Euphorbia pilulifera is recognised in the British Pharmaceutical Codex and is used in asthmatic conditions, chronic bronchitis, emphysema, and sometimes in hay fever. It has a depressant action on heart and respiration and causes relaxation of bronchi by central action. According to Dixit and Kameshwar Rao,¹ experiments conducted on cats, dogs and rabbits, with and without anaesthesia, show that the drug has got a fairly marked effect on the respiratory system, depressing the respiration and producing a well-marked dilatation of the bronchioles.

The plant has a good export market in America and several samples have, of late, been examined both pharmacognostically and chemically at the Biochemical Standardisation Laboratory. A description of *Euphorbia pilulifera*, along with its microscopical characters, is given below for the advantage of those interested in the collection and pharmaceutical utilization of this herb.

It is an annual herbaceous plant attaining a height of 6 to 20 ft. It possesses a conical taproot, of light brown colour, and bearing four rows of rootlets. The stem measures 2 to 3 mm. in diameter, is terete, branching, of light yellow to faint brown colour, and covered with bristly hairs. Leaves are simple, opposite, shortly petiolate, 20 to 40 mm. long and 4 to 12 mm. broad, ovate or obliquely lanceolate in shape, with a dentate margin, acute apex and asymmetric base. Upper surface of the leaf is dark green, lower surface, of light yellowish-brown colour. Both surfaces of the leaf are hairy, upper surface rugose. Leaves are very brittle and usually much broken in the commercial article. Flowers are unisexual, monoecious, small, numerous and crowded in small globose cymes. The fruit is a capsule, 1.25 mm. in diameter, hairy and contains 3 yellowish-brown, four-sided, wrinkled seeds.

A transverse section of the stem shows the following characters under the microscope (Fig. 1). The epidermis is thick-walled, wavy with hairs of

two kinds, unicellular and multicellular; the tips of unicellular hairs drop off with age. The hypodermis

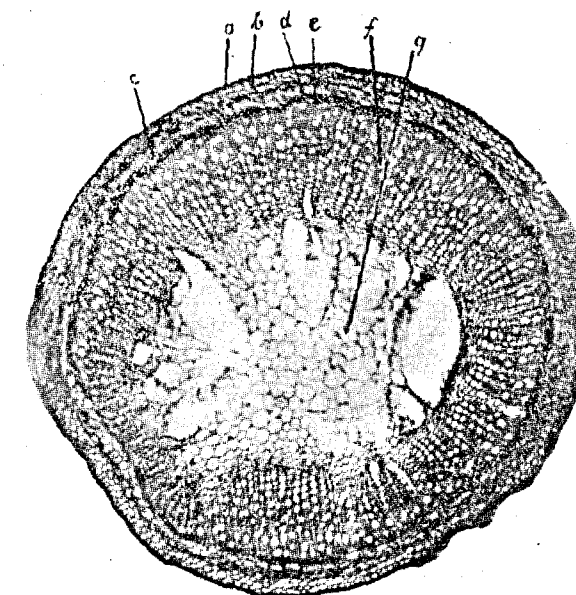


FIG. 1. Transverse section of stem of *Euphorbia pilulifera* Linn. a, Epidermis; b, Cortex; c, Latex Cells; d, Phloem; e, Cambium; f, Xylem; g, Pith.

consists of oval collenchymatous cells. Below the hypodermis lies the cortical region consisting of three to five layers of cells. Small groups of sclerenchymatous cells occur in the cortex. Oval cells, slightly larger than the adjoining parenchymatous cells, are also present in this region; these are very prominent and contain latex. The vascular bundle, composed of phloem, cambium and xylem, forms the central cylinder. Parenchymatous cells containing large air-space form the pith; this occupies a large portion of the central region of the stem.

Thanks are due to Dr B. Mukerji, D.Sc., M.D., Director, Biochemical Standardization Laboratory for his interest in this work.

A. B. BOSE

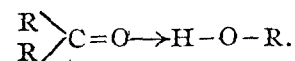
Biochemical Standardization Laboratory,
110, Chittaranjan Avenue,
Calcutta/Kasauli, 3-11-43.

¹ Dikshit, B. B. and Kameshwar Rao, D., *Proc. Ind. Sci. Congress*, p. 349, 1931.

MOLECULAR ASSOCIATION IN ALCOHOLS

IN continuation of the previous work¹ on molecular association in amides¹, the author has investigated the association characteristics in methyl and ethyl alcohols and phenol. The alcohols were investigated at temperatures of 5°, 30°, and 60°C (in the case of methyl alcohol) and 70°C (in the case of ethyl alcohol). The effect of solution in polar solvents like water and non-polar solvents, such as, benzene and carbon tetrachloride was studied. The effect of solution in an oxygenated solvent, acetone, was also investigated. Phenol has been studied in the solid and liquid states and at different temperatures (50° and 135°C) and in solutions of polar and non-polar solvents.

With the change of temperature, the changes observed in the Raman frequencies are inappreciable, except for the OH bands in methyl and ethyl alcohols, whose structure and frequency is altered, indicating depolymerisation at the higher temperature as in the case of water and heavy water. Among the solvents studied, water is found to produce conspicuous shifts in the C—O line of the alcohols. The 1032 line in methyl and the 1052 in ethyl alcohol are found to progressively shift to lower frequencies with increasing concentrations of water—a change which is explained as due to the formation of complex between alcohol and water molecules. In ethyl alcohol the C—H lines shift prominently towards the higher frequencies while no perceptible change is observed in the C—C line. In solutions of non-polar solvents, C₆H₆ and CCl₄, no changes are observed, the spectrum of the mixture being merely a superposition of the spectra of the constituents. In solutions of acetone, perceptible shift to lower frequency is observed in the C—O line of the alcohols, which has been interpreted as due to the formation of a weak intermolecular hydrogen bond between the hydroxyl group of the alcohol and the keto oxygen as



The study of the complimentary effect of the alcohols on the acetone lines confirmed the above conclusions. The different changes observed in the Raman frequencies of phenol with temperature showed that the degree of association has not been appreciably changed. The changes observed in solutions of CCl₄ and (CH₃)₂CO are analogous to those observed in methyl and ethyl alcohols.

Full details of the results will be published elsewhere.

Andhra University,
Waltair, 15-11-1943.

A. L. SUNDARA RAO.

TOTAL ALKALOIDS IN *ALSTONIA SCHOLARIS*—THE POPULAR AND WELL-KNOWN INDIGENOUS ANTIMALARIAL DRUG

RESEARCHES on the isolation of alkaloids from the bark were started since 1875.¹ A few of the alkaloids, which were easily separated, were tried in Physiological Research Laboratories² to ascertain medicinal value of each individual one isolated in state of purity. Pharmacological laboratory experiments were also done in India using chloroform soluble alkaloids, and some weak extract of bark in alcohol, with unsatisfactory results.³ It was thought worth while attempting to find out reason for the popular belief being not corroborated by laboratory experiments using mainly bird and monkey for pharmacological researches.

Although *Alstonia scholaris* is found growing wild in forests all over this country yet rather an incidental sample only was examined by Goodson.⁴ Previous authors presumed that all alkaloids were liberated *in tact* by the two stages of alkalisation and were totally isolated by extraction with immiscible solvents—ether, chloroform, or benzene. They did not consider the possibility that some *Alstonia* alkaloids may not be soluble in the above solvents.

Unstable nature of *Alstonia* alkaloids and difficulty of solubility of products deposited by weak or strong alkalies were noticed before. But the existence of a large amount of water soluble alkaloids left in the alkaline mother liquor after extraction with chloroform, ether, or benzene were not recorded. Consequently the amount of total alkaloids shown in published papers does not represent the actual drug contents of barks.

The following details were worked out which gave uniform results. Ten grams of air dried powder No. 60 were repeatedly extracted with 90 per cent alcohol till the final washing was free from any alkaloid. All alcoholic extracts were evaporated to syrupy consistence, dissolved in 10 times its own volume of water, acidulated with dilute sulphuric acid, filtered, unfiltered residue thrice washed with water using 5 c.c. each time, filtrate with washings neutralised with chalk powders, filtered again, unfiltered residue washed thrice with water using 5 c.c. each time, and the clear filtrate was evaporated to syrupy consistence again. The extract was dissolved in 90 per cent alcohol, filtered, filter paper washed with alcohol using 5 c.c. each time, and the filtrate evaporated to dryness. The product thus obtained was dissolved in 10 c.c. water and thrice extracted with chloroform using 5 c.c. each time to remove any lactone, organic acid, or waxy matters, and then aqueous solution of sulphates of alkaloids was evaporated on water bath, finally dried in a desiccator, and weighed as total alkaloids.

Place of origin.	Name.	Total alkaloids as sulphates
1. New Delhi ...	<i>Alstonia scholaris</i>	4.0
2. Haldwani, Naini Tal, U. P. ...	" "	11.2
3. Kalimpong, Darjeeling ...	" "	5.9
4. Shillong, Assam ...	" "	8.9
5. Sibpur, Royal Botanical Garden ...	" "	6.6
6. Do. Do. ...	" <i>macrophylla</i>	8.2
7. Ambasamudram, Tinus valley ...	" <i>scholaris</i>	4.1
8. Mannarghat, Palghat, Madras ...	" "	6.1
9. Nilambar, Madras ...	" "	4.9
10. Kannothe, Wynad Manantoddy, Madras ...	" "	2.9
11. Begur, Manantoddy, Madras ...	" "	3.0
12. Kassargod, Mangalore, South Canara ...	" "	6.4

Total alkaloids thus obtained are, however, not entirely free from contamination of small proportion of impurities like colouring matters, and organic acids, etc., which are slightly soluble in alcohol and do not coagulate by heat or acid. The alkaloidal products thus obtained were practically free from ash and matters which reduce Fehling's solution. Such a method would have been perfect and unquestionable had all the bases been entirely separated by precipitation or by extraction with one or more solvents. Unfortunately, none of these general principles are applicable in the case of this drug. Because, firstly, a large proportion of essential bases are soluble in the aqueous liquor containing added carbonates or caustic alkalines, and which are not taken out by immiscible solvents; and secondly, some of the bases seem to undergo decomposition as can be seen from difficultly soluble sticky and tarry products resulted after addition of alkalies, which are only partially soluble in ordinary solvents like chloroform etc. Under such circumstances the above figures seem to be useful in commercial and pharmaceutical valuation of this well known antimalarial indigenous drug, which is so abundantly procurable all over India. On the other hand, results obtained by this method are not so grossly erroneous as those recorded before.

The older figures for total alkaloids mainly consisted in alstonine, villalstonine, macralstonine, macralstonidine, echitamine, echitamidine. These were found to be practically free from antimalarial properties by the former investigators, whereas total alkaloids obtained by the present process possess definite antimalarial constituents. These total alkaloids have been investigated by medical men exhaustively, who will publish their results in proper medical journal.

The author thanks Messrs. Calcutta Chemical Co., Ltd., Calcutta for permission to publish this

paper, and all Government Officers who were kind enough to send samples for chemical examination.

JITENDRA NATH RAKSHIT.

Calcutta, 1-12-1943.

¹ Gorup-Besanez, *Annalen*, 176, 88, 1875.

² Goodson and Henry, *J. C. S.*, 1643; 1925; Goodson, Henry and Macfie, *Biochem. J.*, 26, 874, 1930; Sharp, *J. C. S.*, 288, 1932; 1228, 1934.

³ Mukherjee, Ghosh and Siddons, *Ind. Med. Gaz.*, 723, 1932.

⁴ Goodson, *J. C. S.*, 2627, 1932.

A PIRANI VACUUM GAUGE

The Pirani Gauge is generally found useful in the range 10⁻² to 10⁻⁴ mm of mercury, but recently a few were constructed in this laboratory which have been found serviceable over wider range.

The circuit is given in fig. 1. The resistances R₁ and R₂ are each of 100 ohms, the power supply was from the mains 220 volt D.C.

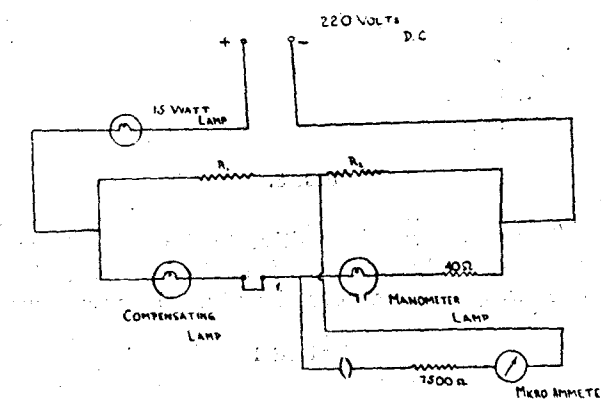


FIG. 1.

The lamp used in the gauge was an ordinary 40 watt tungsten filament lamp opening into the vacuum line. Carbon filament lamps were not found suitable.

The calibration of the gauge was made with a standard MacLeod gauge reading up to 2.10⁻⁵ mm of mercury. The calibration curve is shown in fig. 2.

The value of ΔR corresponding to the different pressures are shown in the table. It will be seen from these figures that much lower pressures can be measured, provided a suitably calibrated MacLeod gauge reading to lower pressure is available.

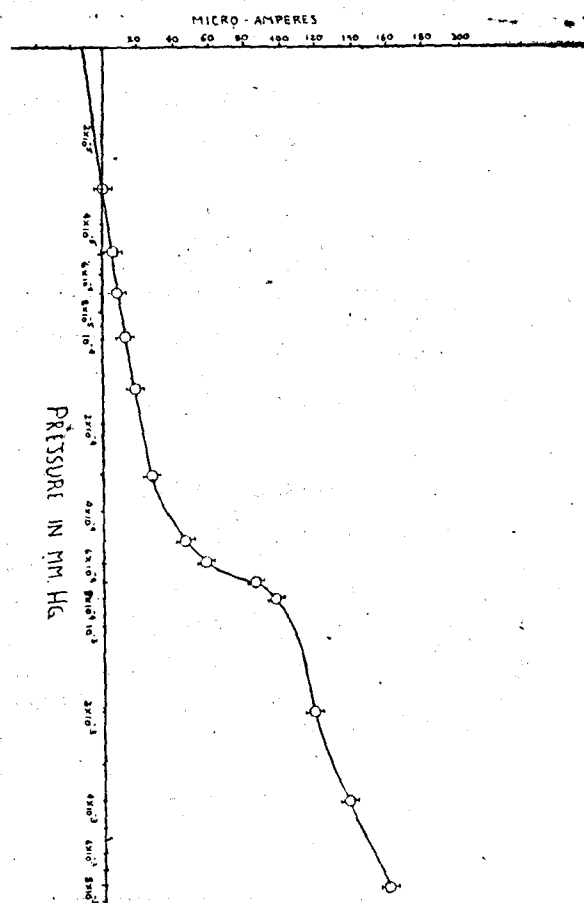


FIG. 2.

The gauge was insensitive to the fluctuations in the mains supply voltage. A slight zero-shift of the gauge was observed occasionally. It was always

TABLE I

PRESSURE IN MM. HG.	R IN OHMS.	ΔR IN OHMS.
6×10^{-4}	147	
7×10^{-4}		3
8×10^{-4}		6
1.5×10^{-3}		10
2×10^{-3}		11
3×10^{-3}		15
9×10^{-3}		19

small and unsystematic and did not change the calibration by sufficient amount to give errors outside the usual instrumental errors and hence was neglected.

It was also noticed that a point of inflection occurs in the calibration curves for tungsten filaments. Several tungsten filament lamps were used of various resistance values and all the curves showed the presence of this inflexion at about the same region of pressures although the carbon filament did not show any such inflexion. It does not seem to have been noticed by any previous worker and is reported here. Investigations on its causes are in progress and will be reported in due course.

The gauge is compact, robust and cheap and can be made at small cost in a good laboratory. It was used for testing the vacuum in the demountable Cyclotron Oscillator Triode Tube, which was estimated to be 4×10^{-6} mm of mercury without liquid air traps. It has been also found very useful in detecting leaks. It is a pleasure to acknowledge my indebtedness to Dr B. D. Nag and Mr B. M. Banerjee for their many helpful suggestions and advices. My thanks are due to Prof. M. N. Saha, D.Sc., F.R.S. for providing facilities for carrying out the work and also for taking a keen interest during the progress of the work. The facilities of the Cyclotron Laboratory are also gratefully acknowledged.

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ON THE BASIC NITRATES OF GADOLINIUM

In a previous communication one of us¹ reported the results of the systematic study of the basic nitrates of the rare earths. There it was shown that the elements of the cerium group give two basic nitrates, both insoluble in water—one analogous to BiONO_3 and the other analogous to $\text{Bi}_2\text{O}_3 \cdot 2\text{BiONO}_3$. Yttrium gives, however, only one basic nitrate of the composition $3\text{Y}_2\text{O}_3 \cdot 4\text{N}_2\text{O}_5 \cdot 20\text{H}_2\text{O}$ which is soluble in water. To see whether this is characteristic of the yttrium group, we have studied the basic nitrate of ytterbium. The conductometric titration of ytterbium nitrate with caustic soda gave a curve analogous to that of yttrium nitrate with NaOH. (Cf. SCIENCE AND CULTURE, 9, 166, 1943—Fig. 2, Curve II). That is to say, it reveals the existence of only one basic nitrate $3\text{Yb}_2\text{O}_3 \cdot 4\text{N}_2\text{O}_5$ showing thereby that the above basic nitrate is characteristic of the yttrium group.

While studying gadolinium and its compounds one of us isolated a basic nitrate of the composition $3\text{Gd}_2\text{O}_3 \cdot 4\text{N}_2\text{O}_5 \cdot 20\text{H}_2\text{O}$ soluble in water and perfectly analogous to that of yttrium. From its position in the "serial order" of the rare earths gadolinium is

expected to possess properties characteristic of both cerium and yttrium groups. For example,

(1) Gadolinium gives an acid tartarate of the composition $\text{HGd}(\text{C}_4\text{H}_4\text{O}_6)_2 \cdot 2\text{H}_2\text{O}$ similar to the corresponding salt of bismuth.

(2) Basic nitrate, $3\text{Gd}_2\text{O}_3 \cdot 4\text{N}_2\text{O}_5 \cdot 20\text{H}_2\text{O}$ analogous to the corresponding salts of the yttrium group.

(3) The addition product of $\text{Gd}(\text{NO}_3)_3$ with antipyrine of the composition $\text{Gd}(\text{NO}_3)_3 \cdot 3\text{C}_{11}\text{H}_{12}\text{ON}_2$ resembles those of the cerium group.

(4) Compound of gadolinium nitrate with hexamethylene tetramine has the composition $\text{Gd}(\text{NO}_3)_3 \cdot 2\text{C}_6\text{H}_{12}\text{N}_4 \cdot 10\text{H}_2\text{O}$ analogous to those of the yttrium group.

(5) Gadolinium platincyanide crystallises with 18 molecules of water characteristic of the cerium group—those of yttrium group crystallise with 21 molecules of water. Its colour, however, is cherry red with beautiful green fluorescence characteristic of yttrium group, those of cerium group have yellow colour with blue fluorescence.

We have recently made a detailed study of the basic nitrates of gadolinium. Conductometric titration curve of gadolinium nitrate with NaOH as well as the thermal decomposition curve of $\text{Gd}(\text{NO}_3)_3$ with increasing temperature revealed the existence of 2 basic nitrates first, having the composition $3\text{Gd}_2\text{O}_3 \cdot 4\text{N}_2\text{O}_5$ previously described by Sarkar², analogous to the corresponding salt of yttrium, soluble in water and a second of the composition GdONO_3 , not previously described, and analogous to that of bismuth and those of cerium group—insoluble in water.

The former is stable between $210^\circ\text{--}220^\circ\text{C}$ whilst the latter between $230^\circ\text{--}250^\circ\text{C}$.

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¹N. K. Dutt, SCIENCE AND CULTURE, 9, 166, 1943.
²P. B. Sarkar, *Annals de Chimie*, 239, 1927.

ISOLATION OF GALLIC ACID FROM MANGO-SEEDS

WHILE searching for new indigenous sources of tannins I was reminded of a common practice of our village potters of imparting black colour to their earthen ware pots by the introduction of mango-stones in the kiln.

In the literature no mention is made of the presence of tannin in the mango-stones. In Nierenstein's

book (The Natural Organic Tannins, 1934) mention is made of the existence of tannin only in the rind of the mango plant (*Mangifera indica* L.)

The hard outer shells of mango-stones were removed and the seeds were dried. 100 g of the dry powder were extracted with 80 per cent alcohol in a Soxhlet apparatus. The alcoholic extract was distilled and residue was crystallised from boiling water (charcoal) and the solid on recrystallisation weighed 6 g. The mother liquors on further concentration gave about 2 g. more of the substance. It is insoluble in cold but readily soluble in hot water. It gives no characteristic tests for tannins but produces blue black colour with ferric chloride solution. It melts at 220° (decomp.) and shows no depression in m.p. when mixed with an equal quantity of an authentic sample of gallic acid. The acetyl derivative, prepared in the usual method, melts at 169° (decomp.). On titration with a standard baryta solution it is found to be a monobasic acid. A portion was sublimed and white needles were obtained, which melt at 132° and respond to the usual tests for Pyrogallol.

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DISTRIBUTION OF TANNIN IN DIFFERENT PARTS OF THE MANGO-PLANT (*MANGIFERA INDICA* L.)

IN the literature mention is made of the presence of tannin in the rind of the *Mangifera indica* L. It was of interest to find out if any other part of the plant contains tannin and if so, to make a comparative study of the tannin-content of the different parts of the plant.

The different parts of a mango-plant were collected fresh, and 10 g. of each of the parts were cut into small pieces and put in 100 c.c. distilled water in conical flasks and heated on the steam bath for two hours when the leaves became colourless. The extracts were filtered through paper and the colours of the solutions were found as follows:—

- (1) Most tender leaflets of the buds—beautiful pink.
- (2) Leaves of 2 weeks' old buds—beautiful light pink.
- (3) Mature green leaves—deep yellowish brown.

- (4) Rind of the new buds—slightly pink.
 (5) Rind of the stem—light brown.

The extracts gave characteristic tests for tannin. The comparative test of tannin-content in different samples was determined from the depth of colour produced with ferric chloride solution. Lest the colour of the solutions to be tested interfere with the colour produced with ferric chloride, equal volumes of each of the extracts were treated with equal amounts of decolourising charcoal and the almost colourless filtrates obtained were tested in the following way. 1 c.c. of each of these solutions was taken in tubes of equal dimensions, diluted with distilled water to 50 c.c. and 2 drops of ferric chloride solution were added to each. The bluishgreen colour generated was carefully observed, the depth of which was found to be in the decreasing order as follows:—

- (1) Tender leaflets; (2) Two weeks' old leaves;
 (3) Rind of new buds; (4) Mature leaves; (5) Rind of the stem.

From the above observation we find that the tannin-content diminishes gradually with maturity. The presence of the largest amount of tannin in the tenderest parts of the plant is most probably associated with the protective action against the depredation of insects and other pests. The findings also point to the fact that the parts where photosynthesis is most vigorous are richer in tannin.

Similar observations have been made with different parts of the Indian persimmon plant, the tannin and pectin of the fruits of which are now being studied in this laboratory by the author.

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FOOD OF FRESH-WATER FISHES

TRUE carnivorous or true herbivorous fish cannot be found among freshwater fishes like higher animals. These are relative terms. Those that take food mostly from the animal world are known as carnivorous, likewise those that take mostly from the vegetable world are known as herbivorous. But strictly speaking each group takes a mixed diet in the true sense of the term. Again mostly both these

groups of fishes take animal food with a minor proportion of vegetable in their fry stages.

Adult fresh-water fishes take a very high percentage of higher aquatic plants in a semi-rotten state with a negligible proportion of aquatic algae. Even those that are carnivorous are not exception to this rule, only difference being less proportionate to animal food. We have adequate data of the stomach-contents which clearly show the semi-rotten condition of the vegetable matter. There is reason to believe that adult fresh-water fishes mostly cannot digest algae as we find them in fresh condition in the lower intestine of these fishes. Specially the diatoms are found as fresh as ever.

As the big carp take mostly semi-rotten vegetable matter, they do not thrive well in a newly excavated pond, although fry and adolescent ones grow vigorously in it for the mere fact that animalcules and algae grow well in it, and these animalcules and algae are the chief food of fry and adolescent stages. The cysted animalcules and spores of algae are already in the dry excavated pond and these become active on the accumulation of rain water.

Shallow seasonal ponds are good for early growth but deep perennial ponds are essential to keep adult big fishes.

It is the duty of pisciculturist to see that water-hyacinth, lotus or other covering plants should not grow profusely in ponds to cover up the water which is detrimental to the growth of fish. All other aquatic plants should remain in the pond in adequate quantity for food of fishes.

It may not be out of place to mention that in the early stages all the principal types of carp take protozoa, crustacea, insect larvae and algae but *Catla catla* have a special liking for crustacea and for this reason they do not thrive well without them. *Cirrhina mrigala* and *Labeo calbasu* take lots of mud apart from living things. *Labeo rohita* take just a little mud and *Catla catla* go almost without it. Mud is taken for organic matter and various salts.

Artificial food (organic matter other than living) such as advocated by most of the fishery departments in India are practically useless for two reasons—(1) excessive cost, and (2) pollution of water. These should be discarded once for all.

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Science Congress

SUPPLEMENT

To

SCIENCE AND CULTURE

JANUARY, 1944

Professor S. N. Bose's Presidential Address
 Life Sketches of the General President and
 Sectional Presidents
 Delhi and its Monuments

The Classical Determinism and the Quantum Theory

*Prof. S. N. Bose's General Presidential Address at the
Indian Science Congress, Delhi*

I wish to express sincere thanks for the great honour you have done me. The Presidentship of the Science Congress is a great distinction, and I confess, I have my own misgivings about the wisdom of your choice. Your first decision had raised high hopes. Many of us expected that a deliberate programme of the future scientific activities of the country would probably be a feature of the opening speech of this Congress. Pandit Jawaharlal had studied the needs of the country. Many of our front-rank scientists and industrialists had met under his leadership, not long ago, and given to questions of future reconstruction much time and anxious thought. The results of this deliberation would have been invaluable at the present moment. My regret is keen that chance has deprived us of the benefits of a sustained and careful study of the problems of the day. I would have liked to present here the results, if they were available. Unfortunately they are not, as most of the reports are inaccessible to me.

One of your former Presidents had remarked that "a scientist is apt to become a man that knows more and more about less and less, so that his opinion upon subjects outside his field of special study is not necessarily of special value". I realise the wisdom of this warning and hope to have your indulgence, if I seem to be more at home with doubts and criticisms than with useful knowledge.

I would like to present before you certain aspects of modern physics and draw your attention to the profound changes in the principle of scientific explanation of natural phenomena brought about by the quantum theory. The last fifty years record remarkable discoveries. I need only mention the electron, and the neutron, X-rays and Radio-activity to remind you of the increase of our knowledge. Our equipment has gained in power-range and accuracy. We possess powerful telescopes to scan the furthest corners of the universe, also precise and delicate instruments to probe into the interior of the atoms and molecules. The alchemists' dream of transmutation has become a reality. Atoms are now disintegrated and synthesised. X-ray reveals invisible worlds and wireless links up the furthest ends of the earth with possibility of immediate inter-communication. These discoveries have their repercussions in the realm of ideas. Fifty years ago the belief in causality and determination was absolute. To-day physicists have gained knowledge but lost their faith.

To understand properly the significance of such a profound change it will be necessary to discuss briefly how it all came about. Classical physics had begun with the study of astronomy. With his laws of gravitation and his dynamics Newton had explained planetary motion. Subsequent study has shown astronomical prediction to be possible and sure. Physicists had taken the equations of celestial mechanics as their model of a universal law. The atomic theory had in the mean time gained universal acceptance; since matter had resolved into a conglomeration of particles, the ideal scheme was to explain all phenomena in terms of their motions and interactions. It was only necessary to set up a proper set of equations, and to take account of all possible mutual interactions. If the mass, position, and velocity of all the particles were known at any instant these equations would theoretically enable the physicist to predict the position and motion of every particle at any other subsequent moment.

The phenomena of light did not at first fit into this simple scheme. To regard it as a stream of particles was impossible due to the discovery of interference. Accordingly the wave theory of light was originated by Huyghens and perfected by Maxwell. With the discovery of the electron as a universal constituent of matter, the electromagnetic theory of Maxwell was converted into an electronic theory by Lorentz. To the dynamical laws were added the electromagnetic equations and the two together apparently gave an exact and ideal formulation of the laws of causality. In the forces of interaction henceforth, were to be included not only the gravitational forces but also those interactions which depended on the charge and the motion of the particles. These interactions were brought about by influences which spread out as waves with the velocity of light. They superimposed, interfered and constituted the field of force in the neighbourhood of the particles, modified their motion and were in turn modified by them. The motion of all particles throughout the universe were thus interlocked. These out-going influences also constituted light, invisible radiation, X-rays and wireless waves. Thus a set of universal laws was supposed to be have been discovered and we had only to apply them suitably to find explanations of all conceivable natural phenomena. In physical science we do not however always proceed in the above way and turn to the

"microscopic" equations whenever we have to explain events. We often study material *en masse*, consisting of an enormous number of corpuscles, and we use either the principle of the conservation of energy or the laws of thermodynamics to explain their behaviour. These laws were however regarded either as simple consequences of the fundamental equations or as statistical laws derivable from them by a suitable averaging. Though in the latter cases we talk about probabilities and fluctuations, it was more or less a matter of faith to maintain that if it were possible for us to obtain all the necessary data by delicate observations, universal laws would enable us to follow each individual molecule in this intricate labyrinth and we should find in each case an exact fulfilment of the laws and agreement with observation. The above in brief forms an expression of faith of a classical physicist. We see that it involves as necessary consequences, belief in continuity, in the possibility of space-time description of all changes and in the existence of universal laws independent of observers which inexorably determine the course of future events and the fate of the material world for all times.

A few remarks about the general equations will perhaps enable us to follow better the criticisms that have been levelled against the system. The structure of the mechanical equations of particles is different from the field-equations of Maxwell and Lorentz. The principles of conservation of energy and momentum were first discovered as consequences of the mechanical equations. Mass and velocity of the corpuscle furnish means to measure its momentum, and its energy, if we leave aside the potential energy which resides in the field. To maintain the integrity of the principle of conservation, the field must also be considered capable of possessing energy and momentum, which however, being associated with wave-motion, must spread out in all directions with the waves. The transfer of energy from the field to the particles must thus be a continuous process, whereby, a finite change should come about only in a finite interval and the process should theoretically be capable of an exact description in space and time.

Physics being essentially concerned with relations between quantities, these should all be capable of exact measurement. We measure always intervals of time or inter-distance between points, hence the specification of the reference frame is just as important as the units of measure. Newton had not analysed closely the conception of mass and time. This vagueness persisted in the dynamical equations for the particles. The field-equations which form the basis of the wave-theory of light have a different origin. With the discovery of the principle of the least action, a common derivation of both has been attempted. But a difference in the choice of refer-

ence frame in the two apparently subsisted. The wave-equations assumed a fixed ether whereas the material laws contemplated a Galilean inertial-frame. An immediate deduction from this distinction was the possibility of measuring the relative velocity of the observer with reference to ether. The experiment of Michelson and Morley showed it to be unrealisable in practice and formed the starting point of the celebrated Relativity Theory. Einstein had subjected the conception of time-measurement to a searching examination and showed the impossibility of conceiving a time independent of an observer, or an absolute simultaneity of events happening at two different places. The same space-time reference should be chosen for the dynamical equations as well as the equations of the field, this being supplied by the observer. In spite of this apparent limitation Einstein demonstrated the possibility of formulation of natural laws independent of all axes of reference and pointed out that the necessary auxiliaries existed already in the invariant theory and the tensor Calculus of mathematicians. In spite of its apparently revolutionary character, the theory of relativity upheld the ideal of causality and determinism. Einstein himself has continued to seek with great earnestness a unifying field theory which will combine gravitation and electromagnetism and render unnecessary a separate formulation of the dynamical equations. No such theory as yet exists.

II

The development of the quantum theory has raised fundamental issues. Facts have been discovered which demonstrate the breakdown of the fundamental equations which justified our belief in determinism. A critical examination of the way in which physical measurements are made has shown the impossibility of measuring accurately all the quantities necessary for a space-time description of the motion of the corpuscles.

Experiments reveal either the corpuscular or the wave nature for the photon or the electron according to the circumstances of the case, and present us with an apparently impossible task of fusing two contradictory characters into one sensible image. The only solution suggested has been a renunciation of space-time representation of atomic phenomena and with it our belief in causality and determinism.

Let me briefly recapitulate the facts. In 1900 Planck discovered the quantum of action while studying the conditions of equilibrium between matter and the radiation field. Apparently interchange of energy took place in discrete units whose magnitude depended on 'h' and the frequency of the radiation emitted or absorbed by matter. Photo-electric emission had similar disquieting features. Einstein therefore suggested a discrete structure of

the radiation field in which energy existed in quanta instead of being continuously distributed in space as required by the wave-theory. This light-quantum however is not the old light-corpuscle of Newton. The rich experimental materials supporting the wave-theory preclude that possibility altogether. Moreover the fundamental relation $E=h\nu$, and $p=hk$, connecting energy and momentum of the photon with the frequency ν and the vector wave number k , makes a direct reference to idealised plane wave so foreign to the old idea of a corpuscle. Soon afterwards Bohr postulated the existence of radiationless stationary states of atoms and showed how it led to a simple explanation of the atomic spectra. The extreme simplicity of the proposed structure and its striking success in correlating a multitude of experimental facts at once revealed the inadequacy of the ordinary laws of mechanics and electro-dynamics in explaining the remarkable stability of the atoms.

The new ideas found application in different branches of physics. Discontinuous quantum processes furnished solutions to many puzzles. Suitably modified, the theory furnished a reasonable explanation of the periodic classification of elements and thermal behaviour of substances at low temperature. There was however one striking feature. It was apparently impossible to characterise the details of the actual transition processes from one stationary state to another, that is, to visualise it as a continuous sequence of changes determined by any law as yet undiscovered. It became clear that the dynamical laws as well as the laws of electromagnetism failed to account for atomic processes. New laws had to be sought out compatible with the quantum theory capable at the same time of explaining the rich experimental materials of classical physics. Bohr and his pupils utilised for a time a correspondence principle, guessing correct laws for atomic processes from analogy with the results of the classical theory. In every case these appeared as statistical laws concerned with the probabilities of transition between the various atomic states. Einstein tackled the problem of the equilibrium of matter and radiation on the basis of certain hypotheses regarding the probabilities of transition between the various states by absorption and emission. A derivation of the Planck Law was obtained by Bose by a suitable modification of the methods of classical statistics. Heisenberg finally arrived at a satisfactory solution and discovered his matrix-mechanics and a general method for all atomic problems. Dirac and Schrödinger also published simultaneously their independent solutions. Though clothed in apparently dissimilar mathematical symbols, the three theories gave identical results and have now come to be looked upon as different formalisms expressing the same statistical laws.

I have mentioned that the photon gave a simple

explanation of many of the properties of radiation and thereby presented its corpuscular aspect while the well-known properties of interference and superposability brought out its wave character. That the same dual nature may exist in all material corpuscles was first imagined by De Broglie. His phase-waves found quick experimental verification, and raised a similar problem of the real nature of the corpuscle. The formulation of wave-mechanics by Schrödinger once raised a hope that by a radical modification of our usual ideas about the corpuscle it might be possible to re-establish the law of causality and classical determinism. Subsequent developments have shown such hopes to be illusory. His waves are mathematical fictions utilising the multidimensional representation of a phase-space and are just as incapable of explaining the individuality of the electron, as the photon is incapable of explaining the superposability of the field. The true meaning of his equations appears in their statistical interpretation.

III

The adherents of the quantum theory interpret the equations in a peculiar way. They maintain that these equations make statements about the behaviour of a simple atom and nothing more than a calculation of the probabilities of transition between its different states is ever possible. There is nothing incomprehensible about such a statistical law even if it relates to the behaviour of a single particle. But a follower of determinism will interpret such statements as betraying imperfect knowledge, either of the attendant circumstances or of the elementary laws. We may record the throws when a certain die is cast a large number of times and arrive at a statistical law which will tell us how many times out of a thousand it will fall on a certain side. But if we can take into account the exact location of its centre of gravity, all the circumstances of the throw, the initial velocity, the resistance of the table and the air and every other peculiarity that may affect it, there can be no question of chance, because each time we can reckon where the die will stop and know in what position it will rest. It is the assertion of the impossibility of even conceiving such elementary determining laws for the atomic system that is disconcerting to the classical physicist.

Von Neumann has analysed the statistical interpretation of the quantum mechanical laws and claims to have demonstrated that the results of the quantum theory cannot be regarded as obtainable from exact causal laws by a process of averaging. He asserts definitely that a causal explanation of quantum mechanics is not possible without an essential modification or sacrifice of some parts of the existing theory.

Bohr has recently analysed the situation and

asserted that we cannot hope any future development of the theory will ever allow a return to a description of the atomic phenomena more conformable to the ideal of causality. He points out the importance of the searching analysis of the theory of observation made by Heisenberg, whereby he has arrived at his famous principle of indeterminacy. According to it, it is never possible for us to determine the simultaneous values of momentum, and positional co-ordinates of any system with an accuracy greater than what is compatible with the inequality $\Delta p \Delta q > \frac{h}{4\pi}$

This natural limitation does not affect the physics of bodies of finite size but makes space-time descriptions of corpuscles and photons impossible. When we proceed to study the behaviour of the elementary particles, our instruments of measurement have an essential influence on the final results. We have also to concede that the contributions of the instrument and the object, are not separately computable from the results as they are interpreted in a classical way with the usual ideas of co-ordinate and momentum accepting thereby a lack of control of all action and reaction of object and instrument due to quantum effects.

It is in this imperative necessity of describing all our knowledge with the usual classical ideas, that Bohr seeks an explanation of the apparently irreconcilable behaviour of corpuscles and radiation in different experiments. For example, if we set our experiments in such a fashion as to determine accurately the space-time co-ordinates, the same arrangement cannot be simultaneously used to calculate the energy momentum relations accurately; when our arrangements have pushed the accuracy of determining the positional co-ordinates to its utmost limit, the results evidently will be capable only of a corpuscular representation. If, on the other hand, our aim is to determine momentum and energy with the utmost accuracy, the necessary apparatus will not allow us any determination of positional co-ordinates and the results we obtain can be understood only in terms of the imagery of wave-motion. The apparently contradictory nature of our conclusions is to be explained by the fact, that every measurement has an individual character of its own. The quantum theory does not allow us to separate rigorously the contribution of the object and the instrument and as such the sum total of our knowledge gained in individual cases cannot be synthesised to give a consistent picture of the object of our study which enables us to predict with certainty its behaviour in any particular situation. We are thus doomed to have only statistical laws for these elementary particles and any further development is not likely to affect these general conclusions.

It is clear that a complete acceptance of all the above conclusions would mean a complete break with

the ancient accepted principles of scientific explanation. Causality and the universal laws are to be thrown simultaneously overboard. These assertions are so revolutionary that, no wonder, they have forced physicists to opposing camps. There are some who look upon causality as an indispensable postulate for all scientific activities. The inability to apply it consistently because of the limitations of the present state of human knowledge would not justify a total denial of its existence. Granted that physics has outgrown the stage of a mechanistic formulation of the principle, they assert that it is now the task of the scientists to seek for a better formulation. Others of the opposing camp look upon old determinism as an inhuman conception, not only because it sets up an impossible ideal, but also as it forces man to a fatalistic attitude which regards humanity as inanimate automata in the hands of an iron law of causation. For them the new theory has humanised physics. The quantum statistical conception of determinism nestles closer to reality and substitutes a graspable truth for an inaccessible ideal. The theory has brought hope and inspired activity. It constitutes a tremendous step towards the understanding of nature. The features of the present theory may not all be familiar but use will remove the initial prejudice. We are not to impose our reason and philosophy on nature. Our philosophy and our logic evolve and adjust themselves more and more to reality.

In spite of the striking successes of the new theory, its provisional character is often frankly admitted. The field theory is as yet in an unsatisfactory state. In spite of strong optimism, difficulties do not gradually dissolve and disappear. They are relegated to a lumber room, whence the menace of an ultimate divergence of all solutions neutralises much of the convincing force of imposing mathematical symbols. Nor is the problem of matter and radiation solved by the theory of complementary characters. Also we hear already of the limitations of the new theory encountered in its application to nuclear problems.

The quantum theory is frankly utilitarian in its outlook; but is the ideal of a universal theory completely overthrown by the penetrating criticism of the nature of physical measurements?

Bohr has stressed the unique character of all physical measurements. We try to synthesise their results and we get probabilities to reckon with instead of certainties. But how does the formalism $\frac{h}{2\pi i} \frac{\partial \psi}{\partial t} = H\psi$ emerge as a certain law? The wider the generalisation, the less becomes the content. A universal law would be totally devoid of it. It may nevertheless unfold unsuspected harmonies in the realm of concept. More than ever now, physics does need such a generalisation to bring order in its domain of ideas.

SHORT LIFE SKETCHES OF THE General President and Sectional Presidents

S. N. BOSE

General President

Prof. Satyendra Nath Bose, General President of the Indian Science Congress for 1944 is Professor and Head of the Department of Physics at the University of Dacca, Bengal.



His election is a well-merited recognition of his scientific eminence. A quiet type of man, Prof. Bose belongs to the front rank of the theoretical physicists who by their contributions have laid the foundation of the New Physics.

After a brilliant school career he entered the Presidency College, Calcutta in 1909 where he specialised in mathematics and stood first in the first class at the B.Sc. Honours as well as at the M.Sc. Examinations in that subject. He was particularly interested in the applications of mathematics to the problems of physics and this attracted the attention of the late Sir Asutosh Mookerjee at whose invitation he joined the University of Calcutta in 1916 as Lecturer in Physics and thus helped in the development of the physics department of the newly created University College of Science. In 1921 when the University of Dacca was just established he was appointed to a Readership in Physics. In 1927 he was appointed Professor of Physics in that University.

Prof. Bose's outstanding work is his contribution to the new statistics which appeared in 1924 with notes from Einstein indicating its great importance. A reference to Bose-Einstein Statistics is to be found in every text book on Modern Physics.

Prof. Bose is very unassuming and hates publicity. He is a selfless worker and knows how to give his best to the students and staff working in his laboratory, without any thought of return. Although pre-eminently a theoretical physicist his interests are varied and cover such wide range of subjects as Chemistry, Mineralogy, Botany, Soil Science, Philosophy, Literature and the Fine Arts. No wonder that his advice is eagerly sought by research workers in other spheres.

Prof. Bose is a staunch nationalist and a great supporter of National industry. He has helped in the growth of various indigenous concerns. His eagerness for the spread of scientific knowledge among the common people has found expression in his starting the Bengali scientific journal 'Bijnan Parichaya'.

VERRIER ELWIN

President, Section of Anthropology and Archæology

Verrier Elwin is a writer and social worker. Born in 1902; he was educated at Morton College, Oxford. He won many high distinctions in his college days and obtained degree in theology.

His career had a stamp of high scholarship. Mr Elwin's father was a missionary bishop and his natural inclination was towards that occupation. He was appointed chaplain at Merton and was also the Vice-Principal of Wycliffe Hall, Oxford and a lecturer at Merton. He came over to India as member of Christa Seva Sangha in 1927, but retired later into



lay life and since 1932 has lived among the aboriginal tribesmen in the Central Provinces, India, where he has founded a Leper Home and settlement for education and research on humanitarian lines. Mr Elwin married in 1940 Kosi Arnu, a Gond lady met in course of his work among the Gonds of Central Provinces. He has been elected a fellow of the Royal Anthropological Institute for his intimate studies of the aboriginal tribes in C. P. and has been awarded Welcome Medal in 1942. He was Honorary Ethnographer of Bastar State in 1940. His publications include—Christian Dhyana (1929), The Dawn of Indian Freedom (1930), Truth about India (1932), Songs of the Forest (1935), Leaves from the Jungle (1936), Phulmat of the Hills (1937), A Cloud That's Dragonish (1938), and The Baiga (1939).

D. V. BAL

President, Section of Agricultural Sciences

Born in 1895, Dr D. V. Bal was educated at the College of Agriculture, Nagpur, Imperial Agricultural Research Institute, Pusa and at the Rothamsted Experimental Station, Harpenden, England. He joined Government service in the Agriculture Department, C. P. in 1913. He was for some time in addition to his duties as the Agricultural Chemist, Deputy Director of Agriculture, Principal, College of Agriculture, Nagpur and Mycologist on various occasions. From 1931 he is professor of Chemistry in the



College of Agriculture, Nagpur and Head of the Department of Studies in Agricultural Chemistry, Nagpur University. Dr Bal is a Member of the Executive and Academic Councils, Faculty of Agriculture and several other standing committees of the Nagpur University. He was the Convener of the Committee of Courses in Agriculture, Botany, etc., under the High School Education Board, C.P. Dr Bal was a Member of the Board of Agriculture in India for the years 1935, 1937, 1939 and 1941. As a representative of the Government of C. P. and Berar

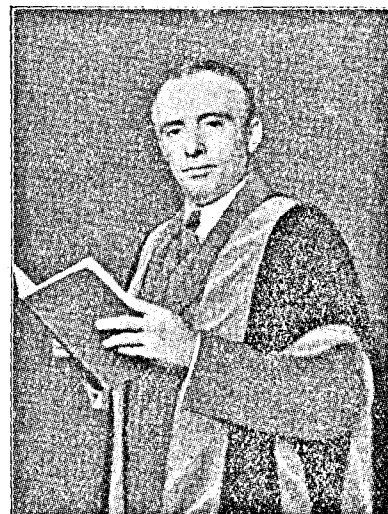
he attended the International Congress of Soil Science held at Oxford in 1935. The titles of Rao Sahib and Rao Bahadur were conferred upon him in 1936 and 1939 respectively.

A. S. KALAPESI

President, Section of Geology and Geography

After graduating from St. Xavier's College, Bombay, he joined the teaching staff in 1916. In 1921 he wrote a book "Elements of Petrology" for beginners. In 1927 Dr Kalapesi went to England for further studies and worked under Profs. W. W. Watts and A. Brammell at the Imperial College of Science and Technology, London. His research work was mainly on the metamorphic aureole at Dartmoor in Devon, for which he got the Ph.D. degree of the London University. After his work in London he spent about a year studying on the Continent, especially at the Bonn University (Germany) under Prof. Hans Cloos and at the Zurich Polytechnique (Switzerland) under Prof. Paul Niggli.

He went again to Europe and studied Regional Geography at the Geographic Institute (Berlin) under Prof. K. Krebs. He has been a Member of the Board of Studies in Geology and also a Member of the Faculty of Science of the University of Bombay for the last twenty years.



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JOHN SARGENT

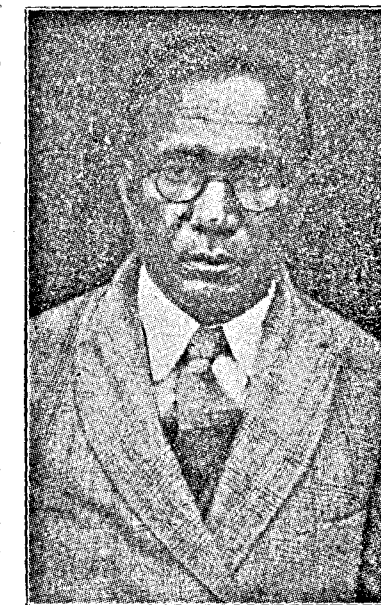
President, Section of Psychology and Educational Science

Mr John Sargent was born in 1888 and was educated at St. Paul's School and Oriel College, Oxford. After his graduation in 1912 in literature, his studies were interrupted during the war. He served in the war with Royal Artillery. In 1923 he obtained his M.A. degree.

S. N. MATHUR

President, Section of Physiology

Dr S. N. Mathur was educated at Kayastha Pathshala and Christian College, Allahabad and at the King George's Medical College, Lucknow. He was demonstrator and later lecturer in physiology at King George's Medical College, Lucknow. Dr Mathur carried on researches at the laboratory of the Lucknow Medical College which work was subsequently elaborated at the Physiological Laboratory at King's College London and Marine Biological Laboratory at Plymouth. He was admitted to the degree of Ph.D. by the University of London in 1932.



T. S. SABNIS

President, Section of Botany

Born at Bombay Dr T. S. Sabnis graduated from the University of Bombay. The results of his post-graduate work are incorporated in the "Flora of Sind" and "Ecology of the Flora of Sind" both published by the Indian Botanical Society. In recognition of his published work he received the degree of Doctor of Science from the Bombay University in 1939. Since 1941 he is, in addition to being the Economic Botanist to Government, U. P. also the Principal, of the Government Agricultural College, Cawnpore.



After experience of teaching and as an Inspector of Schools Mr Sargent became Assistant Education Officer, Birmingham (1920-27), Director of Education, County of Essex (1931-38), Educational Commissioner with the Government of India (1938-43), and Educational Adviser to the Government of India (1943).

Mr Sargent was President, Educational Science Section of the British Association for the Advancement of Science—1938, President, Association of Directors and Secretaries of Education—1934, and is Member of the Council for Art and Industry, Member of the Executive Committee of the Association of Education Committees, and the Education Committee of the County Councils Association.

J. J. GHANDY

President, Section of Engineering and Metallurgy

Born in 1896 Mr J. J. Ghandy was educated at St. Xavier's College, Bombay, and at the Columbia University, New York, and trained in Metallurgical and Steel Works Engineering at the Carnegie Institute of Technology, Pittsburgh. He joined the Tata Iron and Steel Company as Metallurgical Engineer on his return from America in 1921.



Earning one promotion after another, Mr Ghandy became General Superintendent of the Works of this Company in 1930, its Deputy General Manager in May, 1937 and General Manager in 1938.

If the works of the Steel Company constitute the largest single steel producing unit in the British Empire and are serving as the largest single arsenal East of Suez in the present war, it is due to no small measure to the dynamic personality and leadership of Mr Ghandy, the first Indian to be General Manager of this Company.

A man of undoubted technical ability and varied human interests, Mr Ghandy is member of the Council of the Institute of Engineers and of the Mining and Geological Institute, India, a Fellow of the Institute of Fuel, Great Britain, and Chairman, Metals Committee of the Board of Scientific and Industrial Research.

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After passing B. A. Honours he was given a Dakshina Fellowship of the Bombay University and for three years was Assistant Professor of Botany in St. Xavier's College.

In 1921 he received the Mangaldas Nathubhai Technical Scholarship for study abroad. He worked under Professor Bateson at the Hohn Innes Horticultural Institute, London and then joined Physiological Institute of the Berlin University.

Dr Sabnis joined the Indian Agricultural Service in 1923 and interested himself in a programme of improvement of the different economic crops such as linseed, mustards, millets, sunnhemp, etc in the capacity of the Economic Botanist to Government of the United Provinces.

In 1930-31 Dr Sabnis was appointed Hemp Marketing Officer of the Imperial Council of Agricultural Research to conduct an All-India inquiry on the condition and marketing of sunnhemp in India.

R. C. RAY

President, Section of Chemistry

Born in 1890, Professor Ray received his school education at the Ranchi Zilla School and the Presidency College, Calcutta. He obtained the M.Sc. degree in Chemistry in 1911.



In 1912 he joined the Indian Institute of Science as a research worker under Dr. M. W. Travers, D.Sc., F.R.S. He carried out investigation on certain compounds of boron and got the Associateship of the Indian Institute of Science, and ten years later in recognition of his further work, he was appointed the first Fellow of the Indian Institute of Science.

Professor Ray was appointed a professor of chemistry in the Patna College in 1915. In 1920,

he went on study leave to England and worked in the laboratory of Professor F. G. Donnan, F.R.S. The result of his investigations on boron and silicon obtained for him the D.Sc. of the University of London. He also became a Fellow of the Institute of Chemistry.

In 1940, he became the Head of the Department of Chemistry in the Patna Science College and the Chemical Adviser to the Director of Industries, Bihar. Under the auspices of the Board of Scientific and Industrial Research, he is now conducting investigations on the utilization of waste mica in Bihar.

VISHWA NATH

President, Section of Zoology and Entomology

Dr Vishwa Nath was educated at the Government College, Lahore. After passing the M.Sc. Examination in Zoology in 1920, Dr Vishwa Nath joined the Mohendra College, Patiala, as Professor of Biology in 1920.



In 1923 he went to Trinity Hall, Cambridge, to conduct researches in Cytology and was awarded the Ph.D. degree in Zoology of the Cambridge University in 1925. On his return to Patiala, a special Chair, Bhupindra Research Professorship, was created by His Highness the late Maharaja of Patiala, and Dr Vishwa Nath was appointed to this Chair.

He joined the Government College, Lahore, in Provincial Educational Service as Lecturer in Zoology.

Dr Vishwa Nath was appointed Professor of Zoology at the Government College, Lahore on the retirement of Dr G. Matthai in November 1942. He is also the Director of the University Zoological Laboratories.

B. M. SEN

President, Section of Mathematics and Statistics

Mr B. M. Sen after his post-graduation went to Cambridge and secured first class in both parts of the Mathematical Tripos with mark of distinction in the special subjects and won Smiths Prize in 1924. On his return in 1915 he was appointed to the I.E.S. as professor of mathematics. He was Principal of Presidency College, Calcutta from 1931 to 1943. Mr Sen is a Fellow of the National Institute of Sciences of India.



K. V. KRISHNAN

President, Section of Medical and Veterinary Sciences

Dr K. V. Krishnan was born in 1896 and was educated in Madras. After taking the M.B.B.S. degree of the Madras University in 1919 he worked as bacteriologist in the King Institute of Preventive Medicine until 1926. During this period he was attached to the research section and published several papers on dysentery, malaria, kala-azar, relapsing fever and meningitis. From 1926 to 1929 with Rockefeller fellowship for post-graduate study



and specialisation in Microbiology he travelled to U. S. A., Great Britain and Europe. On his return to India in 1929 he was appointed Member of the

Kala-azar Commission and was associated with the work on the transmission problem of the disease. In 1934 he was appointed professor at the All-India Institute of Hygiene and Public Health where he interested himself in the study of protozoal immunity. He was elected a foundation fellow of the National Institute of Sciences and later in 1938 he was awarded the Minto Medal for medical research on his investigations on the aetiology and treatment of Black water fever. With the starting of the Blood Bank at the All-India Institute of Hygiene and Public Health he undertook investigations on the preparation and standardisation of various transfusion material including albumin and protein hydrolysates.

D. S. KOTHARI

President, Section of Physics

Professor Kothari received his early education at Udaipur (Rajputana) and Indore, and then went to Allahabad where he was a student of Professor M. N. Saha. From Professor Saha he imbibed his interest in theoretical physics and astrophysics. Later on he went to Cambridge on being awarded the Allahabad University foreign scholarship and worked at the Cavendish Laboratory under the late Lord Rutherford and Professor R. H. Fowler. On his return from Cambridge in 1933, he first went to Allahabad. A year later, he was appointed a Reader in the University of Delhi and last year Professor in the same University.

Professor Kothari has published several papers on quantum statistics, properties of degenerate matter, internal constitution of the stars, energy generation and related objects. In his earlier papers he determined the electrical and thermal conductivities of dense matter and showed that in degenerate matter the transport of energy is mostly by conduction and not by radiation. He also discussed the



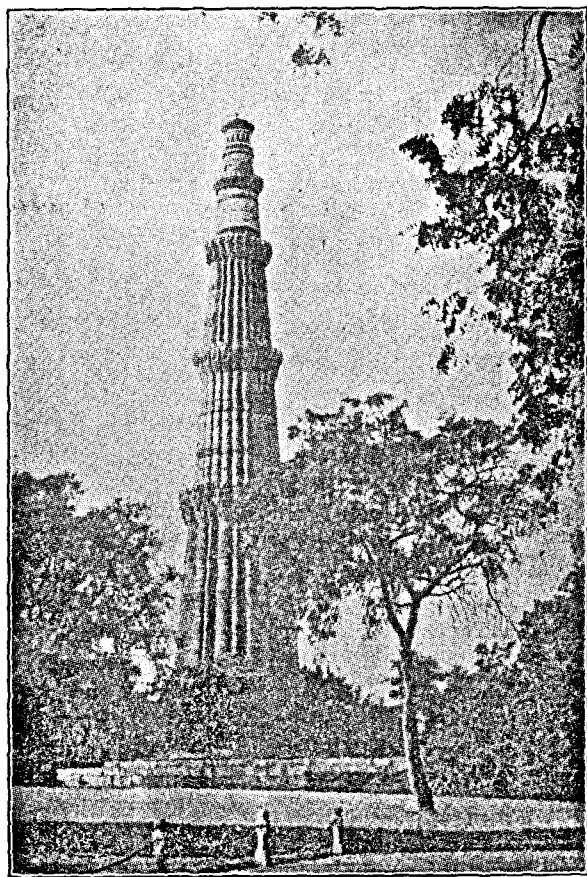
and Allauddin Khalji (1295-1315) contributed to its extension. Quwwat-ul-Islam is now in complete ruins but parts of the lofty arches still remain as a testimony to its vanished grandeur. Within the holy precincts sleep Iltutmish and Allauddin, two of the greatest leaders that Muslim India ever produced, and not far off from the mosque stands the tomb of another Sultan, Ghyasuddin Balban (1260-1285), great alike in peace and war. The walls of Iltutmish's tomb are sumptuously sculptured but the dome they once sustained is gone. A similar fate has overtaken Allauddin's madrasa and his tomb but the superb domed gateway that the Khalji monarch built still survives. It is most elaborately ornamented and its horse shoe arches offered marked contrast to the pointed arch of the main cathedral. The Alai Darwaja can be seen to the greatest advantage in the light of the morning sun. Outside Allauddin's gate, not ten yards from it, is a lovely little tomb which Imam Zamin, a contemporary of Sultan Sikandar Lodi (1489-1517), built for himself. Near the Alai Darwaja, to its north stands in its solitary grandeur the lofty minar that goes by the name of Qutb.

THE QUTB-MINAR

Two hundred thirty eight feet in height, the minar is divided into five storeys. Its history is to be found in its inscriptions. According to Sir Syed Ahmed, one inscription runs as follows: "Amir of Amirs, Commander in Chief, the Chief in the State, Qutb". Two inscriptions refer to Muhammad bin Sami. Two other epigraphs assert that the building was commenced and completed by Iltutmish's order. Yet other two refer to the repair and restoration of the minar by Firuz Shah bin Rajb and Sikandar Shah Lodi (1489-1517). There is reason to believe that the two top most storeys were entirely rebuilt by the Tughluq ruler as they differ in style as well as material from the rest of the tower. If General Cunningham's reading of the *nagri* inscriptions is accepted, Firuz Shah had employed a Hindu architect in repairing the minar when it was damaged by lightning in 1378 A.D. Firuz Shah had furnished the minar with a cupola which was in existence till 1794. In 1803 Major Percy Smith built another superstructure which appeared so grotesque that Lord Hardinge ordered its removal in 1848. It is now to be seen in the lawn near the Dak Bungalow. Such in short is the story of the tower which Fergusson judged to be "the most beautiful example of its class known to exist anywhere."

Was it a tower of victory? Or was it an adjunct of the neighbouring mosque, a *ma'zina* wherefrom the *mu'azzin* used to summon the faithful to prayer at specified hours? Probably it served both purposes. A tower built so near the mosque, copiously

embellished with Quranic texts, could not but share the sacred character of the neighbouring edifice, but its very height rendered the upper storeys super-



QUTB MINAR, DELHI.

fluous for the *Mu'azzin's* purpose, though they served very well to illustrate and emphasise the superior might of the power against which Rajput daring and chivalry had proved of no avail.

Who gave this unique tower its name, Qutb, the King, or Qutb the saint? If the King's name finds a place in one of the inscriptions, the saint was the preceptor of the Sultan under whom the minar was completed. In popular estimation probably the saint was a greater personage than the soldier, for he was believed to have been endowed with supernatural power. Qutb-uddin Bakhtiyar Kaki came from Ush in Central Asia. He was a disciple and the apostolic successor of Sheikh Muinuddin Chisti. The shrine of Qutb Sahib has afforded two of the *roi faineants* of Delhi, Shah Alam II (1761-1803) and Akbar II (1803-1837), their last resting place. A third would fain sleep here but fate decided otherwise. Bahadur Shah II, the last titular Timurid emperor of Delhi

died an exile at Rangoon (1857). It will be wrong to suppose that only puppet kings sought the protection of so potent a saint. The first Shah Alam (1707-1712) lies buried in Qutb Sahib's *dargah* and the privilege is shared by famous historians, physicians and other notables of Delhi. Strangely enough Zabita Khan, the Rohilla Chief of Shaharanpur, and if local tradition is believed, his infamous son, Ghulam Qadir, from whom the proud house of Timur suffered the greatest wrong, also lie in close neighbourhood of their royal victims in the same compound. Sultana Raziya (1236-1239), the only lady who occupied the throne of Delhi, however, found no place either near her father in the Quwwat-ul-Islam compound or in the shrine of Qutb Sahib. Her unassuming tomb is to be found in an obscure lane near Turkman gate.

THE KHALJI-DELHI—SIRI

Old Delhi lost some of its importance with the death of Balban in 1287. His worthless grandson transferred his head-quarters to Kilokheri, near modern Okhla, which became the new city for the time being. Kaiqubad either built a new palace there or renovated an old castle that was in existence before his grandfather's reign. It was from here that he was kicked into the river and out of existence by the partisans of Jalal-uddin Khalji (1290-1295) who continued to live at Kilokheri, though the honour of the ceremonial capital still belonged to Quila Rai Pithora. No vestige of the Kilokheri palace has been preserved. Alauddin Khalji (1296-1316) built a new capital for himself at Siri. His palace of thousand pillars, which witnessed so many pageants and tragedies, has completely gone to ruins. The Mughal menace had assumed serious proportions when this palace was built and beneath the foundation were buried thousands of Mughal heads. It was here that Allauddin's general Malik Kafur displayed the rich booty that he brought from the south and it was here again that the great general met his end. On the terrace of this palace was Allauddin's son Mubarak Shah (1315-1319) unceremoniously murdered by his lowborn favourite and for a brief spell the throne of the Khaljis passed to a Hindu outcaste who assumed the title of Khusru. Happily the palace of thousand pillars was not the only work on which Allauddin's fame as a builder rests. Reference has already been made to the superb domed gateway of the Quwwat-ul-Islam that bears his name. He had started building another minar opposite Qutb's that would outdo its predecessor in height and grace, but he did not live to finish the column and it stands to-day a living testimony to the futility of mortal efforts. At the western extremity of the new town Allauddin built a magnificent

tank over an area of 70 acres. It was extensively repaired by Sultan Firuz. Timur (1398) encamped on the bank of Allauddin's tank after his victory over the Delhi troops. The reservoir had at the time enough water to meet the needs of the people of the city. It presents to-day a sorry sight. The tank has entirely gone dry though the stone steps built by Firuz Shah are still intact. The piety of that monarch built a madrasa here which is now in disuse. The good King was buried near this College and his tomb is in a fair state of preservation.

TUGHLAKABAD

Ghyasuddin Tughluq (1320-1325) went south in search of a suitable site for his capital. Of the fortress city of Tughlakabad, nothing remains but the bastioned walls and some underground chambers. The lofty gateways and the triple storeyed towers still look impressive and the only monument from which some idea of the new architectural style can be formed is the Mausoleum of the Sultan built on an island-like mound and connected with the fort by a long causeway. Ghyasuddin's tomb is worthy of a hardy soldier. Extremely severe in outline and sparing in decoration it offers a remarkable contrast to the profusely ornamented gateway of Allauddin and the tomb of Iltutmish. The sloping walls offer a sense of strength and support to a marble dome massive yet well proportioned. Does the tomb reflect the reaction against the profligacy and pomp of the preceding period? According to the prevailing tradition, Ghyasuddin shares the tomb with his wife and eccentric son, Muhammad (1325-1351). How far this tradition is true we do not know. Muhammad died in far off Sindh and the army was in a state of rebellion. It is more likely that a younger son who shared his father's doom was also interred with him.

Muhammad transferred his capital to Adilabad on the hills opposite. The ramparts were of the same style as those of his father's city. But Adilabad was abandoned for old Delhi again. Siri and the older city was enclosed within a protecting wall and Muhammad built another palace of thousand pillars in the enlarged capital which he styled as Jahanpannah or asylum of the world. The tower of Bijai Mandal and the Satpalah bund are the most notable remains of Jahanpannah. Muhammad's palace of thousand pillars was still extant at the time of Timur's invasion and its fame aroused the curiosity of some ladies of his seraglio.

FIRUZABAD

Muhammad's cousin and successor Firuz (1351-1388) was a milder man but he could not rise above

the all too common temptation of founding a fresh city. Somewhat of an archaeologist, he repaired and renovated some of the older monuments of Delhi but the urgent need of building materials led him to deeds of vandalism which to his own cost were readily emulated by others. As Hindu and Jain temples yielded materials for Qutb-uddin's mosque so the ruins of Siri and Jahanpannah were despoiled to find stones and bricks for Firuz Shah's capital. The pack animals of the local traders were requisitioned for a day and bricks were brought from the old city to the banks of the river. Firuzabad was a fairly big town and stretched from the river to Allauddin's tank and from the Kushak-i-Shikar on the ridge to the traditional site of the Pandava city. It included a large part of the later town of Shahjahanabad. Within the battlemented enclosure of the fortress Firuz built many palaces and public buildings. Not a trace however remains of his palace of grapes, the palace of the wooden gallery and the palace of the public court which, in all likelihood, corresponded with the hall of public audience of the Mughal days. The ruins of the cathedral mosque that extorted unstinted admiration from Timur can be seen opposite the pyramid that bears the Asokan pillar. Alas it cannot be described even as a shadow of its departed grandeur. Every old castle has its traditional secret passages and Firuz's Kotla is credited with no less than three, wide enough to allow his ladies to ride in palanquins. One led straight to the river, the second connected the palace with the hunting box on the ridge and the third and the longest went towards Quilah Rai Pithora. A deep hollow on the ridge is popularly believed to be the exit of the second of these tunnels but its mysteries are yet unsolved.

Firuz's minister the second Khan Jahan was also a great builder. He has three notable mosques to his credit. The Kalan Masjid near Turkman gate, the Khirki Masjid and the Begampuri mosque illustrate well the architectural style of the later Tughluqs. The sloping pillasters lend the buildings an Egyptian air and the arches are without any keystone. The Mausoleum which the minister built for his father (the first Khan-i-Jahan) to the south of Sheikh Nizam-uddin Aulia's shrine supplied the model for the Sayyid and Lodi tombs.

From Firuz Kotla we may turn due south to Ghiyaspur where the *Dargah* of Hajrat Nizam-uddin still attracts thousands of devotees every year. He commands the veneration of Hindus and Muslims alike. We have already referred to Qutb and Main-uddin Chisti. Nizam-uddin was third in apostolic order from Mainuddin and the second Chisti saint to lend sanctity to a suburb of Delhi. He came from the city of Badaun as a humble student to Delhi and

refused to be tempted by the wealth and honour that the Sultanate, then at the height of its power, had to offer. His immediate apostolic predecessor was Sheikh Farid-uddin whose association converted Ajodhan into Pak Patan. Farid-uddin wrought many miracles and the admirers of Nizam-uddin credited him also with similar power. The shrine contains a cistern, the saint's tomb and the superb mosque, attributed to Khizr Khan, eldest son of Allauddin Khalji. Of the distinguished personages who sought their last resting place in this shrine, are Amir Khusru, the parrot of Hind who wrote verses in Hindi, Persian and Arabic, the gentle princess Jehanara, daughter of emperor Shah Jehan who shared the misfortunes of her father and the Emperor Muhammad Shah (1719-1748) who probably expected to be forgiven for all his lapses in this world through the intercession of the saint in the next. Near the shrine of Nizam-uddin stand two mausoleums of a later day. Shams-uddin Muhammad, Akbar's foster father was done to death by Adham Khan, a spoilt son of another of the emperor's foster parents. Akbar, then in the prime of youth, stunned the murderer with a single blow of his fist and hurled him down a precipice. Adham Khan was interred on the outskirts of Rai Pithora's city and his tomb is still to be seen there. His victim was buried in a pretty tomb specially built for the purpose by his son Mirza Aziz Kukaltash who himself sleeps in the Chausat Khambah near by.

The Sayyids (1414-1450) who followed the Tughlaks were shadow Kings. The first of the line preferred to rule as an agent of Timur rather than in his own rights but even he indulged in the vain luxury of a new capital. Khizrabad has gone the way of Kilokheri and not a brick of Khizr Khan's palace is to be found. His son gave his name to Mubarikabad, another city of fleeting fortune where the founder was entombed. The third King of this dynasty was buried in the village of Khairpur.

Of Lodi monuments (1450-1526) only two deserve special mention. Bahlol (1450-1489) the founder of the family, probably ruled at Siri. His son Sikandar (1489-1517) transferred his capital to Agra and Delhi suffered a temporary eclipse. But the honour of receiving the mighty Sultan after his death was not denied to the traditional seat of Muslim power. The tomb of Sikandar Lodi looks like a fortress, a worthy resting place for so brave a warrior. The battlemented enclosure gives the place a martial air which was quite in keeping with the departed monarch's taste. By a clever device the outer pillars are given a sloping effect so characteristic of this period and copious use is made of enamelled tiles of many hues both for inner and outer decoration. Sikandar's minister built the beautiful Moth ki Masjid and thereby hangs a tale.

PURAN QUILAH

Babur (1526-1530), the founder of the dynasty of Great Mughals died in India but his mortal remains were carried to the milder climes of Kabul. His son Humayun (1530-1540, 1555-1556) was chased out of the country by his Pathan rival Sher Shah. Under Sher (1540-1545) and Humayun after him, Indra-prastha once more came to its own. The Purana Qila where they held their court is within the bounds of New Delhi of to-day. As Firuz despoiled the older cities of Siri and Jahanpannah, Sher obtained his building materials from the ruins of Firuzabad. One emperor pulled down the city of another without any compunction and many ancient monuments were thus lost to posterity. Popular opinion attributes the enclosing walls of the fort to Humayun and the buildings inside to his rival. If so, Akbar must have inherited his predilection for indigenous art from his father, for in the gateways of the old fort we find a happy synthesis of Hindu and Muslim styles. The pointed arch happily combines with Rajput Chhatris. Hindu pavillions are supported by Hindu brackets and the northern gate better known as Tallaqui Darwaja has among its decorations a rude representation of the solar orb and two panels depicting a man engaged in a mortal combat with a lion in half relief. Over the northern gate we find similar panels with elephants instead. The palaces inside the fort are gone and it is not possible to reconstruct the old plan until archaeology comes to the aid of history. Only two notable buildings have been preserved, the Quila Kona Masjid which may rightly be regarded as the forerunner of a new style and Sher Mandal on the steep stairs of which Humayun missed his step and tumbled out of the world. Visitors may be interested in a well in the compound of the mosque which testifies to the munificence of Amir Habibullah of Afghanistan (died 1919). Opposite the main or western gate of the fort and not far from it is Khair-ul-Manzil. It is a combined mosque and college built by Akbar's foster mother Maham Anaga. Like the Quila Kona Masjid it has a single dome. There is reason to believe that the Khair-ul-Manzil was meant exclusively for women and girls were admitted to the attached school.

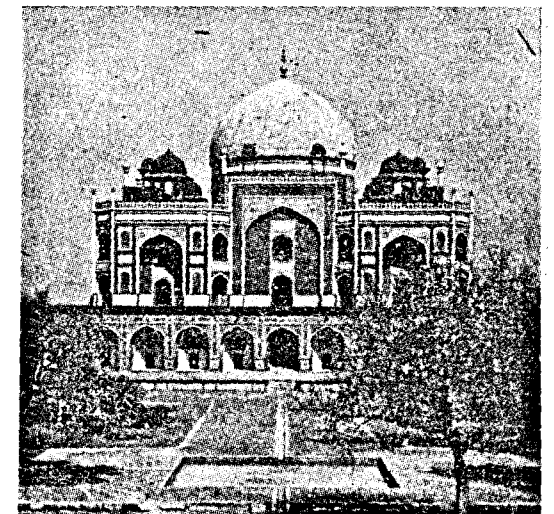
THE EARLY MUGHAL DELHI—DIN PANHA

Humayun's Delhi or Din Panha probably extended as far south as his own cemetery which furnishes a fairly good example of Mughal garden tomb. The Mughals delighted in terraced gardens with plenty of running water and fountains playing at intervals. They would provide for a cascade or a wide sheet or *chadar* of water if circumstances so permitted. The ground surrounding Humayun's tomb still retains the narrow courses through which water

ran and several terraces can still be traced. Unfortunately most of the Mughal gardens have suffered from neglect and interference from people with a different taste. The Shalimar has gone wild but some idea of what a Mughal garden was like can be formed from what remains of Rausheinara garden near Sabji Mandi, the Talkatora garden at the foot of the ridge behind the Viceregal estates and the Quasiya garden outside the Kashmir gate. The Mughal garden in the Viceroy's palace however offers a better illustration than any of its prototypes. Besides the garden with its fountains and running streams the tomb had for its complement a Madrasa and a mosque. The upper storeys of Humayun's tomb were designed to serve as a Madrasa. Ghaziuddin's tomb near the Ajmer gate still houses an educational institution, the Anglo Arabic College. Although none of the most illustrious emperors of the house of Timur was interred here Humayun's mausoleum may be regarded as the imperial cemetery par excellence and more than one hundred members of the imperial family were buried in its vaults. It was in Humayun's tomb that the last titular emperor Bahadur Shah had sought refuge after the mad orgies of the mutiny were over. Verily this mausoleum is a mute witness of the rise, decline and fall of the Timurid power in India.

HUMAYUN'S MAUSOLEUM—A NEW SYNTHESIS

Humayun's mausoleum marks the beginning of a new era in the history of Indian architecture. It was built by his widow Haji Begam who had shared his exile in Persia. The architect drew his inspira-



MAUSOLEUM OF HUMAYUN, DELHI.

tion from that country but had to adjust his design to the materials locally available and allowance had

to be made for the taste and habits of his workmen. The materials were not new. Ghyasuddin Tughluq's tomb is built of marble and redstone, his nephew Firuz had used marble and sandstone in rebuilding the fourth and fifth storeys of Qutb Minar, the same combination was successfully utilised in Sher Shah's Quila Kona mosque. White marble and sandstone were used with marvellous effect in the new mausoleum. It is situated in a pleasant enclosed park of a fair dimension. The enclosure is pierced by four lofty gateways wide enough to admit a full view of the building inside from a distance. The main entrance is approached by another gateway and the space between is planted with green shady trees. The mausoleum has a simple dignity all its own. As a work of architecture it can rightly claim a superiority in some respects over the more famous Taj. The architect has successfully avoided the conventional severity of the later Pathans and the over ornamentation of the voluptuous Khaljis while courageously refusing to yield to the romantic sensuousness which mark Mughal works of a later age. The marble dome combines strength and solemnity and compares favourably with the bulbous superstructure below which rests Shah Jahan's queen. Nor is it defaced by harsh black ribs which disfigure the dome of the Jami Masjid. Indian workmen have left their indubitable mark on Humayun's tomb, though it is not perceptible from below. Around the dome they built four small rooms, airy and well-lighted with pillars and corbelled arches so characteristic of the country. From the roof of Humayun's tomb can be obtained a panoramic view of Delhi, old and new, on a clear sunlit winter morning when the sky is blue and the atmosphere is dust free. On one side the lofty minar towers above the green outlines of the hamlets below, the cyclopean ramparts of the forsaken city of Tughluq Shah frown gloomy and forbidding and the marble dome of Ghyasuddin's tomb shines bright and dazzling, on the other side spread the two cities of Delhi and the war memorial and the Viceregal lodge can be clearly seen with the old fort, Firuz's Kotla and the tapering minarets of the Jami Masjid beckoning the weary wayfarer.

From the terrace of the mausoleum is seen, outside the enclosure, the blue dome of another tomb, the barber's as it is commonly believed. Most probably Fahim Khan, the faithful friend of Khan-i-Khanan Abdur Rahim Khan, lies buried here. The dome must have once looked very lovely in its beautiful encasing of blue enamelled tiles. Abdur Rahim's own tomb, not far off, has unfortunately been shorn of all its ornaments. Irreverent hands removed all the marbles and only the naked core of the building remains. Yet Abdur Rahim deserved better of his country and country men. Son of Bairam Khan and

a trusted minister of Akbar, he represented all that was best in Muslim and Hindu cultures. A good general and able administrator he devoted his scanty leisure to the cultivation of arts and his Hindi devotional verses have been universally admired. No Hindi anthology will be complete without some hymn from Rahim's *Satsai*. He knew how to reconcile the catholicity of the country of his birth, with the rigid demands of the faith to which he was born. The last notable garden mausoleum of Delhi is that of Safdar Jang, founder of the Oudh family but even a casual visitor will perceive that the style is conventional and decadent.

Outside the main enclosure of Humayun's mausoleum once stood a spacious hotel called Arab Serai. It is now in complete ruins but Isa Khan's tomb, which stands next, has happily escaped this fate. It is a typical Pathan mausoleum of the later days where the pseudo sloping pillars at the angles of the octagonal plinth conform to the common style. Yellow, green and blue enamelled tiles were used with good effect in the mosque confronting the tomb.

SHAH JAHAN'S DELHI—SHAHJAHANABAD

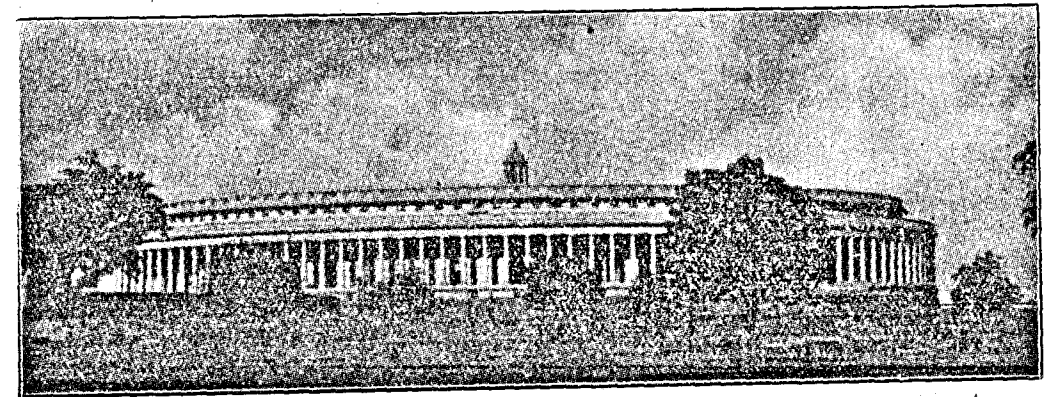
Akbar (1556-1605) left Delhi for Sikri and Agra. His son (1605-1627) passed through the old capital on his way to Kashmir. It was left for Shah Jahan (1627-1658) to restore to the old capital its lost prestige and past pre-eminence. Din Panha was associated with Humayun's misfortunes and Shah Jahan decided to build a new city and fortress palace that would excel those of Agra in grace and elegance. While his grandfather built in red sandstone Shah Jahan built in costly marble, but at Delhi the red stone was once again permitted to play its part. The lofty ramparts, the tall gateways, the music hall (Nakar Khana) and the spacious hall of public audience are in red stone. The principal palaces and the exquisite pearl mosque were built of nobler materials. Shah Jahan himself planned the fort and divided the space into regular squares and rectangles. Inside the fort were office buildings, cantonment markets and residences of the palace officials besides the palaces where the Emperor and his family lived. But a palace could not be considered complete without its complement of gardens, fountains and water courses. Two lovely gardens, the Mahtab (moon) and the Hyat Baksh (life giving) embellished the open space and streams of water flowed not only through the gardens but through the very halls of the palace. A constant supply of water was for this purpose obtained from the Jumna by the ingenuity of Ali Mardan Khan, perhaps the greatest irrigation engineer of his time. His stream of paradise (Nahr-i-Bihist) came over a scalloped marble cascade in the open arcade by the Shah Burj and fed

the tanks and fountains and rippled over the marble flowers and foliages in their shallow bed in the Rang Mahal creating an illusion to which none but a poet can do justice. To revive the glory that Lal Quila once was, the visitor will have to call his imagination to service. Man and time have caused havoc here. One of the gardens is completely gone, the female quarters have been entirely demolished and ugly barracks have raised their monstrous heads. Modern utilitarian buildings offer but an incongruous setting for the poetry that Shah Jahan wrought in stone. Yet some idea can be formed of his work from what remains of it. The Lahore gate almost faces the cathedral mosque opposite and leads through a vaulted passage flanked with shops and stalls to the Nakar Khana where music used to be played in the palmiest days of Mughal glory. Beyond the Nakar Khana is an open space where the nobles used to crowd under a rich canopy on their way to the pillared hall of public audience. Gone are the carpets, the awnings, the gold and silver railings that added

previous stones with which the marble pillars were exquisitely inlaid. After their cupidity was satiated came others who removed marble baths and other objects of art across the sea. In the days of Akbar II the stately Dewan-i-Am became a common lumber room.

The Jami Masjid need not keep us long. Its open courtyard can accommodate twenty thousand worshippers at a time and its twin minarets lend grace and lightness which the ribbed dome might minimise.

The Chandni Chawk is not to-day what it was in the early days of Shahjahanabad. A wide avenue ran from the Lahore gate of the fort to where the Fatehpuri Begam's mosque now stands and along it used to flow a pleasing *nahr* (water-course). The trees and running water gave the market place of the imperial city a rare attraction. We can imagine noble warriors riding along the avenue and the feudatory chiefs



COUNCIL CHAMBER, NEW DELHI.

to the grace of this far famed hall. But the richly carved and inlaid marble platform where the Emperor sat high above his subjects is still there. Here one can see some specimens of Italian pietra dura work and a small piece depicting Orpheus fiddling to wild animals is attributed to Austin de Bordeaux. The hall of private audience with its well-known legend in Persian is still extant and so are the hamam, the Tasbih Khana, Rang Mahal, Khwabghah and the Pearl Mosque which served as the Emperor's personal chapel and two small pavilions named after two months of the rainy season Sawan and Bhadon below which running water with artificial illumination caused an illusion of the monsoon. Three of the principal Burjs and all the gateways have been preserved but everything else is gone. The Persian, the Afghan, the Maratha and the Jat all in the dire days of the Mughal downfall despoiled the palaces of their gold and silver ceilings and the

passing by on gigantic elephants, while veiled ladies in covered palanquins, with richly liveried attendants running by, added mystery to the busy market place. Chandni Chawk has also its own history and shared the misfortune of the palace fort. It witnessed the ghastly procession in which the unfortunate Prince Dara's head was carried. It was from the terrace of the Sonheri Mosque, opposite the fountain, that the infuriated Persian invader Nadir Shah (1737) ordered a general massacre of the Delhi citizens and blood flowed like water through the wide thoroughfares of Chandni Chawk and Dariba. At a later date a remarkable lady whom history knows as Samaru's Begam lived in one of the buildings of this quarter.

The brick wall that Shah Jahan built round his city is no longer in existence. The present bastioned wall was built by Sir David Ochterlony in 1803. Originally the enclosing wall had fourteen gates and

fourteen wickets. Now only seven gates are known, though some of them have been demolished.

The most important late Rajput relic is outside the city walls. Almost opposite the New Delhi Municipal Hall are some stout masonry works popularly known as Jantar Mantar. This is one of the Observatories that Jai Singh II, the astronomer King of Jaipur, (1727-1746) built under orders of Emperor Muhammad Shah at Benares, Ajmer, Jaipur and Delhi. He was quite familiar with the work of western scientists and had some of the Latin textbooks on the subject translated into Persian and got the Arabic version of Ptolemy's *Almagest* translated into Sanskrit under the name *Siddhanta Samrat*. The observatories were built on the plan of Ulugh Beg's Observatory at Samarkand. The Marathas once held Delhi under their sway but only two buildings bear testimony to their connection with the city. The present Nili Chhatra temple near Nigambodhi Ghat is a Maratha work and the Hindu Rao hospital bears the name of a Maratha noble.

During the Mutiny Delhi suddenly sprang into a transitory importance. The city walls near the Kashmir gate still bears the scars of those dismal days and not far from the wall are interred the mortal remain of Nicholson, one of the Mutiny generals.

No account of Delhi will be complete without a reference to another early nineteenth century character, Col. Skinner, who gave his name to an intrepid body of irregular horse. Field Marshall Birdwood calls Skinner an Englishman, but Emily Eden found him too swarthy of complexion. Skinner was a Eurasian in the true sense of the term. His father had married a Rajput girl and the son in his turn took a Muslim spouse. He began his career in Sindhia's army and unlike many of his Christian colleagues refused to fight against his former master, though he resigned

his commission when the second Maratha War broke out. Skinner however rendered distinguished services to the new paramount power and his merit did not pass unrecognised. In the days of his prosperity he paid an equal homage to the religions of his father, mother and wife by building a church, a temple and a mosque. The Hindu College is at present housed in Skinner's Delhi residence and he lies buried with his friend Theophilus Metcalfe in the church he built (St. James's Church).

From the early Muslim days there have been two Delhis, new and old. Kilokheri, Siri, Tughlakabad, Firuzabad and Din Panha each in its turn claimed and lost the distinction of the new town. Shah Jahan's city has to-day attained the dignity of Purana Shahar, while over the ruins of the old town of his time has been built the present capital of the Indian Empire (Raisina). The new city was to be built in conformity with the past practice north of the old city, but Nature intervened and anopheles disposed of what man proposed. Another site was found for the new metropolis but the old Viceregal Lodge was not doomed to share the evil fate of the palaces of thousand pillars. When the capital moved south a new seat of learning, the University of Delhi, started its career in the former Viceregal Lodge. While in New Delhi, the city of officials and politicians, the political life of the races of India is slowly evolving to a new synthesis, the new Temple of Learning is busy creating a new generation, composed of all elements of India, for the service of the Motherland. After a period of stagnation, thanks to the initiative of the present Vice-Chancellor the University area is growing to the dimensions of a city of learning and let us hope that in the days to come, it will attain the position and fame of some of the most renowned seats of learning in India and abroad.

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BEQUEST OF PAVLOV TO THE ACADEMIC YOUTH OF HIS COUNTRY*

WHAT can I wish to the youth of my country who devote themselves to science?

Firstly, gradualness. About this most important condition of fruitful scientific work I never can speak without emotion. Gradualness, gradualness and gradualness. From the every beginning of your work, school yourselves to severe gradualness in the accumulation of knowledge.

Learn the ABC of science before you try to ascend to its summit. Never begin the subsequent without mastering the preceding. Never attempt to screen an insufficiency of knowledge even by the most audacious surmise and hypothesis. Howsoever this soap-bubble will rejoice your eyes by its play it inevitably will burst and you will have nothing except shame.

School yourselves to demureness and patience. Learn to inure yourselves to drudgery in science. Learn, compare, collect the facts!

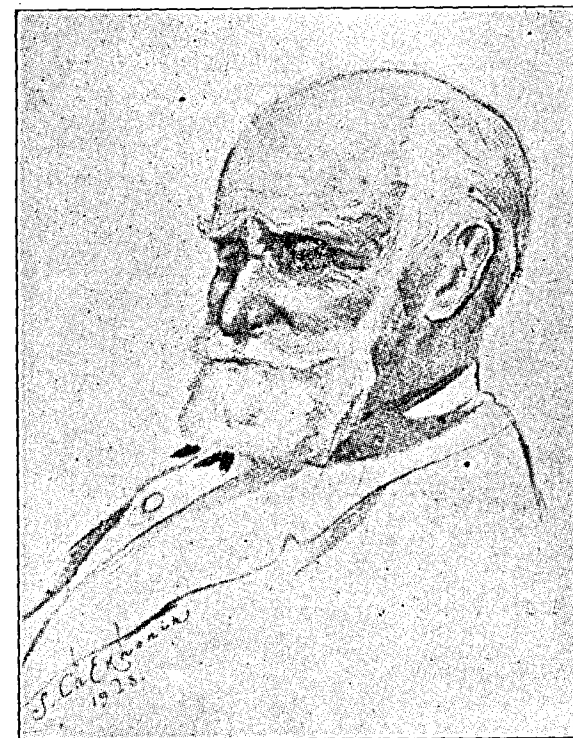
Perfect as is the wing of a bird, it never could raise the bird up without resting on air. Facts are the air of a scientist. Without them you never can fly. Without them your "theories" are vain efforts.

But learning, experimenting, observing, try not to stay on the surface of the facts. Do not become the archivists of facts. Try to penetrate to the secret of their occurrence, persistently search for the laws which govern them.

Secondly, modesty. Never think that you already know all. However highly you are appraised, always have the courage to say of yourself—I am ignorant.

Do not allow haughtiness to take you in possession. Due to that you will be obstinate where it is necessary to agree, you will refuse useful advice and friendly help, you will lose the standard of objectiveness.

Thirdly, passion. Remember that science demands from a man all his life. If you had two lives that would be not enough for you. Be passionate in your work and your searchings.



IVAN PETROVITCH PAVLOV

[* We are thankful to Prof. A. V. Hill for communicating to us the above "Bequest" of the great Russian Physiologist Prof. I. P. Pavlov (died 1936) to the young scientists of his country. We feel that the "Bequest" is for all humanity. —Ed., Sc. & Cul.]

PROF. HILL ON PRINCIPLES OF ORGANISATION OF SCIENTIFIC RESEARCH

PROF. A. V. HILL, Secretary of the Royal Society of London, has been in this country for some time, having been invited by the Government of India to advise them about the organisation of scientific research in India. At the invitation of the Indian Science Congress he was kind enough to deliver on the 5th January, 1944 before a crowded gathering of scientists at Delhi an address on the scientific organisation, official and unofficial, in the United Kingdom. Through the courtesy of Prof. Hill and the authorities of the Indian Science Congress, we have been enabled to reproduce this lecture in full in the current issue of the journal. Coming from a great scientist and a great investigator and one who has been Secretary of the Royal Society of London for several years and has been in intimate contact with every scientific institution and organisation in his country, his lecture is full of information which are very badly needed in this country at the present moment to clarify our own ideas on these points. His opinions, which are the result of years' of experience, are therefore entitled to the most serious consideration by officials and non-officials alike in this country. Let us therefore examine the principles as enunciated in detail and compare them with the conditions in this country.

There will be no difference of opinion about the part science is destined to play in the development of this country during the post-war period provided a scheme of development is decided on, hence it is extremely necessary that scientific research is properly organised. Prof. Hill's lecture therefore comes at an opportune moment.

Prof. Hill maintains that progress of science and of its application to public welfare depends upon four M's

MEN, MATERIAL, MONEY, MACHINERY OF ORGANISATION

He confined his remarks to the last item possibly because men and money are available in plenty in the United Kingdom. But is that the case in this country? The source of supply of men who are capable of doing scientific work are the universities, technical institutes, and institutions of university rank and other research organisations. Not every one of these can supply the proper personnel but only such as have organised Research Schools in pure and applied sciences and have taken steps to maintain them on proper scale. Prof. Hill did not say how men are trained and secured for this purpose in his own country, possibly because that phase of struggle is

already over there. But can that be said of this country? Before 1916, the Calcutta University, and before 1921, most other universities of India had not recognised establishment and maintenance of research schools as one of their obligations. It is true that after the reforms of 1921, most universities have tried to organise schools of research, but what has been the experience of Indian men of science as research workers and directors of scientific research? Most of the prominent research workers are without proper laboratories, grants and other amenities which alone can enable them to develop the lines of activity in which they have specialized. In England and elsewhere in the world, research schools have been methodically fostered by the award of sumptuous grants by the State and private organisations to professors who have developed distinct lines of activities of their own and ample provision has been made for those who receive training under them in the form of employment in the research institutions and scientific services which have sprung up since the last war. But all prominent Indian scientists who have tried to develop schools of their own have a painful experience. It is not because that there has been a lack of young aspirants after scientific distinction. The Indian youth has been always attracted by the glamour of research, for knowledge and learning has always been highly prized in this country, but it has been often his experience that after he has spent a number of years on some problem, made substantial contribution to its solution and got his doctorate on the subject, he has found it extremely difficult to get any suitable employment and is forced to take up a post where he cannot do any scientific work or develop his ideas. The preparation stage for doctorate is usually one of training in methods of scientific investigation and hardly enables a scholar to find out the problem in which his future life work will lie: further no problem, even if found, delivers its secret unless one is long at it. The research workers in this country have not infrequently to give up his work at the most productive part of his life owing to absence of any long term research fellowships. Further so many research workers have remained unemployed or without suitable employment for years that for some years past youngmen with brilliant university careers prefer to seek other lines where prospects of earlier and more remunerative employment exist. We cannot afford to ignore this partial drying up of the source of supply of trained personnel for scientific work, this can only be stopped by opening more avenues for the employment of the trained re-

search worker and by the creation of long term fellowships under distinguished professors.

The next M is money. We need hardly make any comment on the insufficiency of monetary grant for research in this country. The universities have got limited budgets and every professor keen on developing his line of research has to wage constant war with the university authorities or be satisfied with the Nirvana of his career, as many prefer to do, as a research worker. Only a small percentage survive the struggle. No grants are forthcoming from any central organisation for research as in the United Kingdom, except for applied sciences to a limited extent nor are there any such large scientific foundations like the Rockefeller and Carnegie in the U. S. A. or the Nuffield Trust in the United Kingdom. No Indian university to our knowledge has yet been able to establish long term Fellowships which are needed to bring out the best in a trained worker. The Government grant on all headings would not amount to more than 50 lakhs and much of it is spent on administration. There should be a sumptuous grant from the Central exchequer to the Universities for research under the heading Universities Research Grant, and this should be administered by a body of scholars as in the United Kingdom.

The third and fourth M's are material and machinery of organisation. Probably by material, Prof. Hill means places of research and their equipment. It is known to everyone that the existing material is extremely poor and in spite of years of agitation, the various national laboratories vital for public welfare and development of national resources have not seen the light of the day.

Machinery of Organisation.—Prof. Hill maintains that good Government depends on a proper balance and reaction between individual enterprise and initiative on the one part, and State enterprise and control on the other, and this is as true of science as of any other field. He has explained how this is secured in England, and the method has become almost standardised. Let us see what the method is. It will be obvious from a perusal of Prof. Hill's lecture that since the last war, all countries follow almost the same principles in spite of the apparent discrepancies in designation. In every country a body of elder scientists like the Royal Society of London in England or the National Academy of Sciences, Washington U. S. A. or the Academy of Sciences in U. S. S. R. is entrusted with the task of coordinating the work of independent scientific organisations on the one hand, and Government organisations on the other hand; is given certain statutory powers by the Government and is consulted on all matters of policy regarding science and its application.

This body of elder scientists is at the apex of the pyramid of scientific societies devoted to particular subjects, and other learned bodies, and form the channel of communication between the Government, and the general body of scientists represented by these societies and learned bodies. Where such a body of elder scientists had not previously existed, as in the case of U. S. A., or Japan, it has been brought into existence by the order of the highest dignitary of the State and endowed with the requisite powers (e.g. the National Academy of Sciences, Washington, or the Imperial Academy of Sciences, Japan).

In India, within the last twenty five years, a large number of scientific societies and academies, had been formed, and have been functioning. In their formation, and management official and non-official elements have freely participated in a spirit of true comradeship, and loyalty to the subject. But such splendid organisations have not yet been utilized by the Government in any of its enterprises so far, and the machinery of organisation so far set up completely violates Hill's principle No. 1. A few scientists are sometimes called to Government committees or councils for advice, but such actions are always taken on the personal initiative of the H. M's or their secretaries.

Secondly, though for administrative and historical reasons some of the Government research institutions may be under different responsible Ministers, the tendency in England has been that research which applies to more than one department is organised outside any department and centrally, directly under an important Minister because as Prof. Hill remarks inter-departmental boundaries are almost as impenetrable in England as elsewhere and this results in lack of co-operation between the different research organisations and leads to loss of efficiency and usefulness. In England all the three chief departments of research dealing with industry, medicine and agriculture are under the central direction of the Lord President of the Council.

The Lord President, and through him the Cabinet, is kept in active touch with the actual research work by the institution of a Scientific Advisory Council* consisting of six members who are three officers of the Royal Society, viz., the President,

* THE WAR CABINET SCIENTIFIC ADVISORY COMMITTEE
The Committee was appointed in October 1940 by the Prime Minister, the late Mr Neville Chamberlain as the Lord President of the Council, after consultation with the Royal Society. Lord Hankey, the Minister without Portfolio, was appointed Chairman of the Committee while Prof. W. W. C. Topley, a distinguished fellow the Royal Society with a colleague from the Offices of the War Cabinet, were to serve as Joint Secretaries.

Secretary, and another, and the three secretaries of the Department of Scientific and Industrial Research (D. S. I. R.), Medical Research Council (M.R.C.) and the Agricultural Research Council (A.R.C.). Thus the proper balance and reaction between individual enterprise and initiative on the one part and State enterprise and control on the other is maintained.

When we compare these organisations with those in India we are at once struck with some fundamental differences. Though we have bodies corresponding to D.S.I.R., M.R.C. and A.R.C., they are organised and controlled under quite different principles. The Chief Executive Officers of the Indian organisations are very seldom scientific men called from active research. The Chief Executive Officer of the I.C.A.R. is styled Vice-Chairman and the next administrative officer is styled Secretary; they have been always Civil Servants generally with no pretensions or knowledge of agricultural science. This violates Hill's principle No. 4 in a very flagrant way. For the I.R.F.A., which corresponds to the M.R.C., the constitution is still worse. Here public health service and medical research are lumped together while in England they have wisely enough been kept in distinct compartments. The Chief Executive Officer, of the I.R.F.A., who is the Public Health Commissioner for India has often been a man without any research experience. The Board of Scientific and Industrial Research for the first four years of its existence had a very curious and cumbrous constitution which we had very often criticised in these columns; the so-called Director of Scientific and Industrial Research was nothing better than a

The terms of reference of the Committee are:

- (a) to advise the Lord President on any scientific problem referred to them;
- (b) to advise Government departments, when so requested, on the selection of individuals for particular lines of scientific inquiry or for membership of committees on which men of science are required;
- (c) to bring to the notice of the Lord President promising new scientific or technical developments which may be of importance to the war effort.

The members of the Committee at the time of its appointment were:

1. Lord Hankey, G.C.B., G.C.M.G., G.C.V.O., Chancellor of the Duchy of Lancaster (Chairman).
2. Sir William Bragg, O.M., K.B.E., President of the Royal Society (since dead).
3. Dr E. V. Appleton, F.R.S., Secretary of the Department of Scientific & Industrial Research.
4. Sir Edward Mellanby, K.C.B., F.R.S., Secretary of the Agricultural Research Council.
5. Sir Edwin Butler, C.M.G., F.R.S., Secretary of the Medical Research Council.
6. Prof. A. V. Hill, O.B.E., F.R.S., M.P., Secretary and Foulerton Research Professor of the Royal Society.
7. Prof. A. C. C. Egerton, F.R.S., Secretary of the Royal Society and Professor of Chemical Technology in the Imperial College of Science and Technology.

Technical Adviser and no executive action could be taken unless files passed through a maze of secretarial channels in charge of over-worked, and otherwise employed secretaries. These constitutions* which were evolved by Civil Servants in the Secretariat and the Hon'ble Members of the Government of India most of whom had no knowledge of scientific organisations of other countries and certainly had never been appreciative of the spirit of science, were extremely complicated but they had one object in view, that is, "Do not trust the scientific men with any real administrative power." Further the three departments are under three different members of the Viceroy's Cabinet, and most of the scientific services are distributed through different portfolios under the present arrangement, and there is no central direction or coordination as demanded by Hill's principle No. 2.

Further our experience has been that though the Hon'ble Members and secretaries can hardly find time to give serious attention to the work of the scientific research departments under their care, they are hardly prepared to part with power.† Sir J. C. Ghosh referred to the wish of Lord Reading as Viceroy to set up something like a Planning Committee; and such wishes have been expressed by many Honourable Members past and present . . . and politicians and widely advertized and glibly talked about. The levity of these talks show that few realize the immensity of the task. Thousands of experts have to be mobilized if the thing is to materialize, and their labours have to be collated, but 'inter-departmental boundaries are impenetrable' to quote Prof. Hill, and there can be no co-ordination or efficiency under the present arrangement. If probably the principle be accepted that every subject should have a section on Research, and another on Service and Development, and the latter ones were distributed under different portfolios, while Research was placed under one Minister of the Cabinet rank, the organisation for National Planning would take a shape from which some real work can be expected.

As we have very often remarked, science is one and the same all over the world and if scientific research is to bear any fruit, its organisation and direction must be guided by the principles which have been formulated in such clear terms by Prof. Hill. We believe that the National Institute of Sciences of India which is the premier body of senior Indian scientists has given the right lead to the country by passing the resolutions for the creation of a National Research Council. If they are properly implemented

* Sir Walter Fletcher was consulted when the construction of the I. R. F. A. was framed, but it is certain that his advice was not followed.

† It is reported to have been amended in recent years.—Ed., Sc. & Cul.

they will be found to satisfy all the principles enunciated by Hill. These resolutions as amended in the Delhi meeting are now quoted below:—

(1) That it is necessary to establish at an early date a National Research Council of India under the statutory authority of the Government of India.

(2) The purpose of the National Research Council shall be

- (a) to plan and watch over the main lines of research and technical developments in accordance with national needs to see that the application of science to the public welfare is adjusted to some consistent plan, to advise the Government on a common policy and to ensure that available resources for research and developments are distributed to the best advantage of the country,
- (b) to advise and help relevant authorities and Institutions regarding the training and supply of scientific personnel for pure and applied research, and
- (c) to distribute grants for promoting approved researches, for the maintenance of selected research scholars, for scientific publication and other purposes.

The President of the National Research Council shall be a member of the Viceroy's Cabinet.

For the performance of its functions, the National Research Council shall, in consultation with non-official scientific organisations, Universities and Institutions of a University rank, Scientific Departments of the Government and Federations of Chambers of Commerce, constitute the following Boards of Research, each of which will be responsible within its own particular sphere for giving effect to the policy of the National Research Council.

- (i) Board of Scientific Research (Mathematics, Statistics, Physics, Chemistry, Botany, Zoology, Geology, Geography, Psychology, etc.).
- (ii) Board of Agricultural Research (soils, crops, animal husbandry, fishery and forestry).
- (iii) Board of Medical and Public Health Research including Medical Science.
- (iv) Board of Engineering Research including Mining, Metallurgy and such other Boards as may be considered to be necessary.

For the purpose of its work each Board will be authorised to constitute Research Committees for all important

subjects, to settle the objects of the research, indicate the individuals or organisations which could undertake the several component parts of the enquiry, receive and co-ordinate the information, make it available to those who will turn it to advantage to form national plan into which all who are in position to contribute information can fit the particular lines on research. Governing bodies of the National Research Laboratories when established shall be constituted in consultation with the relevant research committees.

The National Research Council shall work in close co-operation with the development organisations in the country.

To enable effect being given to the policy of scientific development determined by the National Research Council the Government should make an annual grant of at least 5 crores of rupees.

Let us hope that the Government of India will see their way to give effect to these resolutions, and in doing so, will be guided by the principles enunciated by Prof. Hill. Some critics have invited our attention to the following passage in the speech "Indeed, if I may say so, it is for you, the independent scientific people of India, to get together and ask clearly *with a single voice* for what you think is required." They have pointed out that the phrase may be interpreted by official quarters in an 'Ameryian-cum-Halifax' sense. But we believe that that was not Prof. Hill's intention. He has applied thermodynamics to the human system, and is well-aware of the fundamental maxim of thermodynamics "that it is impossible to convert the whole of heat energy to ordered work, unless you reach the absolute zero of temperature and that absolute zero is theoretically impossible to attain." The 'Single Voice' is impossible to attain in any country of the world, including the United Kingdom, but there cannot be the slightest doubt that the assembly of scientists who passed the resolutions on the formation of the National Research Council was as near 'Single Voice' as could be attained in any country of the world.

THE SCIENTIFIC ORGANISATION, OFFICIAL AND UNOFFICIAL, IN THE UNITED KINGDOM*

A. V. HILL,

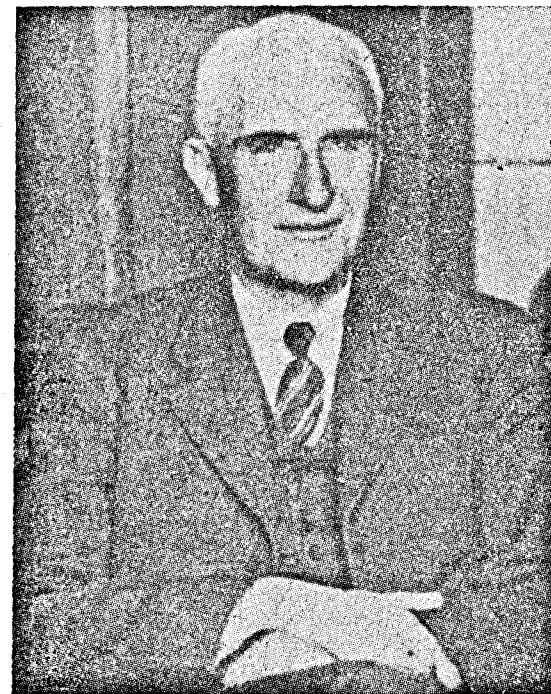
SECRETARY, ROYAL SOCIETY OF LONDON

THE MAN OF SCIENCE

MAY I introduce this lecture by a word of greeting from British scientific people to their Indian colleagues; and then a word of comment on both of us. We scientists are a peculiar lot. Before the last war people used to think we were a bit mad—we were interested in such funny things and for such funny reasons—and some professors (not all of them) had long hair and beards, wore strong spectacles, looked like nothing on earth and were quite inexperienced in the ordinary affairs of life. The last war produced a change in this idea of us, and we became magicians. The scientists were found to be able to do all kinds of things that other people couldn't and the public and its leaders (who prefer to believe in magic anyhow) went to the opposite extreme and supposed that science could do everything. The result was that all sorts of quacks and frauds and magic mongers got going and tried to put it across in the name of science. Between the wars the position tended to revert—though not completely: and in the present war the public has realised once again the extreme importance of scientific knowledge and scientific research to the community.

The attitude, however, of some administrators still is that although science may get them out of a hole when things go wrong, scientists as a whole are a funny lot, that science should be, as the saying is, "on tap and not on top". Scientists are still paid considerably less than administrators of equal or less ability and standing. Our claim is not yet admitted that we ought to be regarded as equal partners with other people of similar expert knowledge in deciding policy. We are getting on, however. We are usually rather poor and don't much mind provided we are allowed to do our work; on the whole, we don't much care about public honours and awards; most of us hate looking important or being called Sir by our younger colleagues; we don't generally believe what we are told; we know that things aren't usually what they seem; we're fairly careful

what we say; and we're generally honest.* In spite of these disadvantages, however, we have much more influence in the end than is commonly supposed;



Prof. A. V. Hill

and the public is realising and the politicians will realise in time that science and scientists must really be taken rather seriously in the modern State.

ETHICS OF SCIENCE

Probably that process has gone further in England than in India, but I expect the trend here is very much the same. Science is on the rising tide of its fortunes, or at least of public appreciation, here as there. It is very important, therefore, that we should work together on common problems and adopt a common ethical standard of what a scientist should or should not do. The oldest science of all—

* "Is honesty a disadvantage?" This admission may sound queer, coming from a scientist of Prof. Hill's eminence but this is also the experience of many of us.—ED., *Sc. & Cul.*

except perhaps astronomy—is medicine, and for thousands of years, medicine has everywhere adopted a high ethical standard for its practitioners. There is a universal brotherhood of medical people, of medical ethics, of medical thought and medical practice. This brotherhood must be recognised also for us scientists. Our interests are common, our needs are common, the services we can render to our fellow men are common and the ethical standards of our behaviour as scientists should be common too. Feeling all this very strongly I have for many years been concerned—both inside and outside my laboratory—with the international aspects of science. This feeling, this conviction that science is a common interest of humanity, has led one into many interesting places and situations—and sometimes I admit into disputes, for example, with Nazis, Fascists and Anti-Semites. It has led me now to one of the most interesting situations of all and I am grateful to the fate and the friends that have brought me to a country so rich in possibilities, both of the improvement of scientific knowledge and of the application of science to public welfare.

We are all in this business together. We can all help each other by our experience, our special knowledge and talents and the special resources at our disposal. If we in Britain are able to help you more at the moment, we know very well that the traffic is already—and will increasingly be—both ways. To take a single example, your knowledge and experience will have a very special application to the problems of our colonial territories. Moreover, in what is sometimes called pure science each kind of people has a special contribution to make. The long artistic and spiritual tradition of India is bound to give a particular bias and direction to yours. That bias will not be given to the facts themselves as determined by experiment: they are Nature's own reply to our questions. The bias will be to the planning of the experiments and the interpretation of the results. In science there is room for all kinds, for practical men and dreamers alike; provided that we recognize always the common ground of the appeal to Nature by experiment, provided that we agree that honesty, frankness, forbearance and a collaborative spirit are the *sine qua non* of all progress.

FOUR M'S ESSENTIAL FOR SUCCESS OF ORGANISED SCIENTIFIC RESEARCH

MEN, MONEY, MATERIAL, MACHINERY
(OF ORGANISATION)

The progress of science and of its application to public welfare depends upon four M's, Men, Money, Material and Machinery of Organisation. They are equally important and the supply of each of them

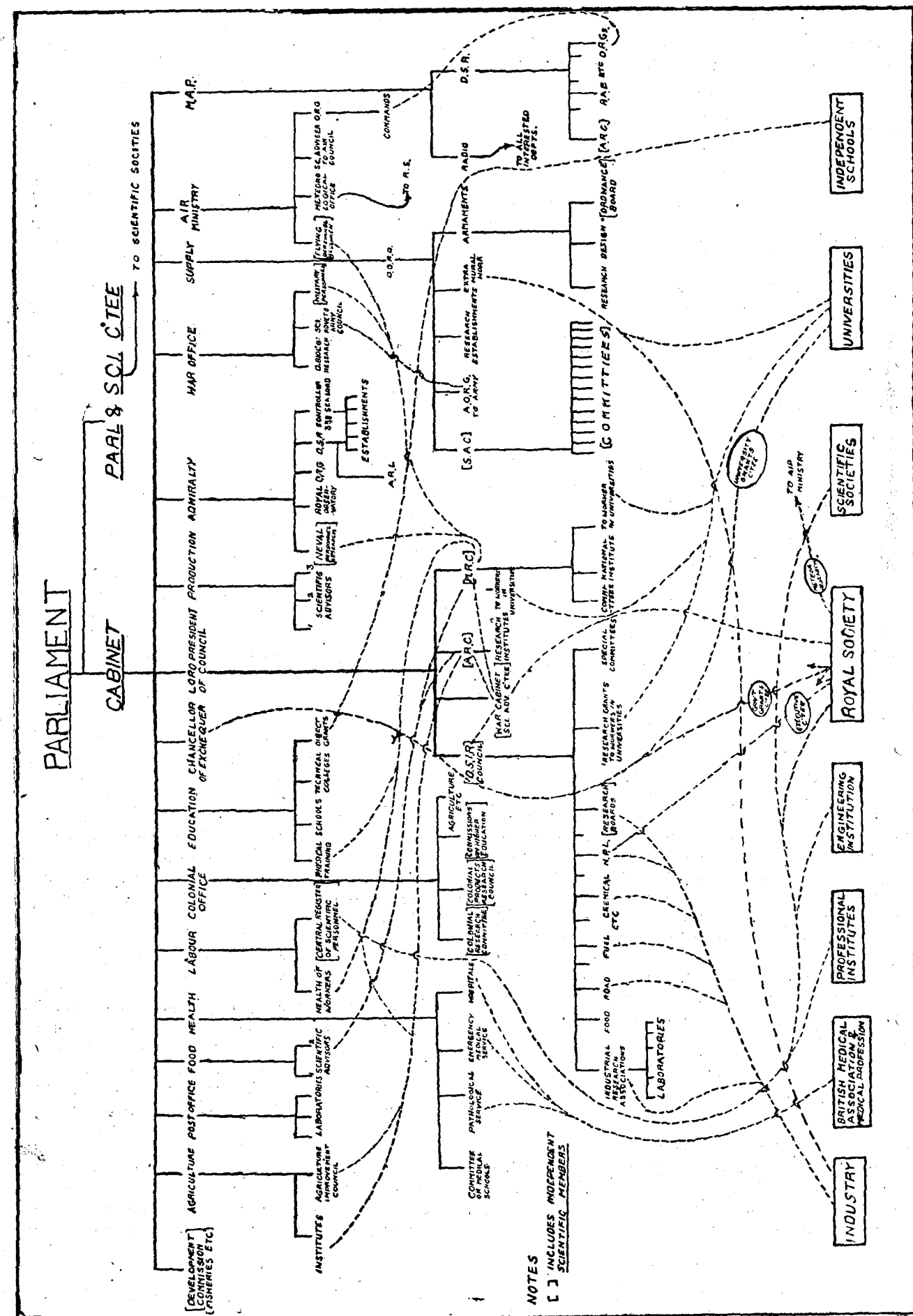
is bound up with all the others. It is about the last of these, the machinery of organisation in the United Kingdom, that I am to speak today. I hope it may be of value to you in planning your own organisation to have the family tree, as one may call it, of ours set out in a diagram. I am very grateful to Sir S. S. Bhatnagar, Director of Scientific and Industrial Research, for the help of his Department in getting it prepared. It is by no means complete and it may not be in all respects quite accurate. It is still growing and changes occur in it from month to month. On the whole, however, it gives a pretty good idea of the situation.

In looking at it you must bear in mind the fact that it evolved and grew, usually without much planning beforehand. It is, therefore, very complicated like all living things. Every biologist knows that in living organisms much is there for historical reasons. If an animal or a plant were to be deliberately planned beforehand it would probably be very different. Our system as you see is very complicated and you would be wise in planning yours to aim at something simpler. On the otherhand our system works, and works now pretty well, though it could really be improved a good deal yet. It works at the moment partly because of the very high quality of the men temporarily engaged in it during the war who for the most part will not remain in the official side of it afterwards. It works also because it embodies certain fundamental principles which I will describe. You would be wise to emphasise those principles in planning your own organisation. If you do, and if you can devise something less complicated than ours and something which will work even when men of the highest scientific quality are to a large extent employed outside the official part of it, you should be able to make something which will be of the greatest value in the developments both of pure science, and of that application of science to public welfare which your country so greatly needs.

CO-OPERATION BETWEEN THE OFFICIAL AND THE NON-OFFICIAL

You will see that I have arranged our organisation in two layers: official and unofficial. In the United Kingdom we have a large number of old and well established institutions, often powerful, sometimes wealthy and generally highly respected, which are entirely independent of the Government. My Socialist friends call me a Tory—my Tory friends call me a Socialist—in fact I have only one political principle that I am aware of, *viz., that good Government depends on a proper balance and reaction between individual enterprise and initiative on the one part and State enterprise and control on the*

* Popular lecture to the Indian Science Congress on Wednesday the 5th of January 1944. The editors express their thanks to Prof. A. V. Hill and the authorities of the Indian Science Congress for permission to publish this article.



other. Where the balance lies at any moment is a matter for discussion, compromise and agreement: but it is the greatest and most disastrous folly to suppose that there is a fundamental antagonism between the two parts. The wisdom and public spirit of private citizens, individually and collectively through their private organisations, must act and react by friendly advice and helpful criticism with the wisdom and public spirit of officials, individually and collectively through their Government machinery. That is the age-long tradition of the British political and social system and I think it is good. There is a tendency always of course for private citizens to be unwise and selfish, for officials to be pig-headed and unreasonably obsessed with their own machinery and importance. If that became general our system would break down. It works because there are sufficient people on both sides who believe in friendly give-and-take between free individuals and their free institutions on the one part and the organised machinery of the State on the other.

THE POSITION OF ROYAL SOCIETY OF LONDON

This is as true of science as of any other field of human activity and we are fortunate in the United Kingdom in having a great number of private organisations, powerful and well established, representing collective scientific wisdom and effort outside the Government system. Of all these, on the purely scientific and technical side, the Royal Society founded 281 years ago (1663) is the elder brother and example: there are learned societies of all kinds and engineering and professional institutions. On the educational side there are the old established "public schools", going back some of them for many centuries, and the older universities. On the medical side there are the Royal Colleges of Physicians and Surgeons, the voluntary hospitals and more recently founded institutions such as the British Medical Association and the Royal Society of Medicine. To this set of old and well-established bodies, with their long tradition of independent enterprise and existence, many new ones are always being added more or less on the same model; the newer universities, the newer schools etc. Many of these—though not all—nowadays are receiving substantial State support: but nearly always when this is done a buffer of some kind is interposed to prevent Government support from becoming Government control. For example the universities receive a substantial Government grant from the Treasury and will have to receive a much greater one if they are to carry on effectively: but the University Grants Committee, a body of independent scholars and scientists advising the Treasury, sees that the distribution of that money

does not mean that the universities will lose their own characteristic freedom and independence. An extreme example is seen in the case of the National Physical Laboratory. Founded initially under the influence of the Royal Society (1901) it was later taken over and is now financed almost entirely by the Department of Scientific and Industrial Research. Yet the Royal Society still appoints the Executive Committee which controls and guides the work of the N. P. L., and appoints and dismisses the staff, all except the Director himself who is appointed by the Lord President of the Council in consultation with the Royal Society.

THE WAR CABINET SCIENTIFIC ADVISORY COMMITTEE

This influence goes to a very high level. The War Cabinet Scientific Advisory Committee (estd. 1939) consists, as to half its membership of the three principal officers of the Royal Society and reports directly to the Lord President of the Council who is himself a member of the War Cabinet. It advises the Government on matters of general scientific policy and on special appointments. The Councils of the three Research Departments (D.S.I.R., M.R.C. and A.R.C.) who direct their work consist in the main of independent scientific people appointed from outside Government circles after consultation with the President of the Royal Society. The many lines of connection given in the diagram show how intimate is the reaction between science and its applications under the Government, on the one side, and science and applied science in organisations entirely independent of the Government on the other.

THE FIRST PRINCIPLE OF ORGANISATION

The first principle of successful scientific organisation are:—

- (1) That there should be a number of large powerful and well organised institutions representing the collective opinion and knowledge of scientific and technical people as a whole.
- (2) That there should be a frank, friendly and welcome collaboration of these institutions and their members in the scientific activities of the Government.
- (3) That there should be the support when necessary, but not the control, of a good many of these institutions by the Government.

THE SECOND PRINCIPLE: CENTRAL DIRECTION OF RESEARCH

The second principle is the existence of a central scientific organisation outside any ordinary department of the Government directly under an important Minister.

This in itself is not enough—there must be scientific work going on in every Government department to which it applies: but it is also essential that research which applies to more than one department should be organised outside any one department and centrally: *interdepartmental boundaries are almost impenetrable in the United Kingdom as elsewhere.* The organisation under the Lord President of the Council represents this principle in a form which could scarcely be bettered. There are three separate bodies under the Lord President: the Department of Scientific and Industrial Research (D.S.I.R.), the Medical Research Council (M.R.C.) and the Agricultural Research Council (A.R.C.).

THE MEDICAL RESEARCH COUNCIL (M.R.C.)

The M. R. C. was founded in 1914, and its first Secretary was a very distinguished scientific man, the well known physiologist Walter Fletcher, who obtained from the very start a clear admission of his claim that the Council should be authorised to engage in and support any research directed towards the main object of the Council, however unlikely it seemed to produce immediate practical results. This wise policy has been entirely justified by results. The Council has worked mainly by the encouragement and support of research, in medicine and the medical sciences but also of related subjects, in the universities and medical schools of the country: but it has encouraged research also on tropical medicine and it has maintained a first class research laboratory at the National Institute for Medical Research. Any suggestion that good work cannot be done within the walls of Government laboratories is negated by the fact that Sir Henry Dale, now President of the Royal Society, was awarded the Nobel Prize for physiology and medicine for work done over many years in that Institute. Its workers are regularly interchanged with workers in universities and elsewhere and its whole conduct is similar to that of a research institution in a university. Indeed it is recognised by the University of London as a School of the University and work in it is recognised for higher degrees in the University. The activities of the Medical Research Council are guided by a Council consisting mainly of independent scientific and medical men.

THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH (D.S.I.R.)

The D.S.I.R. was founded on similar principles in 1916 during the last war. It has grown to be a very important organisation indeed, the many activities of which can best be described by the diagram. Its workers also are interchangeable with those elsewhere. Its Council (Scientific Advisory Council)

similarly consists mainly of independent scientific men, engineers and industrialists. Its expenditure considerable sums in making maintenance grants for students in training for research and for encouraging research in universities and elsewhere "of special timeliness and promise". *Its Secretary ranks in pay and status with the chief secretaries of the Government departments—though he is and will always I hope remain a scientific man.* Like the M.R.C. it is assisted by a large number of Boards and Committees of independent experts in various subjects. It maintains a large number of stations and establishments of its own and a very large scientific staff. Its constitution is very flexible—for example when it was desired to establish a liaison officer at Ottawa with the National Research Council of Canada, and no other department, not even the Dominions Office, could think of any way of doing it, the D.S.I.R. just sent Sir R. H. Fowler, F.R.S., famous mathematical physicist, there to represent us. That flexibility comes from being outside any ordinary department with its rigid rules and red tape, and also from the facts (1) that its Secretary has the same status as the chief permanent officers of the other departments and (2) that his Minister is of high rank in the ministerial hierarchy, but not the head of an ordinary Department.

One of its most important activities is the Industrial Research Associations which are joint concerns with organised industry.

THE AGRICULTURAL RESEARCH COUNCIL (A.R.C.)

The A.R.C. was founded later than the other two with a constitution and function similar to those of the M.R.C. Recently to complement its activities an Agricultural Improvement Council has been established in the Ministry of Agriculture. This is intended to take the results of research obtained by the A. R. C. and other bodies and to apply them to the practical problems of agriculture. The Agricultural Improvement Council promises to exercise an important influence in bringing the results of research to practical fruition.

These three Research Councils, by their independence and the relative absence of departmental restrictions and red tape, set a standard and example to research under Government which is most valuable, and we are fortunate indeed in the United Kingdom that so satisfactory an arrangement has been evolved. Its success, however, is not due only to the machinery and organisation—men are just as important as any—it is due largely to two facts which I will exalt to my third and fourth principles.

THE THIRD PRINCIPLE OF ORGANISATION

The third principle is that every scientific organisation should be watched over, advised and guided

or controlled by a Council, Committee or panel largely consisting of independent scientific men.

This has two results, first that all its work is kept in touch with outside scientific ideas and criticism, second that its workers are not shut off from the outside world, but feel that they and their interests are being looked after sympathetically by scientific colleagues, not by pure administrators. This principle is found at work in a good many other parts of our organisation, as can be seen in the diagram. A powerful advisory committee with an active chairman is the surest way of preventing a Government organisation from becoming sticky, sleepy and incompetent. In some parts of the diagram—I will not specify too closely—you can see organisations which hitherto have resisted this principle: by reason of vested interest, fear of being shown up for incompetence, undue obsession about secrecy, etc. The weakness of some of these organisations was more obvious in peacetime and the earlier years of the war than it is now, when a lot of fresh blood and a number of first class people have been introduced from outside. When, however, conditions revert to those of peace, most of these good people will withdraw to their previous jobs and it will be necessary to continue the fight to get some measure of independent criticism and control on the inside of these water-tight compartments.

THE FOURTH PRINCIPLE

The fourth principle is that the head of every scientific organisation should himself be a good scientist, not purely an administrator.

This means, I know, that a good research worker is going to be sacrificed, or at least largely removed from his research: I am sorry for him: but the net gain is very great.

The ordinary civil servant, like the ordinary politician, is unfortunately nearly always quite ignorant of scientific matters, and to put him in charge directly of a research organisation is to stultify the whole thing. It is quite untrue that a good scientist is likely to be less competent than any other intelligent, educated man at administration. Some able scientists it is true are incompetent at such things—but so for that matter are some professional administrators: some scientists, however, are as competent as anyone else at administration and some of these must be sacrificed to administration for the good of the rest. Perhaps the fairest and wisest thing might be to appoint the heads of scientific organisations for a limited period only, arranging for them to return to university or research jobs of their own after a few years: thus preventing them from

becoming—whether they like it or not—bureaucrats. This would give them the inducement, all the time they are in office, of keeping personal touch with real scientific work against the time when they return to it. Having spent nearly five years now, against my will, far away from my own laboratory, I know the home-sickness which is produced by visiting someone else's. It is a good thing that those who are trying to organise scientific research for others should remain homesick for their own, and look forward to returning to it. What is quite certain is that people who prefer to sit in offices should not be allowed to organise the scientific work of others!

THE FIFTH PRINCIPLE

The fifth principle is that of interchange of scientific persons between universities, Government laboratories, industrial and research laboratories and research institutions and enterprises of all kinds.

It is a very good thing for people in universities, who are apt to be a bit high-browed in their attitude, to learn, for example, what excellent work and of what high intellectual quality is done in Government laboratories or industry and be made to find out something about it. It is a very good thing for people in the Government service or industry to learn something at first hand about the latest developments of their science and to be in touch with young students during their years of training. It is a good thing for students to be taught by people who are in touch with the practical problems of the real world. The first condition of interchangeability is a common pension system so that no pension rights are lost in going from one service to another. That to a large extent we already have in England. The other condition is that the need of fresh air and a change of mental diet should be recognised explicitly in all the different scientific services, so that a young man or indeed an older one does not lose by applying to change his job for something more suitable, or to him more interesting. We are trying in the United Kingdom to ensure that the principle of interchangeability of scientific personnel is as widely recognised as possible.

These then are the principles which I should apply in any scientific organisation anywhere. I will illustrate them by referring to the various departments in the diagram. You will see the complexity, the unnecessary complexity as I think, of our scientific set-up; but you will see also how it has been made to work by insisting, so far as vested interests and departmental proprieties allow, on the principles I have recounted. If you can apply the principles in

India and avoid the complexities you will have done well.

At present, if I may make a single comment on your system in India, as shown in the other diagrams, you are avoiding some of the complexities but you are not yet applying—perhaps you have not yet the means to apply—the principles. The latter may not be easy for you but it will happen all right in the

said of course that I was doing it all for my own private ends—though what those ends were they did not clearly specify.

Sometimes I have felt pretty bad about it all and once made a new beatitude, "Blessed is he who remains innocently in his laboratory and grumbles; for it is a thankless task trying to put things right". But things do get right in the end if one goes on

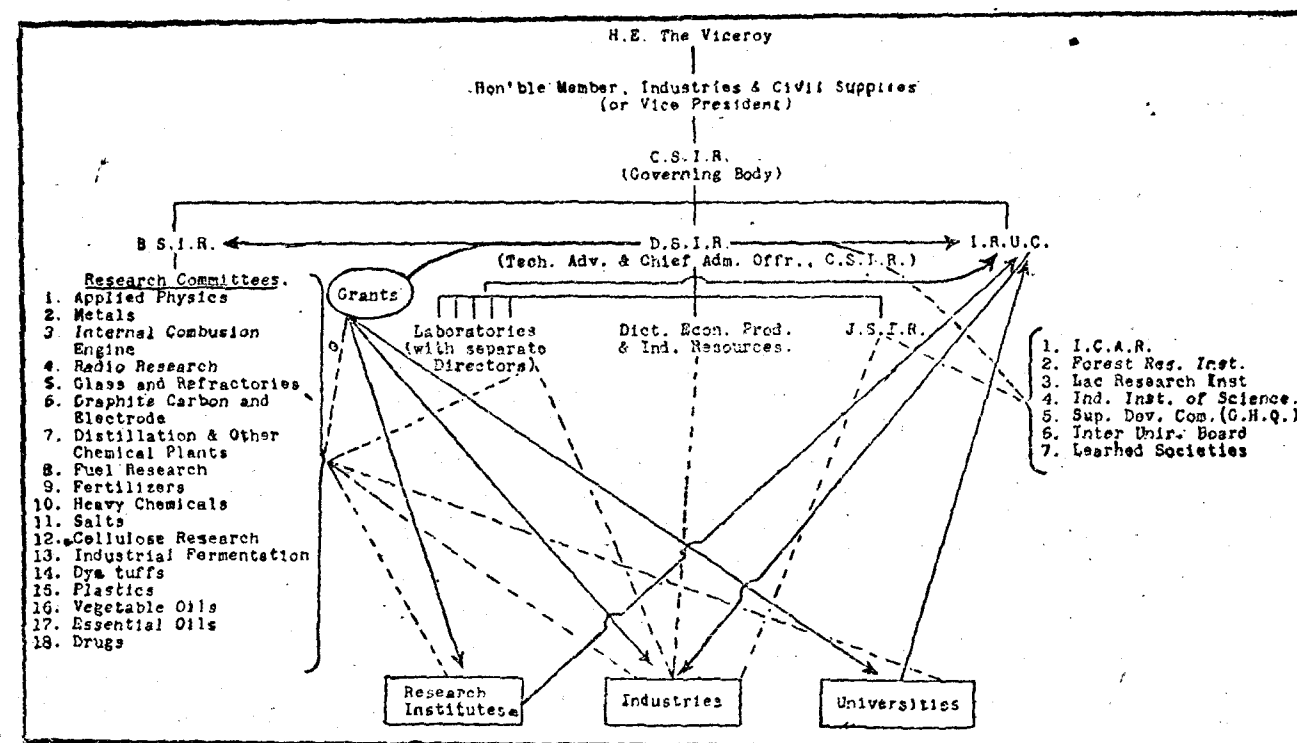


Fig. 2

end. It means the creation of a much stronger scientific public opinion, the building up of much stronger and more representative institutions of scientific men; it means inserting science into the machinery of Government at a much higher level than at present. But all this you can and you will do. Don't forget that we too have had our struggles in Great Britain, for instance, I have had to make myself very unpopular now and then by private and sometimes by public criticism of the scientific set-up in various departments.

PROF. HILL, AS PUBLIC ENEMY NO. 1

Indeed in one department, where certain things were badly wrong and needed urgently to be rectified, it took years of hard work, in private and in public, before things were put right. In that department I was regarded as public enemy No. 1 and they

trying; and I am convinced myself that the Government of India is sincerely anxious to do its best for science and its many applications to the public welfare. If they had wanted someone to say that everything was beautiful already in the garden they certainly would have invited somebody else to come and advise them; not one who has had to make himself a public nuisance for several years in England in trying to get a scientific move-on. Indeed, if I may say so, it is for you, the independent scientific people of India, to get together and ask clearly with a single voice for what you think is required. Your co-operation, your advice, your constructive criticism, individual and collective through your scientific organisations, is what is wanted; and if you give that collective advice clearly and sincerely and co-operatively, I honestly believe that you will succeed in bringing into existence the kind of national scientific machinery which your country needs.

NOTE TO PROF. HILL'S LECTURE

For the convenience of our readers, we are adding the following notes to Prof. Hill's Lectures particularly for explaining the diagrams. These notes have been prepared by our own staff, and for any omissions or inaccuracies, we are solely responsible. They have been mostly collected from *Nature* and other British scientific journals.

The British organisation can be roughly divided into three sections. The left part deals with the scientific services under the different departments. These are distributed under the different ministries, and have in recent years been linked to active research by the institutions of bodies of scientific advisers. The central part deals with pure peace-time research departments under the Lord President of the Council. Their activities have enormously increased during the War, and the cross linkages show how results of their activities are made available to services and to war-effort. The right hand section deals with the departments directly concerned in the war-effort. Some of these departments date from old times, others are new, and all have undergone considerable expansion during the current war, and the cross linkages show how their activities have been vitalized by active research.

The Indian organisation for research is shown separately. We have taken it from the handbook of Delhi prepared by the local Committee of the Indian Science Congress.

The fundamental difference between the British and Indian systems will be at once apparent. At the head of the British organisation stand 'The Parliament', i.e., the people of Britain. At the head of Indian organisation, is H. E. the Viceroy, and the H. M.'s and steps have not yet been taken that they should represent the people of India. The other grave defects of the Indian organisations have been pointed out in our editorial.

APPENDIX

COLONIAL RESEARCH AND DEVELOPMENT

It is only in recent years that Great Britain has given serious thought and consideration to the question of colonial research and development. Up to about the eighties of the last century, British Colonies comprised mainly Ceylon and a small part of Malaya in the eastern hemisphere, a number of trading settlements on the coasts of Africa, and in the western hemisphere, the old British possessions in the West Indies. Since then parts of Borneo, an extended area in Malaya, some of the Southern Pacific Islands and a vast area in Africa, equal to British India have been added to the British Colonial Empire.

British colonial policy was guided in the past mainly by political considerations where there was hardly any room for such thought as the promotion of the social welfare, the health and the standards of life of the colonial people. The recognition of the obligation and responsibilities on the part of the parent country towards its colonies, in the

matter of social, cultural, economic and industrial development is, however, only of recent origin and has taken place through several successive stages. In conformity to this new outlook, first steps were taken towards making the colonies self-supporting. The Colonial Development Fund was instituted in 1929 to give practical shape to this idea. The Fund was authorised to spend the maximum sum of £1,000,000 on development work. The principle, then pursued when the Colonial Development Fund was created, was that a colony should have only those services which it can afford to maintain out of its own resources, and accordingly development was confined within the limits of the internal finances of each territory.

This was, however, a narrow outlook in the provision for colonial development. It was subsequently realised that in many cases colonies cannot, however, efficient their economic administration, finance out of their own resources the research and survey work, the schemes of major capital enterprise, and the expansion of administrative and technical staffs which are necessary for their full and vigorous development. This led to the formation of the West Indies Royal Commission under the Chairmanship of Lord Mayne in 1938. The present liberal and broad-based policy of colonial research and development is largely the outcome of the recommendation of this Royal Commission. According to the recommendations of the Commission, the Colonial Development Fund which was previously limited to £1,000,000 a year has now been replaced by a greater sum amounting to the maximum of £5,000,000 a year for ten years. This will be available not only for schemes involving capital expenditure for colonial development, but also for helping to meet recurrent expenditure on certain services, such as agriculture, education, health and housing.

Along with the expansion of the Development Fund, special provision has been made for research, following the proposals of Lord Hailey in his famous 'African Survey'. Hitherto, expenditure on various forms of colonial research received assistance from the Colonial Development Fund and the Colonial Office used to call upon the assistance of scientific and technical experts in dealing with colonial problems. The colonial office also set up a number of advisory committees consisting of experts, members of Parliament and men with long colonial experience to advise on these problems. To place Colonial Research and Development on a permanent basis the Colonial Research Advisory Committee, with Lord Hailey as its Chairman, was set up in 1940 and a separate sum of £500,000 a year was placed at its disposal to assist in the various fields of research. These special funds and provisions for colonial research and development were provided by the Colonial Development and Welfare Act passed in 1940.

Finally a brief reference may be made to the varied colonial problems in which research and investigations are imperative. The demographic information requires to be placed on a more satisfactory basis. There is now lack of vital statistics concerning the total population of colonies and as such these should be established. There should be considerable extension of land survey, with special reference to geodetic triangulation. Geological survey should also take place on a vaster scale. There is at present great need for nutrition survey in the colonies to ascertain the dietary requirements of the different colonial peoples with wide variation of social habits and peculiarities. In the field of Health and Medical survey the scope of research is, in fact, unlimited. Above all, there is now great need for intensive anthropological and sociological studies of the colonial people. Without a proper understanding of the culture, traditions and habits of these people which these studies can alone make available, no workable development

programme can be formulated and any that may be devised in disregard of them is destined to be a failure.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH (D. S. I. R.)

The exigencies of the war of 1914-18 evolved the Department of Scientific and Industrial Research in Great Britain on an elaborate system with a far sighted view. It may be mentioned that England at this stage was not properly industrialized, nor that technical enterprises were much encouraged, and that scientific research were more confined in the corners of the laboratories. It may be mentioned that the pioneer aviators in England were much discouraged by the Government. But the 20th century warfare demanded all these technical activities which were so much neglected before and "already the early months of the war of 1914-18 had revealed the dangers and difficulties in which Great Britain was placed through the neglect of science by industry and the absence of an adequate scientific personnel."

The Department of Scientific and Industrial Research was created by the Act of Parliament in December 1914. It was later on felt that the Department cannot function properly unless an adequate Advisory Council is appointed for the organisation. Mr J. A. Pease who was then the President of the Board of Education introduced a Bill in the House of Commons to appoint an Advisory Council for industrial research in Great Britain, to be specially entrusted with the supervision and encouragement of scientific research particularly in relation to industry, and much stress was laid on the training up of technical personnel. The Advisory Council of the Scientific and Industrial Research was established by Order in Council on July 18, 1915, and great credit goes to the Advisory Council which has been instrumental in increasing greatly the number of efficient British workers and for the unprecedented expansion in the application of scientific research in industry and in every phase of national life during the period of some 28 years of its existence.

The Advisory Council (S. A. C.) is composed mainly of eminent scientific men of the country like Lord Rutherford, Sir William Bragg, Prof. Fowler, Lord Rayleigh, Sir J. H. Jeans, Prof. A. V. Hill and others. The prime functions of the Advisory Council were and are to advise the Committee of Council on proposals for instituting specific researches, or for establishing or developing special institutions or departments of existing institutions, for scientific study of problems affecting particular industries and trades, and on the establishment or award of research scholarships or fellowships. The Advisory Council is also available to advise the education departments as to the supply of workers competent to undertake scientific research.

Although the Department of Scientific and Industrial Research was created during the war it was not merely an emergency organisation. The Department was planned entirely on permanent national basis, taking into account the emergent necessities of the war as well as the post-war reconstruction.

One of the most important issue was the creation of National Physical Laboratory. The N. P. L. co-ordinates the scientific and technical problems in its own laboratories or have them co-ordinated in specially controlled places, such as, universities and industrial factories or their associated laboratories and then pass on the result of the industry with its hall-mark of precision. The standardization of fundamental units of measurements has its essential bearing on the stability of industrial reproduction and in maintaining adequate specifications for the producer as well as for the consumers.

The Department has its different boards and sub-committees to deal with different problems: for instance, Fuel Committee, Radio Research Board, Iron and Steel Committee, Water and Atmospheric Pollution Research, Medical Research, Agriculture, Food Investigation Board, Textile, Aircraft, Electrical Apparatus, etc., are treated elaborately under each of these Committees.

The Department of Scientific and Industrial Research did not restrict its attention only to the works of industrial nature since it was appreciated that no technical processes or its application can be fully evolved without the proper understanding of the fundamental science—or so-called 'pure' science. "The service which the Department of Scientific and Industrial Research has rendered to the development of pure science is far from being limited to the provision of maintenance allowances for students or even special assistance to independent research workers, whether by helping young research workers of exceptional ability to pursue their work for a limited period without the necessity of finding other employment, by the provision of funds for research of technical assistants or the purchase of special apparatus and equipment, or, in special circumstances, by making really substantial grants. The Advisory Council has consistently shown in its reports a wise concern for the conditions of employment of the research worker, whether in regard to salary or security of tenure; this is a contribution to the raising standards in the last two decades which has earned the cordial appreciation of all scientific workers." (For fuller account, see SCIENCE AND CULTURE, Vol. V, p. 649).

MEDICAL RESEARCH COUNCIL (M. R. C.)

Medical Research Council (formed in 1914) is one of the three research departments of the Privy Council. Numerous are the services rendered by the Medical Research Council with its forty-five committees and sub-committees. At present the activities of the Medical Research Council are not confined only within the domain of medicine but extend far beyond it. It is directly concerned with all the problems that affect man's health and efficiency.

The activities of the Research Council were found to be extremely satisfactory and the Committee has been allowed full scientific freedom and complete control over the funds at their disposal.

The activities of the Council are manifold. The results obtained by the Nutrition Committee are invaluable as it is well-known that nutrition in war time affect both the population as a whole under the conditions of rationing and the armed forces in respect of great use of tinned foodstuffs. It has taught the people how to make the best use of food that they can get and how to keep good health.

Another important committee is the committee of Preventive Medicine which has studied methods of immunization against diseases such as diphtheria, whooping cough, etc. and outbreak of epidemics.

Medical Research Committee is helping different authorities to select proper man to the proper place.

The activities of Medical Research Council now extend far beyond medicine. The Health of Munition Workers Committee was appointed to consider and advise on individual fatigue, hours of labour and other matters affecting the personal health and efficiency of workers in munition factories and workshop.

The M. R. C. is directly under the Lord President of the Council, and has nothing to do with the Public Health Service, which is under the Ministry of Health. In India, the two are lumped together, with no happy result, as mentioned elsewhere.

MINISTRY OF AIRCRAFT PRODUCTION (M. A. P.)

The war of 1914-18 necessitated the formation of Department of Scientific and Industrial Research in England with a view to mobilise the scientists to war effort. Though the services rendered by the department were numerous yet it was found that the present scientific warfare requires the fullest mobilization of the scientists and co-ordination of the sister departments.

At the early stage of the war England had to face severe bombing and finding the superiority of German planes of various kinds, England felt the necessity of the formation of the Ministry of Aircraft Production.

Formerly the function of the Ministry of Aircraft Production was to expedite the production of the various kinds of aircrafts, and to speed up the production of the parts that go to build up the aircrafts. Its duty is also to look after that no factory engaged in the manufacture of aeroplane parts suffers for want of labour, material and equipment.

Soon it was realised that the war is a total and a truly scientific war and that the war would not be won merely by the physical ascendancy of race but rather by the ingenuity and skill of those who have been trained in secondary schools, technical schools and universities. Mere mass production would not suffice, quality is also essential. With the view to improve the quality of planes the Aeronautical Research Committee (A. R. C.) was formed. The members of the Aeronautical Research Committee and its sub-committees were drawn from Government technical staff and non-official scientists with the necessary qualifications. From time to time the membership of these bodies is changed with the view of giving a freshness of outlook.

In addition, to this there are advisory committees consisting of engineers and scientists from whom advice is sought for a specific problem.

The workers acting under this research committee are all engaged for the developments of aircrafts. The Chairman of the Aeronautical Research Committee is also a member of the Ministry of Aircraft Production Supply Council and of Air Council thereby giving a scientific link to the Air Ministry and the Ministry of Aircraft Production.

The Aeronautical Research Department is solely engaged for developing better and varied types of aeroplanes to suit different purposes. It has no concern for manufacture.

The Ministry of Aircraft Production also has an important organisation devoted to Radio development under the Controller of Communications Equipment; though there are in addition many scientists operating outside the research sphere, both in development and production and on operational planning.

The proper distribution of planes and pilots to the field necessitated the formation of Air Council. The Ministry of Air Council keeps close touch with the military authorities.

* The first President was Sir Henry Tizard, F.R.S.

ties and is responsible for the distribution of planes and pilots.

For the recruitments of men suitable for air force the Air Ministry has set up Flying Personnel Research Committee. This Committee works in conjunction with the Medical Research Council.

Finding that without meteorological forecasting no operation in air can be undertaken, a meteorological section was incorporated in the department. In the early part of 1942 under Air Council a Meteorological Research Committee was formed to advise and assist in the carrying out of Meteorological investigation under the Chairmanship of Professor S. Chapman, Professor of Mathematics at the Imperial College of Sciences and Technology. The Committee would welcome contact and co-operation with University Departments or other institutions engaged on work that bears on meteorology (vide SCIENCE AND CULTURE, Meteorology in Peace and War, Vol. 8, p. 156).

Air Ministry has now handed over most of its research work to the Ministry of Aircraft Production for better management and co-ordination.

ARMY OPERATIONAL RESEARCH GROUPS (A. O. R. G.)

Army Operational Research Groups came into existence in Great Britain in order to secure effective co-operation between the scientific and the fighting men. Today science is playing a very great role in the prosecution of war and the closest association between science and the services is a vital necessity to ensure the maximum war effort.

The practice that is usually followed is to hand over to the operational research sections the specific problems faced by the services. Sometimes the research sections may take the initiative in carrying on investigations for the solution of problems which they regard to be vital to war effort. However, the research sections have no authority to demand any specific course of action. They analyse facts, past experiences, arrive at conclusions which they hand over to the military authorities. It remains entirely with the latter to follow this advice and carry out operations in the light of advice given.

A. R. C.—Agricultural Research Council.

A. R. L.—Admiralty Research Laboratory.

D. G. R. D.—Director of Research and Development. This is in charge of Dr Gough (Engineer), head of the Engineering Department of the National Physical Laboratory. The department employs about 1,000 scientists and engineers.

O. R. G.—Operational Research Group (employs about 200 scientific men with all command groups).

S. A. C.—Scientific Advisory Council.

R. A. E.—Royal Aircraft Establishment.

Extra-mural Work—is the work done in the laboratories and workshops of universities, and other educational institutions, industrial laboratories, etc., for the war effort.

AN APPRECIATION OF THE WORKS OF PROF. A. V. HILL

IT is very rarely that a physicist and mathematician turns his mind to the study of problems connected with life and tries to find order and law in the chaos apparently prevailing in vital phenomena. Archibald Vivian Hill belongs to this rare class, along with Helmholtz or Nernst. A. V. Hill has always tried to probe into the mysteries of life in a direct manner. He has attempted "to include the complex and the variable phenomena presented by animal functions within the procrustean bed of mathematical formula" and has always protested that physiology is treated merely as 'the hand maiden of medicine'. He hopes that as 'in recent years the works of physicists and chemists have given us certainty that theories of atoms, molecules and stereochemistry are based on real objective fact, so it will be with physiology—though our way may be much harder and longer than those who deal with such simple things as molecules, atoms and electrons'. A. V. Hill belongs to an age which produced a galaxy of brilliant physiologists like Sherrington, Dale, Hopkins, Heymans, Meyerhoff, Embden and Lundsgaard.

Hill's earliest work dates from 1910, when in his "new mathematical treatment of changes in ionic concentration in muscles and nerves, under the action of electric current, with a theory as to their mode of excitation" (*Journal of Physiology*, Vol. 40), he elaborates and improves on Nernst classical theory of excitation of nerves.

Soon A. V. Hill interested himself in the study of output of heat by resting and by working tissues. Fletcher in 1902 and Fletcher and Hopkins in 1907 had established that the actual contractile process in muscle is not associated with consumption of O_2 or giving out of CO_2 but that the only demonstrable change was appearance of lactic acid—the accumulation of which leads to fatigue and the oxidative removal of which means recovery. Hill improved the technique of recording minute changes in heat production by contracting muscle and began to study in detail the heat output during anaerobic contractions and aerobic recovery. He established that there is a direct relationship between tension developed and heat given out, that the heat output or tension developed is proportional to the initial length of the muscle fibre and not to its volume and independent of the rate of stimulation. He calculated the mechanical potential energy to be $\frac{1}{2} Tl$ (Tension-Length) which may be wholly available for being turned to external work. That is, the theoretical mechanical efficiency should be 100 per cent but was reduced in two ways viz., (a) loss of energy due to frictional causes—a contracting muscle being a viscous elastic

system and (b) loss of energy in the subsequent recovery process. Later on, he concerned himself with elucidations of time relations of events in muscular contraction, by a study of the sequence of thermal changes during excitation of muscle in absence of oxygen and of thermal changes during the subsequent oxidative recovery period. All these observations were possible on account of the construction, with the help of Hartree and Downing of a very delicate thermopile which can record changes of temperature of the order of $2.5 \times 10^{-8}^\circ C$.

A. V. Hill's work in connection with viscous elastic properties of muscles has already been alluded to his critical examination of the Fenn effect is another notable contribution. He demonstrated that the Fenn effect is found not under all modes of stimulation but depends on the original length of muscle and work done.

Adventures of A. V. Hill in various aspects of biophysics are too numerous to refer to in the article. He was the first to explain vapour pressure changes and osmotic pressure changes in muscles during activity. This v.p. changes in muscles not only leads to concentration of body fluids but is of such magnitude as to indicate an increase of 50 per cent in number of osmotically active substances in the muscle, which cannot be adequately explained in terms of the known chemical changes associated with muscular activity. Hill is therefore again in a position to prophesy that unknown reactions of considerable magnitude must be taking place in muscle during activity and must be searched for. Other interesting sojourns was the study of the steady state in muscular exercise and the state of water in tissues.

Last but not the least is A. V. Hill's contribution to the problems of nerve physiology including heat output by resting and active nerves, with the help of a still further improved thermopile which is doubly as delicate as the previous one. Action potentials of active nerves are according to Hill, due to discharge of a dielectric across a polarised surface film of the nerve fibre and the action current is itself associated with the mechanism of transmission of nerve impulse. The active element in a nerve fibre is a monomolecular film maintained in the resting polarised state with potassium ions inside and anions outside at the expense of oxidative reactions of rest. Stimulation means momentary depolarisation due to increased permeability—a discharge of electricity from in—outwards, associated with movements of potassium ions. Thus electrical excitation of nerves and electrical basis of nerve impulse transmission are put on the basis of chemical action—the so-called "chemical wave transmission in nerves".

S. Banerjee

THE THIRTY-FIRST SESSION OF THE INDIAN SCIENCE CONGRESS

THE Indian Science Congress held its thirty-first Session in the metropolis of India on January 3—6, 1944, and from all accounts, it appears to have been a grand success. The Session is memorable in many respects; for this was the first Session of the Indian Science Congress held at Delhi, which city, though the metropolis of India since 1912, has not so far ranked high in the estimation of the scientists of India as a possible venue of the Indian Science Congress during the last thirty one years. But within the last ten years, Delhi as a scientific centre has grown rapidly, thanks to the transference of the Imperial Agricultural Research Institute (originally established at Pusa, Bihar in 1905), the Board of Scientific and Industrial Research (1940), Malaria Institute of India, the Upper Air Observatory (Agra) Office and the Central Revenues Control Laboratory. The offices of the Indian Research Fund Association, the Imperial Council of Agricultural Research and the All-India Radio and the office and the museum of the Archaeological Survey of India have been there already. The non-official element in scientific talents at Delhi is still very weak, being represented only by the professors of the University of Delhi, and of its constituent colleges, but due to the energetic action of the present Vice-Chancellor, these elements are being steadily strengthened, and let us hope that when the Science Congress holds its next Session at the capital city, it would show as strong a non-official group of scientists as any other older centre of education in India.

Besides the members from different parts of India, the Congress was attended by many members of the Viceroy's Cabinet and important citizens of Delhi. Much credit is due to Sir Maurice Gwyer, the Vice-Chancellor of the University, and other university authorities particularly those of the St. Stephen's College for agreeing to accommodate the Indian Science Congress at such short notice.* The success of the Session was due to the untiring efforts of the local secretaries, Sir S. S. Bhatnagar and Prof. D. S. Kothari, ably assisted by an energetic band of volunteers. It was pointed out that this was the fourth occasion that Sir S. S. Bhatnagar piloted the Indian Science Congress as local secretary (Benares 1923, Lahore 1927 and 1939, Delhi 1944), and it was only befitting

that in recognition to his services to the Indian Science Congress, his eminence as a scientist, and his services as an organiser of Scientific Research that he should be elected as the General President of the next Session of the Congress to be held at Nagpur.

Sir Maurice Gwyer, Chairman of the Reception Committee, in delivering his welcome address, said:

"The conflict which was once supposed to exist between science and humanism is for all wise men at an end; and indeed if the aim of both is, as it must be, the spread of learning and the establishment of truth, it is strange that there should ever have been any question of rivalry between them. Each learns something from the other, each makes the other more fruitful; and from this happy union may a new generation arise, reflecting the beauty and vigour of both its parents.

Indian science has already achieved a position second to none in the world, and Indian men of science have it in their power to make a contribution to the future welfare of India almost beyond human computation. They can transform the face of India, they can multiply its wealth, they can solve the problems of ignorance and poverty; and who knows whether they may not even be able to solve the most intractable of all, India's constitutional problem? It is the earnest prayer of all who have the happiness and welfare of this country at heart that all these problems, surveyed in the calm and serene atmosphere of science by men consecrated to the search for truth and nothing but the truth, with minds free from prejudice or bias, may find a solution, or at least the beginnings of a solution, at the meetings this week in Delhi.

By the irony of circumstances, war, that great enemy of human progress, affords the most powerful stimulus to scientific research that we know; but good can come out of evil, as war is followed by peace; and that part of the world which still loves peace and still believes in human personality in the dignity of man and in honest dealing between nation and nation, will benefit hereafter from the labours of scientists to put new and ever more potent weapons in its hands to defeat the enemies of mankind. For those and for the many other blessings which, by the goodness and mercy of God, men of science have bestowed upon us, we tender them our gratitude; and we hope that their labours this week and the discussions and contacts which a gathering like this makes possible will bear fruit a hundred-fold."

Just before the Congress formally started, the gathering was temporarily converted to a meeting of the Royal Society of London, and Prof. A. V. Hill, Secretary of the Royal Society, who has come out to India on a tour of goodwill mission, on whom the authority of a Vice-President of the Royal Society was conferred, performed the pleasant function of admitting two newly elected Indian Fellows, Sir S. S. Bhatnagar, and Prof. H. J. Bhabha, formally to the Royal Society.

* The Congress was to be held at Trivandrum but the programme was upset at the last moment due to transport difficulties.

The Session was then formally opened* by H. E. Viscount Wavell, Viceroy of India, with the following speech :

"India, one of the oldest civilisations, has perhaps felt the impact of modern science later and less than any other great people. A large proportion of her population still lives the old life untouched by the vast changes of this century. Her realm has been of the spirit rather than of the earth. It may be said of the West hereafter that we took too much from India materially and too little spiritually.

But if India is to play the part in the world to which her size, her population, her history and her position entitle her, she too must make every possible use of scientific advancement. She has already produced many great scientists, she bears many more in her fertile womb. Her contributions to science have always been on the side of peace and progress. She was everything to gain by combining modern science with her old culture, her traditional outlook should enable her to make an increasingly fine and characteristic contribution to natural knowledge. Indian science has, in fact, made a very remarkable stride forward during the last 25 years, as is shown by the foundation of many new societies, new journals and new departments of science in Universities and under Government.

In this war science has played a great role in India as elsewhere. It has made a splendid contribution to maintaining the health of the fighting men, through the activities of such bodies as the Malaria Institute, the Indian Research Fund Association, the Nutrition Laboratories at Coonoor, and others. It has also played an important part in munitions production and in solving problems of supply. As a ex-Commander-in-Chief, I should like to thank Indian science for the invaluable assistance it has given to the armies in the field.

It must play a great part also in post-war development. The coming years will be vital to India. She must learn to make use of her abundant resources with the aid of science, which is the most international of all human interests. Professor Hill has himself said in an address elsewhere : 'I believe that the pursuit of knowledge for the welfare of mankind is one of the greatest agents for goodwill between men in every land.' It is in that belief that he is here to-day.

This session of the Indian Science Congress has a momentous task to perform; to discover how best to bring the aid of science to the development of India's great resources in agriculture and industry, to the improvement of health and to social advancement and prosperity. This Science Congress is a body of high repute, with a great and growing membership and influence. Gentlemen, I wish all success to your deliberations.

Prof. S. K. Mitra, General Secretary of the Science Congress in thanking the Viceroy said :

We are extremely grateful to His Excellency the Viceroy for coming here this morning to open the proceedings of the Thirty-first Session of the Indian Science Congress. It has been customary in all ages and in all countries for the royalty and the wealthier section of the community to be the patrons of arts, science and learning. It is therefore but proper and natural that His Excellency, as representative of His Majesty the King Emperor, should come here to inaugurate our Proceedings. We would, however, love to think that His Excellency is in our midst today not as

* It has been a general custom that the Indian Science Congress is formally opened by the Viceroy, whenever available, or in his absence by the Governor of the Province or ruler of the State in which the Congress is held.

a matter of duty—because he represents the Crown—but because he is a soldier and he thinks the scientists as his comrades-in-arms, who have helped him in fighting the Axis powers abroad, and who would now help him in fighting the Axis combination within the country—the combination of Poverty, Ignorance and Disease. Ladies and gentlemen, His Excellency has already, some time ago, referred to the urgency of fighting and exterminating this combination. On the eve of his departure from England, His Excellency said at the Pilgrims luncheon : "It has always seemed to me a curious fact that money is forthcoming in any quantity for the war, but that no nation has ever yet produced money on the same scale to fight the evils of peace—poverty, lack of education, unemployment and ill-health. When we are prepared to spend to this end, our money and our efforts as freely and with the same spirit as against Hitler, we shall really be making progress. In the country to which I go, these evils of poverty, lack of education and disease have to be met on possibly a greater scale than any where else. Ladies and Gentlemen, in the name of the Indian Science Congress Association, which is a representative body of scientific workers in India, I can assure His Excellency, that the scientists of this country, are always eager to lend their fullest support to his efforts in fighting these evils which act and react on each other in a vicious circle in this ancient and unfortunate land of ours. Ladies and gentlemen, will you now kindly join me in very sincerely and heartily thanking our soldier and fighter Viceroy for his interest in the Indian Science Congress and for the trouble he has taken, in spite of his multifarious duties, to come over here to open our proceedings.

The following messages of welcome were received from the Rt. Hon'ble Mr Winston Churchill and Field-Marshal Smuts respectively through Prof. Hill.

(1) "I am very glad to have the opportunity to send through you my greetings and good wishes to Indian men of science and especially to the six Indian Fellows of the Royal Society, of which I am honoured to be myself a Fellow.

"It is the great tragedy of our time that the fruits of science should by a monstrous perversion have been turned on so vast a scale to evil ends. But that is no fault of science. Science has given to this generation the means of unlimited disaster or of unlimited progress. There will remain the greater task of directing knowledge lastingly towards the purposes of peace and human good. In this task the scientists of the world, united by the bond of a single purpose which overrides all bounds of race and language, can play a leading and inspiring part."

(2) "I am much interested to hear of your coming mission to India, and feel certain that you will be able while there to place your large and varied scientific experience at the disposal of the Government and other organisations in all matters in which science plays a part. There as elsewhere scientific research in relation to industry, agriculture, war and in other directions is of paramount importance, and you will find a rich field for your knowledge and energy.

I am specially interested to know that you will probably attend a meeting of the Indian Science Congress, and will also act on behalf of the President of the Royal Society in admitting to the Fellowship of the Society a number of distinguished Indian scientists. As a past President of the parent British Association for the advancement of Science, and a senior Fellow of the Royal Society I should like to express through you my congratulations and cordial good wishes to these gentlemen on their becoming members of the greatest and most famous scientific society in the world.

In the great forward movement of India in our day, which is so universally acclaimed, there is nothing more outstanding than the part her sons are taking in science and scientific research, and some of the most notable advances in physics, mathematics and the biological sciences have come from Indian workers. Among them the names of our Indian F.R.S.s—Raman, Saha, Sahn, Krishnan, Bhabha and Bhatnagar are known over the whole world of science and have added lustre to India even outside the domain of science. It is therefore fitting that your scientific mission of goodwill should also be the occasion of honouring these scientific sons of India and conveying to them the congratulations of the whole scientific world."

A number of public lectures, and symposia were arranged, list of which is given in the appendix. The public lecture which excited the greatest interest was the one delivered by Prof. A. V. Hill, F.R.S. on 5th of January, 1944. The lecture is reproduced elsewhere in this issue with our editorial comments.

The Science Congress week affords an opportunity for scientists for all parts of India to assemble at one place for one week, to exchange views and establish personal contacts. It is also the occasion for all the important learned societies to hold their annual functions. A list of such functions which were held at Delhi is given in the appendix. Full members and Session members attended the Congress and in spite of transport difficulties from which Delhi suffers, the local authorities spared no pains in arranging for excursions and providing other social amenities.

The National Institute of Sciences, the premier learned body of senior scientists in India, held its annual session at Delhi on the 29th and the 30th December 1943, under the presidency of Sir J. C. Ghosh, and held a symposium on the proposed National Research Council for India. The symposium was attended by 55 Fellows, and 35 representatives of learned bodies from all parts of India. The National Institute of Sciences passed a series of important resolutions on the Aims and Objectives of a National Research Council of India, on its constitution and on the formation of research committees and recommended that, following the practice in the United Kingdom, one per cent of the national budget should be set apart for scientific research. We also understand that the authorities of the National Institute of Sciences are in correspondence with the Government of India regarding the acceptance of these resolutions.

Some of the presidential addresses delivered in the sections will be published in our subsequent issues as the space permits.

APPENDIX

1. Titles of Addresses of Sectional Presidents :
Mathematics & Statistics—'Fundamental Equations of Quantum Mechanics,' by Prof B. M. Sen.
Physics—'Cold Dense Matter,' by Dr D. S. Kothari.

- Chemistry*—'Some Aspects of Modern Inorganic Chemistry,' by Prof R. C. Ray.
- Geology & Geography*—'The Bombay Island,' by Dr A. S. Kalapesi.
- Botany*—'Progress of Botany with Special Reference to Economic Plants,' by Dr T. S. Sabnis.
- Zoology & Entomology*—'The Golgi Apparatus,' by Prof. Vishwa Nath.
- Anthropology & Archaeology*—'Truth in Anthropology,' by Mr Verrier Elwin.
- Medical & Veterinary Sciences*—'Medical Education,' by Prof. K. V. Krishnan.
- Agricultural Sciences*—'Some Aspect of the Present and Post-War Food Production in India,' by Rao Bahadur D. V. Bal.
- Physiology*—'Harmony and Rhythm in Nature,' by Prof S. N. Mathur.
- Psychology & Educational Sciences*—'The Practical Aspects of Educational Reconstruction in India,' by Mr John Sargent.
- Engineering & Metallurgy*—'Industrial Research,' by Mr J. J. Ghandy.

2. The following discussions were held in the various sections :

- (a) Food Economics.
- (b) Ethnology in Indian Museums.
- (c) The Manufacture of Photographic materials in India.
- (d) Mental life as pictured in contemporary psychology.
- (e) Locusts and the species problem.
- (f) Science and Practice of Soil tillage in India.
- (g) Biological assay of drugs in India.
- (h) Electro-Chemical Industries.
- (i) Correlation of Stone Age Culture of India.
- (j) Achievement Tests and Accomplishment quotient on their educational applications.
- (k) Zoology and the Food Problem.
- (l) Methods for the Improvement of Yields of Paddy in India.
- (m) Insecticides.
- (n) Standardisation of certain terms in Indian Geology.
- (o) Position of Physiology as an independent Science.
- (p) The need of Eugenic studies in India.

3. The following learned societies held meetings as follows :

- (a) Annual Meeting of the Society of Biological Chemists, India.
- (b) Annual Meeting of the Indian Physical Society.
- (c) Annual Meeting of the Indian Psychological Association.
- (d) Annual Meeting of the Physiological Society of India.
- (e) Annual Meeting of the Entomological Society of India.
- (f) Annual Meeting of the Indian Botanical Society.
- (g) Annual General Meeting of the Indian Pharmaceuto Association.
- (h) Annual Meeting of the Indian Society of Soil Science.
- (i) Annual Meeting of the Institute of Chemistry of Great Britain and Ireland (Indian Section).
- (j) Meeting of the Indian Ecological Society.
- (k) Annual Meeting of the Indian Chemical Society.
- (l) Conference on Food and Nutrition under the auspices of the All-India Nutrition Board.

4. Popular lectures were delivered on the following subjects :

- (a) Architectural Education in India.
- (b) The Scientific Organisations—Official and Non-official—in the United Kingdom.
- (c) Food and the Food Crisis.

5. There was a symposium on 'Place of Science in the Indian Educational System' under the auspices of the 'Sub-Committee on Science and its Social Relations'.

6. A special broadcast talk was given by Prof S. K. Mitra, General Secretary of the Indian Science Progress Association, on 'Indian Science Congress—its forthcoming session from Delhi station on 2nd January, 1944.

STATE CONTROL AND ORGANISATION OF THE MISSISSIPPI RIVER BASIN

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THE drainage basin of the Mississippi comprises 1,240,000 sq. miles (which is some 16 times the area of Bengal) and includes more than 40 per cent of the total area of U. S. A. About 13,000 sq. miles of the above total drainage basin cover two Canadian Provinces. The very existence and well-being of a considerable part of U. S. A. depend, therefore, largely upon the proper maintenance of the river-system. Although some general studies of the rivers were made in the earlier part of the last century, and earlier still, it is since 1861 that more thorough and systematic investigations were undertaken by the Mississippi Engineers. In those days attentions were paid on the regular survey of the rivers, with special reference to their discharge rates, methods of levee (embankment) construction, bank protection, effect of training works, change of river course, etc.

The entire drainage system of the Mississippi and its tributaries embraces six great natural divisions as detailed in Table I. (See also the map annexed, fig. 1).

TABLE I
SIX DIVISIONS OF THE MISSISSIPPI BASINS

Drainage systems of the Mississippi.	Percentage of total basin area	Slope (ft. per mile)	Flood Section (in thousand sq. ft.)	Max. discharge (cusecs)	Min. discharge (cusecs)
Ohio Basin ...	16	0.44	150 to 200	1,233,000	42,000
Upper Mississippi Basin ...	13	0.59	100	337,000	25,000
Missouri Basin ...	43	0.97	75	370,000	19,000
Arkansas Basin ...	15	0.62	50	460,000	4,000
Red River Basin ...	7	...	...	228,000	4,000
Central Valley ...	6	0.35	...	373,000	...
				At St. Francis*	

It may be mentioned that though the Missouri-Mississippi is a very long river (4250 miles) compared to the Ganges-Brahmaputra system (Ganges 1550

* A very high flood discharge of 580,000 cusecs was recorded at this station in 1897. (cusec = 'cubic feet per second').

miles, Brahmaputra 1800 miles) the total amount of water discharged by the Ganges-Brahmaputra system is far larger than that of the Missouri-Mississippi. The maximum flood discharge of the Ganges near Sarah (before the confluence with the Brahmaputra) is 2 million cusecs,* and the minimum is about 50,000 cusecs. These figures are almost equal to that of the Mississippi near its mouth. The discharge of the Brahmaputra has not been measured but it is probably fifty per cent higher than that of the Ganges. The total water carried by the Ganges-Brahmaputra system (4 to 5 million cusecs) into the Meghna, therefore, exceeds that of the Mississippi system at its mouth which is some 2,850,000 cusecs.

EARLIER MAPS AND SURVEYS OF THE MISSISSIPPI BASIN

The history of the discovery of the Mississippi river by the people of the old world dates to the voyage of Columbus. The "Admiral's Map" in the Royal Library at Madrid furnishes the evidence that the mouths of the river were seen by Columbus in his fourth voyage which he launched from Spain in March, 1502. The map appears to have been engraved in 1507.

More detailed voyage through the interior of the river and its tributaries was undertaken by the Spanish party headed by Hernando de Soto in 1539, and that is why De Soto is commonly believed to be the discoverer of the river. De Soto died on April 17, 1542 of malaria when they reached the confluence of the Red River. His party, however, continued the expedition up to the mouth of the Arkansas River and came down and settled at Tampico.

Garcilaso de la Vega in his history of De Soto's expedition described a heavy flood of the Mississippi below the confluence of the Arkansas River, which the Spaniards witnessed. The flood began on 10th March, 1543 and cresting about 40 days later. By the end of May the river had returned within its banks, having been in flood for approximately 80 days.

* A maximum of $2\frac{1}{2}$ million cusecs was recorded in 1910.

After De Soto's voyage the Spaniards apparently lost interest in the Mississippi expedition, when the French made further systematic survey. Radisson and his brother-in-law Croseilliers explored in 1655-56 near what is now known as Prairie Island. Joliet and Marquette were deputed by the Governor at Quibec, to survey the mouth of the great river for the expansion of his territory. Their expedition was conducted between May 17 and July 17, 1673. In August 1678, La Salle set out from Lake Michigan, thence down the Illinois River. On February 6, 1682 the Mississippi River was reached, and two months later, on April 6, they reached the Gulf of Mexico.

The credit of the discovery of the Lake Itasca, the source of the Mississippi River, goes to Mr Henry R. Schoolcraft who discovered it in July 13, 1832.

Among the earlier maps, those prepared by Lieut. Ross (1765), Capt. Philip Pitman (1768) and Gen. Victor Collot (1796) are extremely valuable. Maps, however, were drawn still earlier by De Lisle (1718), and Marquette's map is probably the first one (1673) ever made which extended from Mackinaw to the mouth of the Arkansas River.

Another map, now preserved at the office of the President, Mississippi River Commission, at Vicksburg, was drawn by one Mr William Wilton in 1774, covering a part of the Mississippi from Manchac to the River Yazoo.

The use of water level gauges on the Mississippi dates back to 1798 when the first gauge was established at Natchez by the Governor Winthrop Sargent.

The history of building levees or protection embankments on the Mississippi may be traced early in eighteenth century with the first settlement on the the lower Mississippi valley. The engineers built up by 1727, levee or dyke of length 5,400 ft. in front of the city of New Orleans which has a very low elevation and is liable to overflowing.* The dykes were extended with the settlements, and each planter was required to complete the levee along his own river front. By 1735 the levee line extended along both banks of the river for a distance of 30 miles above the city and 12 miles below. By 1844 the levee ran, on the right bank, from 12 miles below the city of New Orleans up to the mouth of Arkansas River, which means a length of about 300 miles. On the left bank the levee ran up to Baton Rouge.

By 1820 the period of discovery and settlement had come to a close. The Mississippi River was now

* The condition of New Orleans may be compared to that of Holland, and to any low-lying country of the Lower Bengal. The sewage of such countries has to face great difficulties. The water of the drainage system and that of rain cannot be led out by the natural slope of the country so that these have got to be pumped out into any adjacent stream. Calcutta is also faced with similar problem.

entirely within the territorial limits of the United States. The lower valley was comparatively well settled especially in its southern areas. A levee system for the control of its floods had definitely begun. River commerce flourished, with a consequent need for navigation improvement. National attention was directed to the river.

MISSISSIPPI PROBLEMS TAKEN UP BY U. S. GOVERNMENT

The Federal Government of the States was interested in the wide system of waterways of the country and took up, for the first time, the navigation problems in the Mississippi in 1820. In this year the Congress appropriated a sum of 5,000 dollars for the preparation of maps, and other preliminary survey of the Mississippi and Ohio rivers. Navigation improvements was first authorised by the Act of Congress in 1824 when the sum of 75,000 dollars were given for the removal of snags* in the Mississippi river below the mouth of the Missouri, and in the Ohio river below Pittsburgh. This and later appropriations for navigation improvements were expended under the direction of the Chief of Engineers, U. S. Army. In 1837 the improvement of the mouth of the Mississippi for the sea-going vessels was undertaken by Congress.

About the middle of the last century the problems of the river, harbour and navigation were perceived to be of deep scientific nature, so that engineers and scientists were recruited for the purpose. In 1843 Professor J. L. Riddell began experiments on the problems of silt carried by river streams. In 1849 Lieut. R. A. Marr of the U. S. Navy, performed series of sediment observations on the Mississippi River near Memphis.

Although the U. S. Government was at first interested only in navigation problems of the country, they felt that the question of flood control is also of great national interest and is an allied problem. The flood havocs of 1849 and 1850 lead to the Swamp Acts. "By the Swamp Acts of 1849 and 1850, the National Congress granted to the several states all unsold swamp and overflowed lands within their limits. Under the provisions of the Acts, funds accruing from the sale of these lands by the states were to be applied to the prosecution of drainage, reclamation, and flood control projects. Louisiana, Mississippi, Arkansas, and Missouri organised offices for the sale of these swamp lands and appointed com-

* These are trees and branches of various size, carried down the river by its flood. They are sometimes as large as 30-40 feet with colossal roots spreading some 20-30 feet. Sometimes they anchor themselves so firmly that they have got to be sawed out or blown up by small dynamite charges. They are removed by specially designed snag boats.

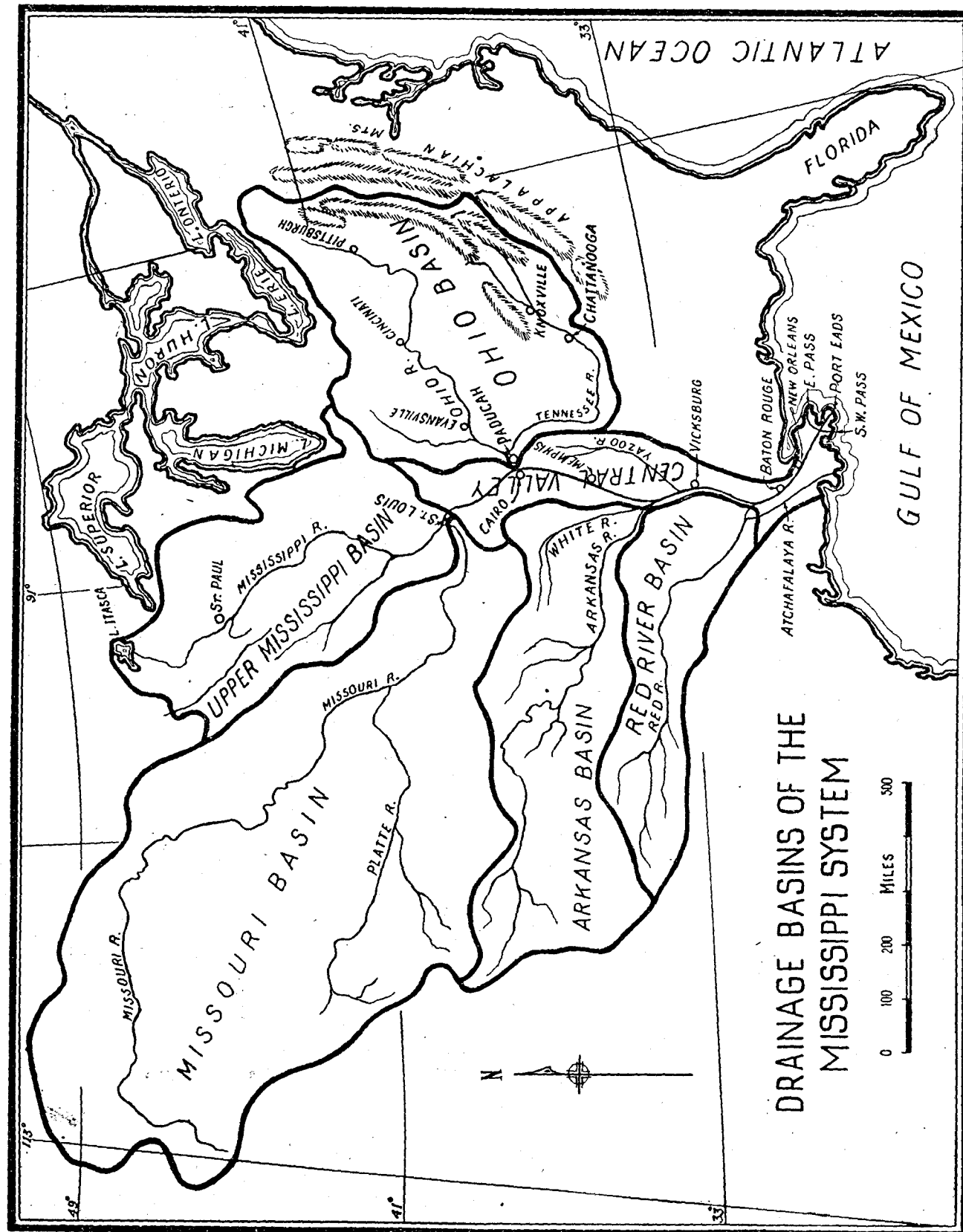


FIG. 1. Six divisions of the Mississippi system.

missioners for the construction of levees. As might have been expected, however, this attempt to secure effective flood protection failed due primarily to the lack of co-ordination among the different states and districts. Within the few years following 1850 some effort was made to secure necessary co-ordination by the passage of laws standardizing levee construction."³ (p. 8)

In 1850 the Secretary of War directed Mr Charles Ellet, Jr., an engineer, to make surveys of the rivers Mississippi and Ohio so that a proper method of flood control may be planned. About the same time Capt. A. A. Humphreys of the Corps of Engineers, and Lieut. Henry L. Abbot made a detailed survey of the lower reaches and prepared the Report on the Delta Survey. A sum of 50,000 dollars was granted for the Delta Survey and the final Report was submitted in 1861 and is published under the name "Report upon the Physics and Hydraulics of the Mississippi River; Upon the protection of the Alluvial Region against overflow and upon the Deepening of the Mouths".

Although studies have been made on the river and its floods, no very satisfactory gauges in adequate number were found to exist for accurate recording of the floods or low water conditions. The Resolution of Congress dated February 21, 1871, directed the Secretary of War to establish gauge stations at important points on the river and its tributaries.

The disturbances of the Civil War practically stopped the activities of the river training works between 1860 and 1867. There was, therefore, great damages on the levees in the floods of 1862 and 1865, which remained unattended. The flood of 1874 caused considerable damage on the levee system in the low valley, and as a result, a board of engineers known as "Levee Commission" was directed to examine the system and to submit a plan for the reclamation of the Alluvial Valley.

The lowest reaches of the Mississippi near the Gulf, offered great problem of maintaining the depth of channel for the vessels. The River and Harbour Act of March 3, 1875 authorized Mr James B. Eads and his associates to build jetties and other works in the South Pass for the purpose of obtaining and maintaining a ship channel. Mr. Eads worked with great success and they built the Port Eads at the mouth of the Mississippi on the Gulf.

THE MISSISSIPPI RIVER COMMISSION

The Mississippi River Commission was organised in 1879. The Commission provides funds for systematic survey of the rivers in order to collect physical data for developing river training methods on

scientific basis. "The final object of the expenditure and their investigations is the improvement of the low water channels of the river and the protection of the country from flood."

As the river and its tributaries flow through more than one state or province, the task of training them cannot, obviously, be laid on a single State. It is therefore a joint concern of the individual states as well as of the Central Government the Congress. It will thus be seen that there exists a sort of dual control over the river training organisation. "The Commission are practically the advisers both of Congress and of the local States, though they have no control over the expenditure of the latter. It is however, said that all concerned work together most harmoniously for the common good

"The Commission consists of three officers of U. S. Corps of Engineers, two Civil Engineers, one Officer Coast Survey, and one representative of the legal profession, with an officer of the Corps of Engineers as Secretary. The office of the President of the Commission is in New York, but that of the Secretary is in St. Louis. (The head quarters of the Mississippi River Commission have been shifted to Vicksburg since 1928). In addition to his Commission duties the Secretary has the management of discharge observations and dredging, as well as the direction of the survey operations. The President of the Commission is the senior member belonging to the Corps of Engineers."¹ (Notes on the Mississippi, F. W. Wawson.)*

WIDENING THE SCOPE OF THE MISSISSIPPI RIVER COMMISSION.

Prior to 1881 the jurisdiction of the Mississippi River Commission was restricted to the lower basin of the river. The River and Harbour Act of March 3, 1881 provided for extension of the Commission's operations and jurisdiction to the tributaries for the perfection of the general and permanent improvement of the river. Then, the year 1882 is also significant as marking the beginning of the levee work by the Commission.

More and more responsibility was given in the hands of the Commission as it was operating in a very effective manner. The floods of 1897, 1912 and

* Mr F. W. Dawson was the Executive Engineer, Bombay, on special duty. In the preface of the volume he writes "The notes were prepared by the writer while on special duty on the Mississippi River for a period of six months under the orders of the Government of Bombay, the object of his deputation being to study the practice of the Mississippi Engineers with a view to recommending the adoption of such of their methods of scientific research and engineering principles as might be suitable to the Indus River.

1913 called for special attention regarding the methods of flood control. In the year 1914 concrete revetment was tried under the Commission and proved to be extremely efficacious though very costly. The River and Harbour Act of July 27, 1916 entrusted the Mississippi Commission with the control of the Ohio river for about a length of 100 miles.

It was, however, gradually appreciated that the jurisdiction of the Mississippi Commission should be wider enough to cope with the problems, the roots of which are seated in the extensive reaches of the entire basin. Consequently, the so-called Flood Control Acts (1917, 1923) widened the jurisdiction of the Commission to almost boundless extent, for, we read in the Report of the President, Mississippi River Commission, "The Act of March 4, 1923, stated that the Commission jurisdiction for flood control work extended from the Head of the Passes to Rock Island, and up the tributaries and outlets of the Mississippi River so far as they might be affected by Mississippi River flood waters".³ (p. 19)

"The present flood control operations include the establishment of a hydraulic laboratory. This laboratory known as the *Waterways Experiment Station*, is situated at Vicksburg under the direct supervision of the office of the President of the Mississippi River Commission. Here experiments and studies are carried on. The solution of river problems by the use of models is undertaken on a large scale. The establishment of the laboratory does, however, provide for the systematic and continuous prosecution of such work and insures the preservation and proper evaluation of results"³ (p. 21). The Waterways Experiment Station covers an area of some 250 acres where the physics and engineering of the Mississippi River is elaborately studied in order to evolve methods of flood control, navigation, irrigation, etc. There are dozens of such hydraulic laboratories in U. S. A. to look after their rivers which are the great assets of the country.

OTHER RIVER ORGANISATIONS

The different parts of the river and its tributaries have been put in charge of relevant bodies, for instance, "From Port Eads to the head of the Passes the river works are in charge of an officer of the Corps of U. S. Engineers, directly responsible to the Chief of Engineers, U. S. Army. From the head of the Passes to Cairo, a length of 1,060 miles, the expenditure of appropriations granted by Congress is under the control of the Mississippi Commission, who are responsible to the Chief of Engineers for the conservation of this length of the river, known as the

Lower Mississippi. From Cairo to the mouth of the Missouri River constitutes a separate charge held by an officer of the U. S. Corps, under the Chief of Engineers, the present incumbent, Major Handbury, being also a member of the Mississippi and of the Missouri Commissions. The Missouri is managed by a separate Commission. The other tributaries are held as separate districts by officers of the Corps of Engineers directly under the Chief of Engineers."¹

Though not included in the Mississippi system, the Colorado River Commission in California is responsible for taming the river and for the construction of world's largest the Boulder Dam.

SOME OF THE RECORD FLOODS IN THE MISSISSIPPI

The following table shows the flood discharges recorded in several years.

TABLE II
FLOOD DISCHARGES IN THE MISSISSIPPI BETWEEN
ST. LOUIS AND COLUMBUS

Year	Mississippi discharge at St. Louis (cusecs)	Ohio discharge into Mississippi (cusecs)	Mississippi observed at Columbus (cusecs)
1897	283,000	1,240,000	1,462,000
1903	377,000	1,016,000	1,483,000
1912	592,000	1,110,000	2,015,000
1913	323,000	1,395,000	2,015,000
1922	311,000	1,137,000	1,501,000
1927	800,000	814,000	1,728,000

The flood of 1927 was extremely devastating when two major flood waves preceded the maximum wave from Cairo to Carrollton. In the States of Kentucky, Tennessee, and the northwestern part of Alabama precipitation averaging 9 to 11 inches was experienced during the month of December, 1926. This excessive rainfall caused a maximum stage of 26'1 feet and a discharge of 413,000 cusecs in the Tennessee River at Florence, Ala (a distance of 256 miles above the mouth) and a stage of 56'1 feet and a discharge of 235,000 cusecs on January 1, 1927, in Cumberland River at Nashville, Tenn. (193 miles from its mouth). Rapid rises in all Arkansas streams and in the Yazoo River also ensued as a result of the heavy December rains in Arkansas and north-western Mississippi.

In the Lower Mississippi Valley 18,268,780 acres or about 30,500 sq. miles of land were completely flooded. Over 800,000 people were driven from their homes, 313 lives were lost, and the total damage to

properties was estimated to be 60 million pounds or some 90 crores of rupees.

TABLE III

FLOOD DISCHARGES OF THE LOWER MISSISSIPPI IN 1927, AND THE MAXIMUM PROBABLE FLOOD ANTICIPATED IN THE FLOOD CONTROL PROJECT—ACT OF MAY 15, 1928.

Station	Flood Discharge (cusecs)	Max. Probable Flood (cusecs)
Cairo	1,800,000	2,250,000 to 2,400,000 (a)
Helena	1,698,000	...
Arkansas City ...	2,472,000	2,850,000 (b)
Vicksburg	2,278,000	...
Red River Ldg. ...	1,779,000 (e)	1,500,000 (c)
Carrollton	1,730,000	1,250,000 (d)

Notes: (a) Birds Point New Madrid floodway will carry 450,000 cusecs of this discharge.
(b) Of this aggregate discharge, from 900,000 to 1,250,000 cusecs will be carried down the Boeuf floodway.
(c) In addition to this discharge down the main river channel 1,500,000 cusecs will be carried down the Atchafalaya floodway.
(d) In addition to the discharge past Carrollton, the Bonnet Carre' floodway (above Carrollton) will carry 250,000 cusecs.
(e) Does not include discharge down Atchafalaya River.

METHODS RECOMMENDED FOR RIVER TRAINING

In 1931 a review on the flood control of the Mississippi was prepared by the Chief Engineer, War Department, U. S. A., in collaboration with all authorities which come under his direction, which consist of the division engineer, Lower Mississippi valley division, assisted by his district engineers; the Mississippi River Commission; and finally the Board of Engineers for Rivers and Harbours. Other bodies including the U. S. Agricultural Department also co-operated. This report containing technical data and costing on the projects, etc. was submitted to the Committee on Flood Control of the House of Representatives of the Congress.

The main lines of recommendations of the various bodies may be summarised as follows:

1. *Levees or Protection embankments.*—Although the protection embankments are essential for keeping the flood waters in bound in its main course, their efficacy is limited. The report of the Board of Engineers for Rivers and Harbours notes "Levees high enough and strong enough for this purpose (flood control) would be impracticable from an engineering standpoint, would be prohibitive in cost, and would greatly increase the flood hazard."² (p. 25).

As we have reviewed in its history, the embankment system is very old so that their maintenance or

some new constructions are comparatively easy.* Levees of compromising dimensions, along with other methods of river training, have been generally recommended.

2. *Floodways and spillways.*—Leveed channels to lead off excess flood waters are effective to reduce the thrust of flood. This would effectively include canal system for irrigation.

3. *Reservoirs.*—"This method of flood control was considered at great length in the preparation of the original report. The whole Mississippi watershed was studied. It was found that a system of reservoirs could be built on the headwaters of the tributaries of the Mississippi which would make substantial reductions in the flood heights on the river, but the cost of such reservoirs would be well over a billion dollars."² (p. 24).

According to the report of Brig. Gen. T. H. Jackson, Division Engineer, Lower Mississippi Valley Division, we find about 270 dam sites were investigated in White River, Arkansas river and Red River basins. Of 13 possible sites on the White River basin, the most desirable combination consisting of eight reservoirs would cost 123,835,000 dollars. This system would reduce flood heights on the Mississippi for a 1927 flood 2'35 feet at the mouth of the White River. The storage provided 10,464,000 acre feet (1 acre-ft. = 43,560 cu. ft.) would reduce the contribution of the White in a 1927 flood 164,000 cusecs.

On the Arkansas basin 28 dam sites out of 130 were found to be practicable. "The system embracing the 28 reservoirs would provide a capacity of 12,730,000 acre-feet and would store only about 40 per cent of the 1927 Arkansas flood flow. Their aggregate cost would be about 137 million dollars. More complete and positive control of the Arkansas would be secured by a single reservoir located just above Little Rock. Such a reservoir would have retained the entire 1927 flood with 20 per cent capacity in reserve. Its capacity would be about 29 million acre feet, exactly equal to the maximum estimated capacity of the Boulder Canyon project, its cost 267 million dollars."² (p. 48).

On the Red River basin 13 sites were found to be suitable. "In the system of 13 most promising reservoirs selected a capacity of 31,310,000 acre-feet would be provided at a total cost of 157,018,000 dollars. . . . Such a system would retain about 80 per cent of the total maximum flow from these stream into the Red River backwater. This would reduce a 1927 flood by about 190,000 cusecs at the

* The average unit cost of levee construction is about 25 cents per cubic yard. About 201 million cubic yards were constructed between July 1, 1928 to Dec. 31, 1931, amounting to an expenditure of about 50 million dollars. (Ref. 3, p. 188).

peak of the Mississippi flood at Red River Landing and the superflood at its peak at the same point from 300,000 cusecs to about 60,000 cusecs."² (p. 48-49).

Reservoirs are becoming more and more popular in river engineering practice in America. "Reservoirs provide a method of flood control which has received wide and serious consideration. From a strictly engineering standpoint, the reservoir is perhaps the soundest method for flood control. Reservoirs may be constructed and maintained with greater certainty and safety than any other flood work."³ (p. 289).

It may, however, be noted that the large number of dams suggested in the various flood control projects could not be undertaken for execution all at a time owing to their high installation costs. U. S. A. notable for world's largest dams, builds her huge artificial lakes for flood control, irrigation, navigation, water supply and electrification, in course of many years, under long-term plans.

4. *Afforestation*.—Although afforestation of bare lands are not directly concerned with flood control, the case should be strongly recommended for preventing erosion of valuable cultivation land. The problem of soil conservation has been a very important item both in agricultural and river training sciences. The problem is more serious in the hilly undulated tracts of U. S. A. and China, and those of the peninsular countries of India. In this connection the report of the Mississippi Flood Control remarks as follows:

"There has been much discussion as to the effect of cultivation and forestry on floods. The improvement of the methods of cultivation to avoid erosion and to conserve ground water, and the forestation of bare areas, both appear to retard or diminish run-off and are to be most strongly encouraged for their intrinsic value. Their effect on floods is too indeterminate in positive result to be relied upon for a cure of the great evil of mighty flood. Yet no help should be cast away or discouraged."² (p. 5)

Not only that afforestation protects the valuable soil of the country but it also prolongs the life of the dams by holding off eroded soil, sand and detritus which might otherwise fill the reservoirs at more rapid rate.

In India the soil conservation problems are more serious for the peninsular countries (including Damodar basin) where the soil is more liable to erosion due to the nature of the soil not properly covered with vegetation and under the forces of hill streams. On the otherhand the great plains of India which take the mighty perennial rivers has the grave problem of meandering and caving of banks, and silting in the sluggish flow at the flatter plains, similar to those of the Lower Mississippi Valley.

5. *Dredging*.—Systematic dredging, particularly in the Lower Mississippi has been found to be very effective in maintaining navigation route in the lower reaches, and the method has been strongly recommended by the authorities.

6. *Revetment*.—Strengthening and stiffening of river banks below water level (revetment) has been recommended strongly but applied only sparingly towards the mouth of the Mississippi, as the cost of revetment is almost prohibitive.

THE TENNESSEE VALLEY AUTHORITY

In 1933, yet another organisation was established to tackle the problem of the Tennessee river 800 miles long, which is the largest tributary of the Ohio which, in its turn, flows into the Mississippi.

The Tennessee River influences the agricultural, economic and industrial life of the basin 40,600 sq. miles in extent and inhabited by two million people on the lower valley (agricultural) and some four million towards the upper reaches (industrial). The principal agricultural products of the valley are wheat, maize, cotton and tobacco: Dairying and sheep farming are also carried on. Mineral resources are abundant at the upper reaches where iron and copper ores are mined. Industries include iron and steel, flour, cotton-seed oil, timber, etc.

The Tennessee river creates frequent flood havoc in the basin and is similar, from certain points of view, to the hill streams of the tropics. The river rises from the Appalachian mountains and runs quite steep at the start. It has an average slope of about 1 ft. per mile between Knoxville to Chattanooga, and about 7 inch per mile from Chattanooga to Wheeler Dam. The lower valley of the Tennessee is only a few hundred feet above sea level. The upper catchment areas on the Appalachian highlands receive torrential rain from the storms coming from the Gulf of Mexico during the months of December to April inclusive. Again, thunder-storms, coming from the west, occur during the West Indian hurricane season from July through November. During these summer months the storms come without warning, release torrential downpours into the drainage areas of the Tennessee and a number of its tributaries.

"The Act of Congress in 1933 creating the Tennessee Valley Authority (T. V. A.) has granted broad powers for the fulfilment of a project, the first of its kind in American history, calling for the complete development of an entire watershed. . . . A mean annual rainfall of 51.2 inches, amounting to about 145 billion tons of water, takes its toll of the river valley annually to the extent of about 2,000,000 dollars in flood damages. Furthermore, the river has

carried downstream untold millions of tons of eroded soil during these seasonal fluctuations, building up sandbars and reducing the river's effectiveness as a navigable water-way.

extending over approximately 37 miles of river bed, is 134 feet, only 33 feet less than Niagara Falls."⁵

All the above projects are the undertakings of the Central Government and the Provincial Govern-

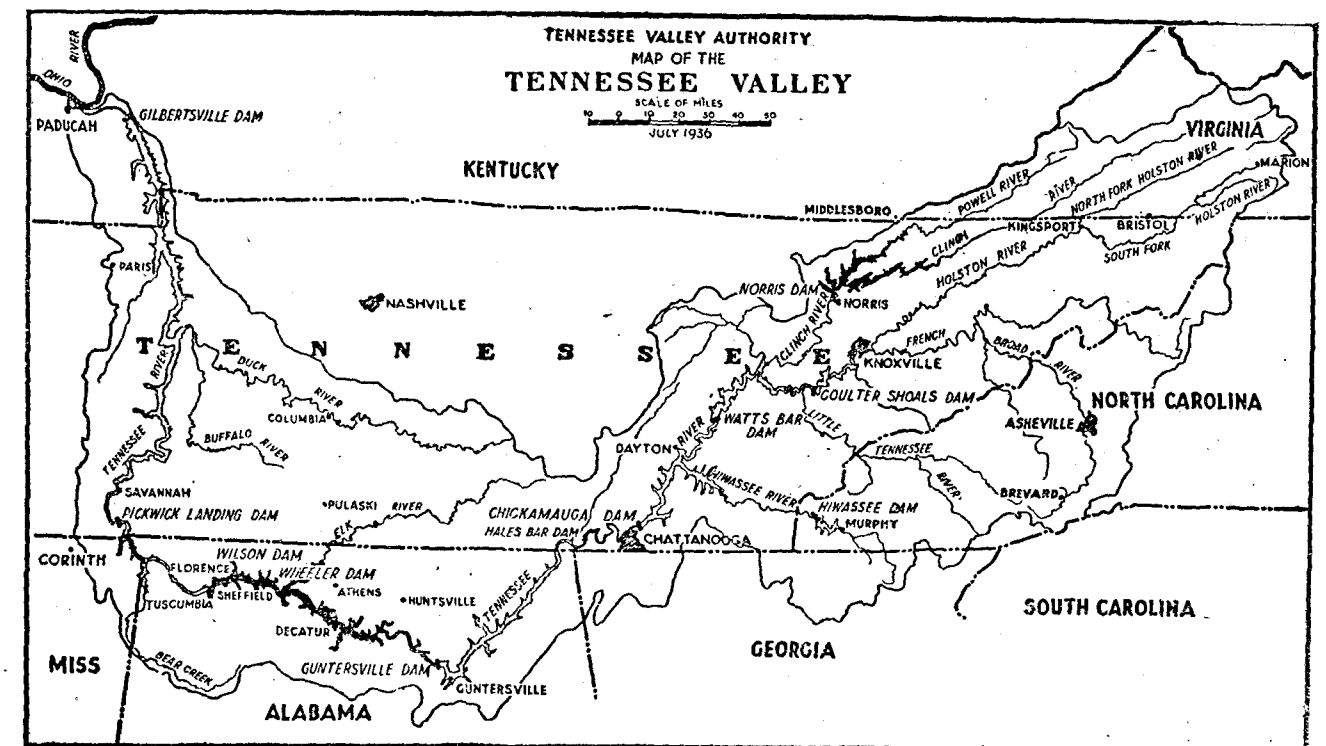


FIG. 2. Contour of the Reservoirs are shown: those completed (1936) are patched black; those under project are only contoured.—(Reproduced from 'Wonders of World Engineering', Vol. 3).

"The authority's answer to these problems is a two-way control program. On the one hand it checks erosion at the head-waters through forestation measures, and on the other, it controls the river itself through an integrated system of storage and run-of-river dams. Storage dams on the large tributaries, such as Norris Dam on the Clinch, will hold back the run-off during the rainy season, thus levelling the flow of the river for navigation and flood control. Run-of-river dams, such as Wilson Dam and Wheeler Dam, in the Muscle Shoals area, graduate the flow of the main stream through a series of long narrow lakes which further reduce flood dangers and are useful for water-borne traffic. From Knoxville, Tennessee, to Paducah, Kentucky, the Tennessee drops 505 feet; narrow stretches of deep water connected by navigation locks will carry river traffic down a gigantic stairway 650 miles in length. Wheeler lake, one of the steps in this stairway, will be 88 miles long.

"The Muscle Shoals area in the Tennessee River is one of the nation's great hydro-electric power sites. . . . The greatest fall in this series of rapids,

ments which are directly concerned, and are planned on a permanent national basis. No piecemeal work can do for the vital problems of the rivers of a country, and the cost of the remedial projects should be gauged not by its figures alone but against the recurring loss of life, property and revenue of the river basin.

Not only that 'saving' indirectly means 'earning', but also that direct returns of the outlay are obtained in various forms under the river training projects. Highways, water-works, etc. can be improved at the embarked river sides and hydro-electric power stations can be built by the side of the storage dams. For example, the Wheeler power house was planned for an ultimate installation of eight main generating units, having a total capacity of 288,000 kilowatts. Norris Dam on the Clinch River is 83 sq. miles in area to hold 3,600,000 acre-feet or 1,56,800 million cu. ft. of water which may be released when the 'mother river' drops. This will make the river perennial as well as generate about 132,000 kw. of electrical power. The estimate of the T.V.A. in 1935 showed that Wilson Dam could be utilised to generate

a maximum electrical power output of 200,000 kw. The Tennessee Valley Authority is building seven high navigation dams, with resulting benefit of flood control and water power in addition.

It should, however, be borne in mind that one and the same reservoir cannot be effectively used for flood control as well as for power production. For, a flood controlling reservoir should be kept empty to receive the influx of flood water, whereas, a power dam is required to be kept full for driving the turbines. Nevertheless, flood control dams may be well utilised, at times, for power production, when the store of water is released to emptiness. On the other hand an auxiliary power dam may also be located adjacent to a flood control dam. Norris Dam, for example, is primarily a storage dam for feeding the river with perennial flow when the mother river drops. During this period of the year, when the stored up water is released, it generates an electricity of 132,000 horse-power.⁶

ECONOMICS OF FLOOD CONTROL PLANNING

Apart from the necessity of sound technical knowledge of the hydraulics of the river which is to be controlled, the question of layout cost and maintenance cost are of serious consideration, and in most cases the economic question become the guiding factor in planning a flood control project.

As has been already said, the cost should not be gauged by its figures alone. The principle of economy requires that the costs of erection and maintenance of a remedial measure should be reasonable as compared with the value of benefits derived therefrom.

To evaluate such benefits a systematic investigation is required to find (i) total damage caused by different types of flood and their frequencies of occurrence and (ii) possibilities of further exploitation of the 'trained' river to add to the wealth of the basin.

As to the first point, the damage should include loss of agricultural products, damage to cultivation land, damage to houses and buildings, loss of live-stock, loss of human lives, damage to other properties, damage to highways, railways, bridges, etc., damage to industrial areas, loss by dislocation of traffic and transport, etc. The next point, the direct benefit obtainable by a flood control project may include improvement and establishment of water works, building of highways, establishment of hydro-electric power stations, water mills, improvement of irrigation and consequent raising of more crops, widening of waterways and river borne trade, etc.

The evaluation of the total benefit expressed in terms of money-value and its interest thereof will

immediately tell us whether a flood control plan is justified or not. Nobody would justify spending millions and billions of dollars over the Mississippi training projects, of the T.V.A. activities, or in the making of the Boulder Dam, unless he gauges the total national benefits derived out of these projects.

COMPARISON OF THE TENNESSEE AND THE DAMODAR BASINS

The natural conditions of the Tennessee River in America and the Damodar River in India are very similar. Both of them flow through extremely fertile land in the lower basin, inhabited by dense population, have rich minerals towards the upper reaches, and are visited by sudden and catastrophic floods.

The lessons taught by the Tennessee floods have evolved gigantic engineering methods to tame the fury of the river and to feed the river with perennial flow at other times of the year. The vast amount of water carried down by the river during flood months has been welcomed, during the later developments of engineering feats, to serve the people living on the basin by widening the water route, developing cheap electric power for industries, and supplying water for irrigation and drinking purposes.

The natural bed of the Tennessee river is far from being navigable as it takes a number of 'rapids' or steep slopes at many points. The Wheeler and Wilson Dams smooth out the steepest part of the river bed which drops more than one hundred feet in course of some fifty miles. Locks have been provided to manipulate the water level for navigation across such rapids. A river traffic of about 3,000,000 tons are at present carried along the river, and the T. V. A. expects to increase it to 17,000,000 tons per year by 1950.

The upper catchment of the Damodar River at the Chotanagpur hills receives torrential downpour from sudden monsoon squalls and rain storms rising from the Bay of Bengal,—a case similar to that of the Tennessee receiving violent downpours on the Appalachian highlands due to the monsoons from the Gulf of Mexico. The methods of flood control in the Damodar has been resorted only to the embankment systems which are built on *ad hoc* engineering methods (details have been discussed in a previous article published in SCIENCE AND CULTURE.⁹) No question of navigation has ever been thought of, on the ground, probably, that the river is too furious to be navigated, and is too low during other months of the year. The slope of the natural river can be controlled by putting water locks to facilitate navigation in the river.

We have seen that the fury of the flooded Tennessee has been tamed down by a chain of large

number of reservoir dams—each several miles in length, and the lower valley have been protected by levees. In the Damodar, however, no attempts have been made to construct dams at its upper reaches and on its powerful affluent the Barakar River. Two pleas were put forth against the construction of dams: first, high cost; and secondly, the possibility of water seepage into the adjacent mines in the Bihar reaches of the river and its tributaries. Subsequently, however, the objection on the geological fault of the bed was removed by the Director of the Geological Survey department, on his closer examination¹⁰ of the site (Parjori) between 1926-29. The upper reaches of the Tennessee lie in the important mining districts of U. S. A., and dams have been constructed on the river with no damage to the adjacent mines. Even if there is any chance of seepage due to faults in the rock-beds at the dam sites, they may be cured by grouting,^{8,11} with cement concrete, as has been done at the Norris Dam by the T. V. A.

The Damodar basin lies in a part of the country which demands badly a perennial stream for irrigation and navigation. It is most unfortunate that the ill-planned levee system of the Damodar has deprived the land of obtaining water from the river for irrigation, and while the tract is capable of raising a number of crops in a year it actually raises only one and that also under the constant threat of flood.

Dams constructed at the upper reaches can save both flood hazards and can prolong the flow up to the autumn crops. The problems of flood control and of making the river perennial go hand in hand and we have already seen how the T. V. A. has solved the problems. The question of navigation can be made possible to facilitate trade and transport in the important rice districts and mineral fields—coal in particular, which lie close to the Damodar basin. There is also great scope for developing hydro-electric power.

The integrated problem of flood control, irrigation, navigation, flushing of the country sides to improve malarial conditions, etc. can be tackled by an organisation of scientists and other officials to form a Damodar River Commission or the like, in the manner of the Tennessee Valley Authority or the Mississippi River Commission. Since the Damodar River and its important tributaries flow through

Bihar and Bengal, both the Provinces have got to cooperate in the improvement project under the general supervision of the Central Government. Such an organisation is badly needed to improve the Damodar basin. Hydraulic Laboratories should also be brought into existence to deal with the Damodar training problems scientifically.

CONCLUSION

The present article which reviews the activities of the Mississippi River Commission, the Tennessee Valley Authority and various other bodies, all working harmoniously to promote the condition of the largest river system of the world, shows how they have been organised by the Government of the U. S. A. on a solid national basis embodying far-sighted plans and long-term projects which are based on scientific principles. The training of the rivers and the improvement of the basins have been deeply recognised to be the responsibility of the Government of the country, as the wealth and prosperity of the country depend largely on the proper maintenance of her river system.*

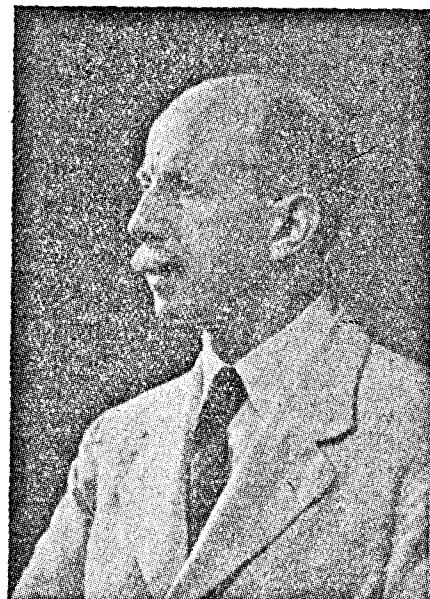
* My thanks are due to Prof. M. N. Saha, F.R.S., and Dr N. K. Bose, Ph.D., Director, River Research Institute, Bengal, for their kind interest and valuable suggestions in preparing this article.

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DR. WILLIAM BURNS

DR WILLIAM BURNS, C.I.E., D.Sc., has lately retired from the office of the Agricultural Commissioner with the Imperial Council of Agricultural Research under the Government of India. He has served the cause of agriculture in India in various capacities. After serving for a short period as assistant lecturer to Sir Frederick Keeble (then Professor of Botany in the University of Reading) he entered



DR W. BURNS.

the Indian Agricultural Service in 1908 and was appointed Economic Botanist and Professor of Botany in the College of Agriculture, Poona. Dr Burns threw himself heart and soul into the teaching of students then drawn from every corner of India and even beyond it. Many of these are now holding high positions in agricultural and revenue services of many

provinces and States. He also took active part in athletic side of the activities of the institution. He took an active interest in military training and during the last war he commanded the Poona Divisional School of Musketry until 1919 when it was demobilised. In 1922, he became principal of the Poona College of Agriculture and in 1932 became the Director of Agriculture, Bombay. In 1936, Dr Burns was appointed Agricultural Expert with the Government of India (title later changed to that of Agricultural Commissioner). He thus became one of the Head Quarters staff of the Imperial Council of Agricultural Research and in this capacity he has done very useful work not only as regards the action of the council itself but also in relation to the work of the Indian Central Cotton Committee, Indian Central Jute Committee and other bodies. In the discharge of his official duties he had to tour the greater part of India and his wide experience of agricultural condition in India and knowledge of agricultural matters have enabled him to render very useful service to Indian Agriculture. He has been a prolific writer in agricultural, botanical and horticultural matters. These papers will be found in the pages of *Indian Journal of Agricultural Science*, *Agriculture and Livestock in India*, *Indian Farming* and various other publications. He was twice elected president of the newly formed Indian Society of Plant Breeding and Genetics and delivered the presidential address to the Society in Delhi this year (1944) on the 'Teaching of Plant Genetics'. Dr Burns was awarded the D.Sc. degree of the University of Edinburgh in 1914, and the Government of India bestowed on him the C.I.E. in 1939. He relinquished the post of Agricultural Commissioner on August 22, 1943 and was thereafter on special duty for two months. His scientific contributions were mainly in the realms of plant genetics and the improvement of grass lands. He edited and wrote Section IV of the highly popular book "Sons of the Soil", of which the second edition is now exhausted and the third in the press.

Notes and News

OBITUARY

ALES HRDLICKA

ACCORDING to a report of *Science*, September 17, 1943, death has occurred of Dr Ales Hrdlicka, the distinguished anthropologist and curator of the Division of Physical Anthropology of the U. S. National Museum. A native of Bohemia, Dr Hrdlicka studied, worked and passed his eventful life in America. He received his early training in medicine and obtained a degree at the Electric Medical College of the City of New York in 1892 and another from the New York Homoeopathic Medical College in 1894. He joined the staff of the State Homoeopathic Hospital for the Insane at Middletown and also became affiliated with the Pathological Institute of the N. Y. State Hospitals.

He gradually became more interested in anthropology in which science he has left his indelible mark. In 1903, he became assistant curator and in 1910 curator of the Division of Physical Anthropology of the U. S. National Museum. In this capacity he published several original articles and books. He founded the *American Journal of Physical Anthropology*, of which he was editor from 1918 to 1942, and established the American Association of Physical Anthropologists in 1929, of which he was president from 1929 to 1932.

Dr Hrdlicka made extensive trips all over the world for field work in his anthropological investigations. He was the recipient of many honours and honorary degrees. He became Chairman of the Anthropological Society of Washington (1907), of the American Anthropological Association (1925-1926), and of the Washington Academy of Sciences (1929). He was a member of the National Academy of Sciences (1929) and of the American Philosophical Society.

SCIENTIFIC RESEARCH IN GREAT BRITAIN

IN the British House of Lords on July 20, there was a continuation of the debate on a motion by Viscount Samuel calling attention to the need for the further expansion of scientific research. Lord Dawson pointed out that "It was difficult to over-stress the importance where science was concerned—and this applied equally to medicine—of preventing the enmeshment of any research body in the close entanglement of a Government department. One of

the chief reasons why these research bodies should receive further support was that they succeeded in combining good order in the work of men of ability with freedom for scientific investigation".

Lord Cherwell said in part "that the importance, from the economic point of view, of fostering pure fundamental research could not be overlooked."

The Government recognized that pure research must be, in a large measure, its responsibility and must be done at the universities; but naturally, they also wished to encourage industry to spend money on pure research. It was the Government's policy and intention to increase its aid for research, and it would welcome any developments of industry in a similar direction. The treatment of scientists in the Civil Service had been mentioned, and he frankly admitted that the Civil Service had not hitherto shown due regard for the contribution scientists were making to the nation's welfare. This matter had now been reviewed, and an investigation had been in progress to make sure that the conditions of service, pay and prospects of Government scientific employees compared favourably with those on the administrative side. He hoped that a definite announcement on these reforms might be made before long. There were probably not more than a few dozen physicists in Great Britain capable of evolving and developing new applications of, say, the various radio devices on which success in this war very largely depended. Every one would agree that it was an anomaly to pay them on lower scales than men of equal educational status who, because they had distinguished themselves in what were usually called "humane" subjects, were often given war jobs of much higher status and pay than the scientist.—*Science*, Vol. 98, No. 2541.

The contact of research workers and research organisations with the highest administrative circles of the Government *vs.* the Cabinet has gone still higher. In course of the war, a pure scientist, Prof. F. A. Lindeman, sometime Professor of Experimental Physics in the University of Oxford, now Lord Cherwell, has been taken in the Cabinet as Pay Master General and we believe one of his functions is not to allow his colleagues of the Government to grow lukewarm about the importance of research, to get money for research and to see that basic principles which lead to efficiency are not sacrificed.

ARDESHIR CURSHETJEE—THE FIRST INDIAN FELLOW OF THE ROYAL SOCIETY OF LONDON

It was so long believed that the late Mr S. Ramanujam of Madras was the first Indian to be elected to the Fellow of the Royal Society of London. Prof. A. V. Hill, Secretary of the Royal Society, however, discovered from the archives of the society that the first Indian to be elected to this honour was one Mr A. Curshetjee in 1841. Nothing was known about him, however, and at the request of Prof. Hill, Sir R. P. Masani, lately Vice-Chancellor of the Bombay University unearthed the following life history of Mr Curshetjee.

Ardeshir Curshetjee was born in 1807 in the city of Bombay. In 1822 he served under his father in Government Dock-yard and became Assistant Builder. In 1833 he built a small steamer "Indus" in the Mazagon Dock and personally fixed up all machinery. He is reported to have made experiments in connection was gas lighting and to have fixed up all pipes and gas machinery in his bungalow at Mazagon, Bombay, and it is recorded in Parsi annals that the Earl of Clare, Governor of Bombay, inspected the installation on 10th March, 1834 and gave him a "Dress of Honour". In 1836 he was appointed non-resident member of the Royal Asiatic Society of Great Britain and Ireland. In 1839 Ardesir Cursetjee went to England for further studies in mechanical engineering. There his services were engaged by the Court of Directors of the East India Company in the workshop of Messrs. Wards and Keppel. The chronicles further state that he was introduced to Queen Victoria on the 1st July, 1840 and that he thereafter published a book of his notes regarding his travels in England. He returned to Bombay in 1841 and was appointed Chief Engineer of the Steam Factory and Foundry on a salary of Rs. 600/-. In 1839, he was elected Vice-President of the Mechanics Institute. He went to England for the second time in 1851, was made a Justice of the Peace in 1855 and retired on pension on 1st August 1857. In 1859 he went to England for the third time and in 1861 was appointed Chief Resident Engineer of the Indus Flotilla Company at Karachi, and there he built three or four steamers navigable in the Indus. In 1864, he went to England for the fourth time and passed there the rest of his life until his death on 16th November, 1877, at the age of seventy.

DAMODAR FLOOD ENQUIRY COMMITTEE

The Damodar Flood Enquiry Committee constituted by the Government of Bengal to advise on permanent measures to control floods in the Damodar river recently held its first meeting, with the

Minister for Communication and Works in the Chair. The Committee has been constituted with the Maharajahdiraj of Burdwan as its Chairman and Dr M. N. Saha, Professor of Physics, Calcutta University, Mr C. C. Inglis, Director, Central Irrigation and Hydrodynamic Research Station, Poona and Rai Bahadur Kanwar Sain of the Punjab as some of its distinguished members. An aerial map of the Damodar river covering a length of 80 miles was exhibited at the meeting.

The Hon'ble Minister, in course of his address, drew attention to this once prosperous track of Bengal, which has now become a moribund land with malaria taking a heavy toll every year. He wanted the Committee to advise particularly on the report which was submitted nearly 21 years ago by Mr Addams-Williams and Mr Glass on behalf of the Government. The above expert enquiry ordered by the Government of Bengal under pressure of public opinion lasted for over seven years, and the recommendations were published in a pamphlet issued by the Government. The recommendations, according to the Hon'ble Minister, deserve serious consideration in the working out of any future plan of action to prevent the incidence of such floods in the Damodar river. He referred to the Tennessee Valley, U. S. A., which offers the nearest parallel to the Damodar. The Tennessee Valley Authority created by the Government, in 1933, have spent within the last ten years about 37 million pounds and have erected 11 storage and navigation dams throughout the entire length of the river, which have converted the river into a great perennial navigation channel. Two huge hydro-electric plants have been erected which are producing twice as much electricity as the city of Calcutta requires, and an area of half the size of Bengal is now prosperous and happy.

In his concluding remarks, he wanted the Committee to suggest long-term remedial measures which will include not merely the protection of the Railway and the Road, but also the entire problem of protection, irrigation and health and not one of them at the expense of the other.

He further informed the Committee that the Central Government, after the Damodar Flood Enquiry Committee was announced, had also appointed a Technical Committee of three to consider this important problem. He also revealed that Mr Savage, the famous American dam expert is at present in this country and that the Government is arranging to make his advice available to the Committee.

We further understand that the Committee has recently visited the dam sites in the Hazaribagh district.

RECONSTRUCTION OF EDUCATION

THE new scheme for educational reconstruction outlined by Mr John Sargent, Educational Adviser to the Government of India, in his Presidential Address on "Practical Aspect of Educational Reconstruction" for the section of Psychology and Educational Science of the Indian Science Congress, has attracted widespread attention in this country. Mr Sargent has summarised the essential educational requirements of India in twelve points as follows:—

(1) Universal, compulsory and free education for all boys and girls from the age of 5 or 6 until 14, in order to ensure literacy and the minimum preparation for citizenship.

(2) A reasonable provision of education before the compulsory age for school attendance in the form of nursery schools and classes. This is important mainly in the interest of health, particularly in areas where housing conditions are unsatisfactory.

(3) Secondary or high school education for those children who show the capacity for benefiting by it. Probably to satisfy this requirement provision should be made ultimately in high schools of various types for not less than 20 per cent of the boys and girls in each age-group. Variety both in types of school and in the curricula of individual schools is essential to suit the varying tastes and aptitudes of the individual pupils on the one hand and the requirements of their future occupations on the other. In addition, so that no boy or girl of outstanding ability may be debarred by poverty from further education, liberal financial assistance in the form of free places, scholarships and stipends must be forthcoming.

(4) University education, including post-graduate and research facilities for picked students. It is difficult to fix a quantitative standard here but probably when a High School system as contemplated above has been fully established, about one pupil in every 15 should be found fit to proceed to a University.

(5) Technical, commercial and art education. The amount, type and location of this will necessarily be determined to a large extent by the requirements of industry and commerce.

(6) Adult education, both vocational and non-vocational of all kinds and standards, to meet the needs of those who were denied adequate opportunities in their earlier years or who recognise the importance of supplementing what they then received.

(7) Arrangements for training the vast army of teachers which a system of this kind will require.

(8) An efficient school medical service, which will see that children are made healthy and kept healthy. This means treatment as well as inspection and the provision of proper nourishment in necessitous cases. It is a waste of time and money to try to teach a child who is underfed or conscious in other ways of serious physical discomfort. Health also postulates the provision of hygienic buildings in suitable surroundings, the right kind of furniture and equipment and ample facilities for physical training and games.

(9) Special schools for children suffering from mental or physical handicaps.

(10) Recreational facilities of all kinds, to satisfy the craving for corporate activity and to counteract the drabness of the conditions in which so large a part of the Indian people otherwise spend their lives.

(11) Employment Bureaux, to guide school and college leavers into profitable employment and so far as possible to adjust the output of the schools to the capacity of the labour market.

(12) An administrative system which will place initiative and authority in the hands of those who understand and care about education.

We perfectly agree with Mr Sargent that these requirements can hardly be described as extravagant. These have been accepted as the minimum educational needs of every civilised country and, as he pointed out, have been covered by the British educational system as it existed even before the war. In many parts of the United States of America and in some European countries far more liberal provisions have been made in the field of education. He has rightly realised that the Indian problem of educational reconstruction is as colossal as it was in the case of Russia before the Revolution and should be dealt with as efficiently and quickly as it appears to have been done in that country.

Mr Sargent proposes to introduce his scheme in the form of eight five-year programmes requiring, therefore, nearly half a century before any visible result of the scheme will be forthcoming. He has estimated the cost of the scheme at about two crores and eighty lakhs of rupees annually. Thus the Government of India, if they finally so choose to give effect to his scheme, must be prepared to bear this huge expense for such a long period.

It is over this imperative question of financing the scheme that grave doubts have been expressed as to the practicability of his plan. Mr Sargent also seems to be aware of this difficulty and has suggested that it will not be difficult to solve the financial problem if the Government of India decide to divert a part of the huge expenditure now incurred on war to education in the post-war period. However sound the suggestion may be, the present foreign Government representing vested interests in India will probably find the scheme hardly acceptable on the traditional ground of paucity of funds. Similar, but far less ambitious, schemes were put forward on several occasions in the past by distinguished and capable educationists of this country. For instance, mention may be made of late Mr Gokhale's scheme of free compulsory education. But none of them has so far been found acceptable on financial grounds. Any scheme for educational reconstruction, however moderate, for a vast country like India with appalling mass-illiteracy needs must be expensive. Reconstruction in education is an important part of nation-building activity for whose promotion the Government exist. Curiously enough the Government have seldom suffered from paucity of funds in financing schemes in which they are interested, and almost invariably such schemes were remotely connected with

any nation-building activity. Only money is not available in financing projects calculated to promote national interests. From these considerations, the fate of Mr Sargent's scheme is almost a foregone conclusion, and as a daily paper puts it in its editorial comment, the scheme would be merely one more decoration for the archives of the Imperial Secretariat.

ANNOUNCEMENTS

APPLICATIONS are invited for Six Scientific Research Scholarships of the value of Rs. 150/- per month each for the year 1944-45.

The Scholarships are open to men and women, and will be tenable for a period of twelve months commencing from the 1st July, 1944. Any or all the scholarships may be extended for a further period of twelve months, within the discretion of the Trustees. All old scholars who desire renewal should re-apply.

Applicants, who must be of Indian nationality, must be Graduates in Medicine or Science of a recognised University.

The subject of scientific investigation which they may select must have a bearing directly or in-

directly on the alleviation of human suffering from disease.

Applications must be forwarded through the Director of a recognised Research Institute or Laboratory where the candidate proposes to work and must be accompanied by a letter from the Director stating that he has critically examined the details of the proposed Research, that he approves of the general plan and that he is willing, as far as possible, to guide and direct the investigation and give laboratory facilities.

Full particulars may be had from the Secretary, Lady Tata Memorial Trust, Bombay House, Bruce Street, Fort, Bombay.

We are glad to announce that a further sum of Rs. 2,500/- donated by Messrs. Adair, Dutt & Co. Ltd. has now been placed at the disposal of the Adair Dutt Research Fund Committee for the Calcutta centre, the total amount donated by the said firm being Rs. 9,000/-.

We note with great satisfaction that Prof. A. V. Hill, F.R.S., Secretary of the Royal Society, London, has been elected honorary member of the Indian Science Congress Association.

SCIENCE IN INDUSTRY

UTILISATION OF CITY SEWAGE

UTILISATION of city sewage waste has attained considerable importance in recent years as a reasonable source of several important products, such as dried sludge as a fertiliser, methane gas for operating internal combustion engines, liquid effluent for irrigation and industrial water, grease, nitrogen and a whole host of useful by-product hitherto neglected. An useful account of these by-products from sewage waste has been given in the *Scientific American*, September, 1943. The dried digested sludge resembling humus in appearance and texture is now widely used for soil conditioning and can also be used as a low-grade fertiliser. The sludge contains, as recent chemical analysis indicates, appreciable amounts of nitrogen (2.25 per cent), phosphorus (1.50 per cent) and potassium (0.70 per cent) and minute quantities of 'micro-nutrient' elements, such as boron, copper, zinc, manganese and others. Some cities of the United States are now producing high-grade fertiliser, using sludge as a base.

The sludge gas is now widely used in U. S. A. and the Continent to operate stationary internal combustion engines and also in running vehicles. According to a report of the American Society of Civil Engineers, 1000 c.c. of sludge gas having an average calorific content of 650 B.T.U. per c.c. are equivalent to 6.4 gallons of butane, or 5.2 gallons of gasoline, or 4.6 gallons of Diesel oil. In 1935, there were about 100 trucks in the Ruhr district, which were equipped to use this gas as fuel. Besides, the conversion of an oil-operated engine into one using sludge gas involves comparatively simple changes.

The war has increased the importance of sewage waste as a source of grease. It has been estimated that about 180 to 365 tons of crude fats are present in the sludge of a city having a population of 100,000 people. Several American cities, such as New York, Chicago and others are now recovering grease from their sewage disposal plants. One plant at Bradford is now alone supplying, it is reported, some 500 tons

of grease weekly. According to a process recently developed, grease is extracted by adding sulphuric acid to the sewage to crack soaps and precipitate the wool waxes. The resulting sludge is then heated and filter-pressed through cotton cloth. Liquid grease and water are obtained in this way, from which the product is finally freed from impurities.

The liquid effluent from the sewage treatment plants is now used in several places of America for irrigation purposes. The sterile soil, covering an area of over 40 acres at Vineland, New Jersey, has now been remarkably improved by distributing through an under ground tile system the sewage of this town. Further the diluted sewage effluent promotes the growth of plant algae and protozoa and has been used in Germany to improve fish culture with good results.

The consideration of such important by-products has made the question of sewage disposal extremely important. Following is the brief account of the modern sewage disposal method largely practised in U. S. A. Water carried wastes collected by the intricate net work of sewars under city streets are either discharged into neighbouring streams or brought together in a single conduit leading to a treatment plant. The plant separates the solids from the liquid and then digests the putrescible solids. Another method is to treat the liquid containing solids in solution or in suspension by aeration or filtration by which most of the offensive organic matter is oxidised and rendered innocuous. It has been estimated that one ton of sewage flow contains only about one pound of putrescible solids to be removed by treatment. A little more than 25 per cent of these solids settles out in the huge, concrete sedimentation tank provided for this purpose, the balance remaining with the liquid to be oxidised or discharged into a stream where natural processes of purification are active. From the sedimentation tank the highly putrescible material, known as raw sludge, is transferred to closed, heated tanks where anaerobic digestion takes place at a temperature of about 80°F. During this process, requiring about 30 days, the raw sludge is decomposed to produce the sludge gas containing about 70 per cent methane. The residue is stable, can be easily dried and subsequently used for soil-conditioning, as referred to above.

INSPECTION TOOLS OF GLASS

THE need for conserving valuable tool steel has necessitated designers to seek newer materials for the manufacture of gages. Outstanding of all these is glass which not only has resulted in the saving of valuable metals, but also in producing gages which outclass steel ones in many respects.

The actual production of glass gages started about one and half years ago, mainly through the efforts of the leading American Glass manufacturers and the United States Army Ordnance Department. At first their design was similar to steel gages. However, as experience accumulated, modifications had to be incorporated to suit the altered characteristics of the material, especially to the risk of chipping, facility of handling and limit breakage. Thus the original chamfered plug gages of glass have now been replaced by a levelled pilot with rounded corners, while the levelling and rounding for snap and ring gages are carried on to a considerably greater extent than in steel. Glass gage sections are generally thicker than like steel ones while the frame of the former is kept inside a wooden or plastic casing to prevent breakage. It is interesting to note that, contrary to the general impression, glass gages are neither fragile nor easily broken, while their abrasive resistance is very high, tests on a ring gage indicating that 2,00,000 passes of a steel plug result in an average wear of only 0.000065 inch.

Glass gages can be produced either by drawing, moulding or rolling as in the case of ordinary commercial glass. At present they are made from ordinary light flint and borosilicate glass, in the form of plug, ring and snap gages (varying from 1/4 inch to 5 inches in diameter); profile, position and chamber gages; and certain types of flush pin gages. With the distinct advantages they possess over their metallic prototypes in the form of greater visibility in inspection, freedom from corrosion and rust, elimination of greasing during storage and shipment, reduction in the secondary effects (and consequent increase in efficiency) due to the lower thermal conductivity of glass as compared with steel, maintenance of high functional properties even with slight scratches and chipping, and a more pronounced sense of feel, a definite place has been established for these glass tools which can be regarded as the most valuable precision instruments for dimensional control in the realm of production engineering.

S. K. G.

GEOPHYSICS AND FOUNDATION ENGINEERING

DR GARLAND, of the Geographical Seminar of Strasbourg University, defines geophysics as that branch of science which lies between pure physics on one hand and physical geography and geology on the other and which in its widest sense deals with the study of the history and constitution of the earth. Among the many branches it embodies, applied geophysics is one with which foundation engineering is directly interconnected.

Applied geophysics aims particularly in discovering the nature of the strata lying below the earth without incurring the full experience of making a direct test by shaft sinking, tunnelling or boring. Several methods have upto now been employed, the commonest being the Gravimetric, Magnetic and the Seismic. Recent advances in Soil Mechanics have, however, led to the development of the Electrical and the Electro-seismic methods of exploration. The former, which is based on Maxwell's Theory of Electrostatic Images aims in detecting the strata by means of electric currents either generated naturally as a result of the oxidation of the ores by the circulating waters and producing a difference of potential at varying points, or by artificially producing an electric current into the earth by two "current" electrodes and investigating the strata by two or at times three "potential" electrodes. By varying the distance between the latter and evaluating their results from a set of formulae developed from known strata conditions, a relation between the depth of strata and its resistivity can be obtained. Important sites for large structures such as bridge piers and dams can very well be investigated by this method provided great care is taken in the final interpretation of results. Some time back, experiments carried out in America revealed the amazing fact that if a wireless set is tuned on to a station, the strength of the signal dies down on approaching a fault and the set becomes completely silent when kept exactly over the fault-plane. Further investigations in this field will probably open out many useful and interesting applications in the domain of geophysics.

In the latter, *viz.*, the electro-seismic method, not only does the work serve to guide the drilling programme and supplement the borings with less expensive tests for the determination of the depth of the strata and its compaction condition, but also serves to determine the actual bearing capacity of the soil. The general procedure is that near a given place, vertical harmonic vibrations are set up by a one or two horse-power electric motor having eccen-

tric disks rotating in opposite directions. By changing the eccentricity the centrifugal force can be changed resulting in an increase or decrease of vibrations at various distances from the vibrator. By means of small seismographs these varying vibrations can be measured and resonance curves plotted. From these it is found that high natural frequencies and high phase-speeds indicate a high bearing capacity of the soil, the actual values being obtained from tables of phase-speeds and frequencies in relation to the respective bearing capacities of the soil obtained from a set of existing and known conditions. The dynamic bedding value (*i.e.* the pressure in lbs. per square inch required to cause an elastic vertical deflection of one inch) which is determined by the natural frequency of vibration, reveals, that as the static pressure increases the dynamic value approaches a constant maximum, a fact which is never revealed by static tests. A further useful purpose served by the vibrator is in the consolidation of the soil as compared with ordinary ramming, for, by the application of the former greater efficiency and depth of penetration can be attained.

When the work of drilling is to be supplemented by seismic methods, a portable type of apparatus can be used. With the detector placed in a line on the gravel, light dynamite charges at 3 feet depth are fired in succession at increasing distances along the line. By film records the time of arrival of the waves can be noted and results plotted as a time distance chart. By this procedure it was found in one of the dam sites, that only 400 determinations on land were necessary with results that would normally have required 15,600 feet of drilling and would have cost four times as much. A similar method seems to be applicable for the exploration in the beds of swift waters. Further advances in these geophysical methods of prospecting will open out a mine of useful information which can be beneficially utilised in foundation engineering.

S. K. G.

THE GLASS-MAKING SAND-ROCK OF JUBBULPORE, CENTRAL PROVINCE

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THE area in the neighbourhood of Jubbulpore has received attention from several geologists, particularly, J. G. Medlicott¹ and Dr C. A. Matley² whose publications comprise standard communications on this area. The glass sands which occur at a short distance to the east of the town of Jubbulpore, so far as the author is aware, have not been examined in detail, and a preliminary investigation was undertaken by the author. A chemical analysis of the Jubbulpore glass sand has been given by Messrs. Mukerji and Drane in their short note on "Indian Glass-Making Sands."

LOCALITY

The city of Jubbulpore is situated about 1,300 feet above the sea-level and towards the east, the Chui hill, the famous repository of fire clay is situated. Towards the north, this hill has a broad east-west elongation and at the northern end these glass sands are exposed at an altitude of about 1,400 feet above the sea-level and the main road leading to Shahpura runs only a little north of it. At this locality the sand-rock is being quarried at present but there are other outcrops of the same rock which occur elsewhere in the neighbourhood. On the north and across the road, the range of granite hills, locally known as Sidh Baba Ka Pahar, occurs.

THE NATURE OF THE DEPOSIT

This deposit of the sand-rock belongs to the Jabalpur Group which comprises in descending order:—

- (i) Clays of variegated colour,
- (ii) Sandstones.

The sandstones can in places be further subdivided, in descending order, as near the quarry into:—

- (i) White clean sand-rock, suitable for glass-making.
- (ii) Reddish, yellowish or brownish felspathic sand-stones.

The sand-rock is succeeded by fire-clays of various colours and grades. The latter are of whitish, yellowish, greyish and almost black colour, in places with dark carbonaceous impressions and tiny inclusions of coal. These clays have a great commercial importance.

¹ Medlicott, J. G., On the Geological Structure of the Nerbudda Valley, *Mem. G. S. I.*, Vol. II, 1860.

² Matley, C. A., On the Stratigraphy, Fossils and Geological Relations of the Lameta Beds of Jubbulpore, *Rec. G. S. I.*, Vol. LIII, 1921.

By the earlier writers, Jabalpur beds were considered to be of Middle Jurassic age but Dr C. A. Matley has suggested tentatively a Lower Cretaceous age.

The sand deposits, which are quarried for the manufacture of glass, occur about 150 yards almost due north of the temples on the Chui hill. The overburden is very small and as observed in December, 1942 it is about one foot in thickness, but in places the maximum thickness does not exceed three to five feet.

The present excavation is almost circular in form. The quarry has a length of about 200 feet in an east-west direction and a width of a little over 100 feet in a north-south direction. The maximum height of the quarry face measured 26 feet.

The rock is a white sand-rock, which is quite incoherent and friable so much so that on every handling some grains of quartz are dislodged. With the aid of a pocket lens it is seen to consist of a somewhat medium-grained particles of quartz loosely cemented together by a somewhat sparse matrix of kaolin. There are occasional specks of biotite, muscovite, hornblende and magnetite. Chalcedony, which is of markedly dull waxy, faint grey colour and sometimes occurs in large grains, is also associated. Some grains of quartz are partially coated with white kaolin. Occasionally, fine lenticles of white clay, scarcely an inch thick and a few inches in length, occur in the sand-rock. In places, where the rock is more fine-grained, the proportion of white clay increases. It has a softer touch and soils the fingers. A solitary small reddish pebble of quartzite was collected from near the top.

Coarser and darker bands are seen interbedded with the sand-rock. They present a very irregular disposition. They vary in thickness from a fraction of an inch to about three inches in thickness. Sometimes these coarse bands are in the form of small lenticles. It is noteworthy that as these lenticles are composed of very coarse grains, they get eliminated largely from the glass sand on sieving.

QUARRYING, WASHING AND SIEVING OF THE GLASS SAND

The rock is soft and therefore holes are bored with chisels by manual labour and then the rock is blasted with gun powder. The broken rock is then transported to the glass works. It is there pulverised into sand with flat wooden

hammers. The sand is then filled in open glass pots and washed with water by coolies. The clay is removed by trampling the wet sand under the feet. It is then dried on fire by heating the sand on an iron-sheet. This dry sand is finally passed through a sieve when pieces of rock and coarser grains are separated. The sieving is so arranged that it passes through 16 mesh and is retained on 100 mesh.

This sand is both used in the Glass Works at Jubbulpore and Condia. It was also exported to Ishapur and Jamshedpur at Rs. 15/- per ton (1942) f.o.r. Jubbulpore.

MICROSCOPIC CHARACTERS OF THE SAND-ROCK

A thin section is seen to be composed of grains of quartz, which have a subangular outline but some of them have an elongated prismatic shape. A few pieces are observed to be almost angular. Inclusions of biotite, tourmaline and diopside are observed in quartz under high power. A few light brownish patches, which are somewhat pleochroic and show a very weak birefringence, are of chlorite formed by the alteration of biotite. In some places it occurs in very fine patches and shows aggregate polarisation. In places tiny flakes of muscovite, showing bright polarisation colours and straight extinction, are present. Tiny particles with yellowish colour, high refractive index, strong but varying birefringence, are of epidote. A dark coloured patch, appearing whitish by reflected light, appears to be of kaolin. In places, the tint appears reddish white under reflected light indicating staining of iron. A prismatic section of brownish tourmaline with characteristic pleochroism and straight extinction is observed. A few minute specks of magnetite, black and opaque by transmitted light and steel-grey by reflected light, are also present. The matrix is composed of kaolin in which islands of grains of clear and colourless quartz are to be observed. Of course it is to be noted that a very great bulk of the rock is composed of quartz grains, the other minerals occur as impurities, some of which are observed only under high power.

MINERALOGICAL COMPOSITION OF THE GLASS SAND

The glass sand, which is actually used in the manufacture of glass, after the rock has been crushed, washed and sieved, was also examined. A very great bulk of the quartz grains are colourless with a partial and fine coating of kaolin. By panning, the coloured particles in the sand were concentrated and collected. Even these contained particles mostly of quartz but some of them showed whitish, yellowish, reddish, brownish and amethystine colour. Besides the minerals, noted above, the following were also observed.

An irregular brown prismatic section, decidedly pleochroic and with an extinction angle of 19° is of hornblende. Prismatic or irregular section of orthoclase, altered to a varying degree and showing turbidity, are also present. An irregularly oval section, copper-red in colour, with very high refractive index and straight extinction, is of rutile.

It was observed that most of the black grains present in the sand-rock prove to be of magnetite. It may be noted that some patches of magnetite under high power show minute inclusions of biotite and felspar. It is interesting to observe that in these inclusions of biotite and felspar dendritic growths of magnetite are to be observed. But it is noteworthy, that these minerals occur only as impurities in the quartz sand, some of which reveal themselves only under very high power.

SIEVE ANALYSES OF GLASS SAND

The following table gives the sieve analysis of a sample of this sand by standard I.M.M. sieves as used in the Glass Works at Jubbulpore. The sieves are arranged one over the other in the order shown below :

Retained on	40 mesh sieve	...	...	24.18
"	60 "	"	"	28.96
"	80 "	"	"	33.50
"	100 "	"	"	6.82
"	120 "	"	"	2.81
"	150 "	"	"	1.29
Passed through	150 "	"	"	1.57
Total				99.13

CHEMICAL COMPOSITION

The chemical composition of the glass sand is represented by analyses No. I and II in the following table :—

	Jubbulpore Sands		Bargarh Sand	Sawai Madhapur Sand
	I (Tata Laboratories)	II (Mukerji & Drane)	III (Mukerji & Drane)	IV (Mukerji & Drane)
SiO ₂	97.08	98.04	97.69	98.44
Fe ₂ O ₃	0.85	0.14	0.04	0.33
Al ₂ O ₃	0.87	0.91	1.72	1.17
CaO	0.40	trace	0.28	0.09
MgO	trace	0.09	trace	trace
Na ₂ O	0.30	...	...	...
K ₂ O	...	...	...	...
TiO ₂	...	0.63	...	...
Loss on ignition	0.30	...	0.54	0.43
Total	99.80	99.81	100.27	100.46

Analysis No. I is of the sand which is used in the coke ovens of Tatas, etc. Analysis No. II is

of the glass sand and is quite satisfactory. The silica content is 98.04 with an iron content of 0.14 per cent. The sand is already being used for the production of varied type of articles, but it is suggested that the washing of the sand should be more

thorough specially in view of its high iron content ; as this operation will not only remove the objectionable clayey matter adhered to the sand grains but will also reduce its iron content.

MEDICINE AND PUBLIC HEALTH

PREVENTION OF JAUNDICE

A "PILOT EXPERIMENT" suggesting that artificial sunlight may be the weapon for fighting the danger of jaundice in persons who get human blood serum for transfusions or protective inoculations is reported in the *Science News Letter*, September 11, 1943.

The problem caused national concern in U. S. A. last year when more than 28,000 soldiers developed jaundice following inoculations against yellow fever. The army solved the problem by switching to another type of anti-yellow fever vaccine which does not contain human blood serum. So far as known this new vaccine has not produced jaundice.

If the findings of the Public Health Service pilot experiment are confirmed by further tests, the danger of jaundice following transfusions might be averted by passing the blood or serum for the big transfusion banks in a thin stream through artificial sunlight. For smaller quantities of human serum, used to prepare vaccines against disease, advantage might be taken of the fact that about two and one-half months after a person has had this jaundice, the disease-producing agent disappears from his blood.

The cause of the disease is believed to be a virus but so far scientists have been unable to identify it, or to give the disease to laboratory animals. For the Public Health Service studies, 189 persons volunteered to get the disease so that their blood could be used to learn more about it. Most of them had only mild attacks and all recovered.

FOOD SHORTAGE SOLVED IN THE LABORATORY

With a lump sum grant of \$24,300 from the Rockefeller Foundation, the Massachusetts Institute of Technology conducted, during the last three years, some far-reaching experiments on diet in their attempts "to pack the utmost of nutritional value into the minimum of food bulk and at the least cost."

Though numerous experiments, under the direction of Dr Robert S. Harris, were carried out first with animals and then with human volunteers, the Institute developed formulae which concentrated into a 1½ pound package of food all the daily requirements for one individual in proteins, calories, vitamins and minerals. With this concentrate as a base, the nutritional biochemists have been able to work out special food problems for several government agencies, including the Army, the Navy, the Merchant Marines and the Federal Surplus Commodities Corporation. Among the problems studied are rations for submarine crews, life-boat rations, and emergency rations for pilots and soldiers detached from the home base. Packaged food concentrates for dropping from aircraft have also been developed. Both Russian and British representatives tested the concentrated food, and certain shipments of it have been made to these countries. These concentrates, made of dried meat, cereals, milk powder, yeast, dried vegetables and seasoning, were also used by members of Admiral Byrd's polar expedition. Dr Harris and his laboratory workers lived on this food, which cost only 6 cents a day, for weeks. They did not grow fat, but they remained in perfect health. This was made in the form of cereal flakes and tested by one dozen business men of Boston for 5 weeks with excellent results.

Food surveys in America showed that in order to obtain the recommended quantities of meat, eggs, fruits, vegetables and milk, an expenditure of from \$2.5 to \$9 per person per week was needed, and the bulk of families with three or more members could not afford this. Hence, some cheap-cost food concentrate was needed for the poorer class of the civil population. A concentrate, containing skim milk powder, corn germ powder or peanut flower, soya flour and powdered peas, along with pepper, salt, vitamins and minerals, was prepared, one ounce of which supplied all the vitamins and minerals needed for the body, plus 1/6th of the protein requirements and 1/20th of the caloric requirements, at a cost of

2·3 cents per serving in the form of soup. It was noticed that equivalent nutrition, not fully reliable, from natural foods would cost more than 25 cents, or above ten times the price of the laboratory-prepared food. This investigators wanted to see if the soup concentrate added to the conventional home diet would correct the ordinary deficiency diseases and safeguard against their recurrence. This was

tested on 760 school children in Michigan and among industrial workers. The results so far obtained are encouraging.

The above experiments are of enormous significance to India, where the population is increasing every year and agriculture is in a quandary. Does India, under these circumstances, desire to utilise the help of scientists to solve the food problem?

THE MYSTERIES OF DUST*

K. N. BAGCHI,

CHEMICAL EXAMINER TO THE GOVT. OF BENGAL, CALCUTTA

IN the beginning of the last century the Scottish minstrel sang that the man whose 'soul so dead' as not to love his 'native land'

"shall go down

To the vile dust, from whence he sprung,
Unwept, unhonoured and unsung."

Little did he realise in those days the extent of vileness of the dust now revealed by science. To the scientist it is not the simple noxious material with which are made that class of mortals whom the poet described in his inimitable verses, but it is a mysterious substance fraught with possibilities for an unlimited amount of harm to all mortals who have to struggle hard for existence.

So much work has lately been done on dust to study its physical, chemical, bacteriological and toxicological aspects that it is not possible for me to do justice to this fascinating subject. I will, however, make an attempt to deal only with the chemical and toxicological aspects as related to industrial cities.

DUST AND CIVILISATION

Civilisation goes hand in hand with industrialisation and production of dust is the greatest curse of industrialisation. "Every fire whether for the production of heat or of power, every grinding or rubbing action, and in general all mechanical function and industrial and constructional activity creates dust." As the incidence of diseases, other than specific occupational diseases, is greater among the industrial workers than the general population and as the expectancy of life of the industrial worker is less than that of other people, the study of dust has, therefore, engaged the most careful attention of the Public Health authorities in all civilised countries and has

developed to form a very important branch of Public Health Science—the Industrial Hygiene.

Dust is considered to be "the greatest single industrial hazard". More workmen are incapacitated for duty because of exposure to dust than for any other cause. It has been recognised by the public health authorities that the diminution of the dust hazard in all trades will result in a corresponding diminution of morbidity and mortality from tuberculosis and other respiratory diseases.

DUST—THEIR SOURCE, SIZE AND NUMBER

Dust normally present in the atmosphere are produced by the action of the winds, rain, variation in weather, etc. and by decomposition of vegetation and animal matter. They are also due to volcanoes and meteors. The nature of the normal dust varies, therefore, with the local geographical condition. Dusts which form the subject matter of this paper are accidentally present in the atmosphere and have come about through the development of civilisation. Broadly speaking, dusts are dispersions of solid particles in air. The particles vary in size from 150 microns (1/167 inch) to 0·5 micron (1/50,000 inch). Those particles which are capable of being inhaled and absorbed in the system, range between 0·5 micron and 10 microns (1/50,000 to 1/2500 inch). It has been calculated that in normal atmospheres, 97 per cent of outdoor dust-particles are less than 1 micron and practically no dust particles larger than 1·5 microns are found in uncontaminated outside air. On the other hand, all dust particles in an industrial establishment are usually larger than 1 micron. "Careful observation has shown that about 60 per cent of the dust particles present in an industrial environment range between 1 and 3 microns only and it is interesting to note that the particles of silica dust isolated by postmortem examination from the lungs of the

victims of silicosis also range between 1 and 3 microns." Apart from the size of the particles, the amount of dust present in the air is also important from the public health point of view, for it has been ascertained that the more intensive the exposure to dust, the more rapid is the development of the specific disease. The atmosphere of an industrial establishment, specially the indoor air, usually contains over 20 million dust particles per cubic foot of air while the outdoor air contains about 5 million.

As dust particles vary considerably in size and weight, the time they take for settling down varies very much. The largest or heaviest particles settle down quickly, while the smallest and lightest ones take the longest time; and the longer the duration of their suspension in air, the further the distance they travel before settling down finally. This is the reason why dusts of heavy metals such as lead, mercury, barium, etc., are mostly confined to the neighbourhood where they are produced, while dusts containing soot, tar, compounds of arsenic and sulphur, silicates etc., are carried by the currents of air to places far away from the source. In this connection, it may be recalled how the fine dusts produced by the eruption of a volcano in Nicaragua in Mexico could be detected at Kingston in Jamaica—a distance of about 700 miles which the dust travelled through an upper air current in about 4 days. Similarly, the eruption of Krakatoa, another volcano near Java, produced such a fine dust that it remained suspended in air for about 3 years and could be detected in places several hundred miles away. It is, therefore, evident that fine dusts, including those which are very toxic, are likely to affect the population extending over a wide area.

THE CLASSIFICATION OF DUST

Dusts have been classified in various ways but the classification of Dr Sayers, according to their chemical and physiological effects, is the best and is as follows:—

- A. Inorganic dusts—
 - (1) Toxic and/or irritant dusts.
 - (2) Fibrosis-producing dusts.
 - (3) Non-fibrosis-producing dusts.
- B. Organic dusts—
 - (1) Non-living organic dusts.
 - (a) Toxic and/or irritant dusts.
 - (b) Allergic dusts.
 - (2) Living organic dusts.
 - (a) Bacteria.
 - (b) Fungi.

INORGANIC DUSTS

Toxic and irritant Dusts:—They produce deleterious effects, both general and local, on the human

system. Those producing local symptoms are usually known as irritants and those producing general symptoms, that is, producing the effects after their absorption in the blood, are termed toxic. The toxic dusts are inherently toxic when inhaled, ingested or otherwise absorbed and include the dusts from heavy metals and their salts such as, lead, mercury, barium, zinc, etc. The oxides and carbonate of lead used as paints for doors, windows, etc., and yellow lead chromate as colour wash for buildings, are the most widely prevalent poisonous dusts. They are set free into the atmosphere not only from the factories where they are manufactured but also from the exterior of the buildings and other structures, due to the crumbling action of the weather. They are readily absorbed through the respiratory passages and produce chronic lead poisoning. Incidentally, it may be mentioned here that in a Hindu household where vermilion adulterated with red lead is used by the womenfolk, the atmosphere there is always charged with this lead compound and thus becomes a potent source of danger of lead poisoning among all the members of the family. Similarly, the arsenic-bearing dusts formed during the manufacture of paints, dyes, insecticides, fungicides, rat-poison, weed-killer and drugs are absorbed and produce chronic arsenic poisoning. Inhalation of zinc oxide during its manufacture produces what is called "metal-fume fever".

Quick-lime, lime, dichromates, etc., form irritant dusts and cause inflammatory lesions in the lungs.

Fibrosis-producing dusts.—Fibrosis is the development of fibrous or scar tissue as a result of inflammation, acute or chronic, caused by irritant substances, such as fine dust from sand, coal, iron, tin and other metals and also from asbestos.

The inhalation of these dusts produces what is called 'pneumokoniosis' or "Dust Disease of the Lung". The most important are siliceous dusts of granite, quartz, sand, pumice, slate, etc., which produce "silicosis"—a widely known disease among the workers in mines and quarries. Silicosis is also known as "miners' phthisis", particularly among the gold miners in South Africa. The condition similar to silicosis, produced by iron and other metal dusts, is known in medicine as "siderosis" and that produced by coal dust is called "anthracosis", while those engaged in the manufacture of asbestos articles develop an equally serious trouble termed "asbestosis". Some of these "Dust Diseases", particularly silicosis, are associated with the increased mortality rate from tuberculosis, pneumonia, pleurisy, etc. In fact, tuberculosis is liable to be a later development in certain forms of silicosis which, however, is not confined only to miners and potters but is met with in almost every industry in which steel and iron are used as raw materials. The possibility of silicosis

* A lecture delivered before the Rotary Club, Calcutta, on 2nd November, 1943.

among these workers is due to the fact that "sand is used in the moulds and cores for metal castings and the dispersion of silica-dust from the sand" thus used is a concomitant feature of this industry.

Non-fibrosis-producing dusts:—These are harmless dusts. Neither they produce any toxic or irritant action nor cause any fibrous tissue to be formed. In out-of-the-way villages, where there are no industries, no metalled or tarred roads and no palatial buildings, the dusts are comparatively innocuous, but they act as carriers of bacteria all the same. In industries connected with limestone, plaster of Paris, gypsum, corundum, emery, etc., the dusts are also harmless.

ORGANIC DUSTS

Non-living organic dusts:—These contain carbon and are derived from animal or plant life as also from various chemical processes involved in the manufacture of dye-stuffs, explosives, drugs, textiles, etc.

(a) Toxic and irritant dusts.—They produce deleterious effects, both general and local, on the human system in the same way as described under inorganic dusts. The common irritant dusts are those of tar, soot, coal, tobacco, certain flours of cereals, and of fibres, such as wool, silk, cotton, jute, flax, etc. The toxic dusts are derived from certain chemical compounds which are extensively used as dye-stuffs, explosives, drugs, etc., e.g., para-nitraniline, T.N.T., picric acid, nitro-naphthalene and other organic compounds. Many organic dusts produce dermatitis.

(b) Allergic dusts.—The term allergy is used to describe the condition of a peculiar inborn hypersensitiveness or susceptibility in which apparently inert substances produce characteristic manifestations particularly on the skin, and in the respiratory system. The allergic dusts consist usually of pollens of flowers, horse-hair, furs, feathers, cat's hair, certain kinds of pulverised wood, dusts from rice, oats and corn, and many drugs and other organic substances. The allergic manifestations on the skin are urticaria, eczema and purpura, i.e., bleeding inside the skin resulting in purple or blue spots or patches, and those in the respiratory tract are attacks of asthma, hay-fever, paroxysmal attacks running from the nose and sneezing. These manifestations, particularly the attacks of asthma and urticaria, are interesting as they are frequently met with in susceptible persons after a meal of lobsters or crabs or after contact with a horse or a cat. In the latter condition, the smell, i.e., the emanations from the animal, and not necessarily the hair of the animal, may also bring on the attacks.

Living organic dusts:—

(a) Bacteria.—The bacterial dusts are aggregates of bacteria, fresh or desiccated, suspended in atmos-

phere either as such or with ordinary dust particles. The most important bacteria are anthrax, tetanus, diphtheria, tuberculosis, small-pox, pus-forming organisms, etc.

(b) Fungi.—They are the mycelia or threads and spores of parasitic fungi. They may grow in the respiratory tract or in other parts of the body and thus cause discomfort if not serious illness.

INDUSTRIAL HYGIENE AND THE STUDY OF DUST

The study of dusts requires the services of physiologists, chemists, bacteriologists and medical men with experience in public health work and the help of various kinds of complicated apparatus that have been invented for this purpose. The collection and identification of dusts and determination of their nature, size and number along with their physical, chemical and physiological properties form the various stages of such investigations and the data obtained therefrom form the basis of Industrial Hygiene—an applied science developed enormously quite lately to protect and improve the health of workers. To achieve this object numerous appliances have been devised and protective measures introduced to free the atmosphere of the industrial establishments from poisonous dusts as far as possible. A rapid development of Industrial Hygiene should, therefore, be aimed at to keep pace with the industrialisation of the country, otherwise the health of the workers would deteriorate and the establishments would suffer heavy loss by way of workmen's compensation and inefficiency of the workers due to ill health.

Calcutta or any other industrial city in India, is very backward industrially in comparison with any large city in Europe or in America. With the present state of her public health organisations having no schemes in view for developing Industrial Hygiene with necessary laboratories and scientific equipments for the study of the dust problem, Calcutta, or for the matter of that any industrial city in India, is at the present moment ill-equipped for rapid industrialisation. We might imagine what would have been the condition of our industrial workers and also of the general population if Calcutta had made the same progress industrially as she has made with respect to her size and population. Those who are in charge of planning post-war industrial expansion, should take note of these facts and proceed accordingly. Illiteracy and want of civic and sanitary consciousness as its corollary, would make the problem more difficult in this country. Dr Sayers, Chief of the U. S. Bureau of Mines, says that "the protection of the health of our workers is indeed an important health function and one which can be handled best through a govern-

mental agency co-operating with the employers and workers. Responsibility for safeguarding the health of industrial workers rests chiefly with State and local government."

Just to form an idea of an industrial city, as it is understood now, we might refer to New York City where "during a typical year there are discharged into the atmosphere 300,000 tons of soot, tar, cinders and fly-ash, and 350,000 tons of sulphur which form about 1,000,000 tons of sulphuric acid." It is needless to say that quite an appreciable amount of these noxious substances get into the system of the workers as well as of the people living outside, but on account of the higher standard of living, good health and increased power of resistance they are able to fight successfully against these heavy odds.

DUST—AN INDEX OF INDUSTRIALISATION

One of the tables (Table I) included in the note, shows some analytical figures obtained by analysis in our laboratory of a few samples of dusts collected from different parts of Calcutta. They were very fine dusts deposited slowly on the tops of book-shelves, almirahs, electric casings on the ceiling, etc., and were absolutely free from any coarse or gritty particles usually found in the floor dust. The metals detected in these samples are partly of industrial origin and partly from other sources, e.g., the traces of aluminium present there must have come from the soil, lead and arsenic from crumbled paints and colour wash and also to a certain extent from few industries in which they are used. Iron and zinc and perhaps calcium, are mostly of industrial origin and their comparatively high figures indicate some industrial activities in this direction possibly due to war efforts.

In Table II, the figures, showing only the inorganic poisonous constituents of dusts, taken from the Public Health reports of the City of Leeds, have been shown side by side with the corresponding figures for Calcutta dusts. They have been magnified for purposes of comparison by simple conversion from 'per cent basis' to 'parts per million basis'.

It is evident from the tables on the next column how Calcutta lags behind in the race for industrialisation. Lead, arsenic or copper is, of course, not the only criterion for judging the industrial development of a place but considering the variety of industries in which these metals are used one would not likely to

TABLE I
COMPOSITION OF CALCUTTA DUSTS
(Figures in percentage)

	Medical College	Amherst Street	Ballygunje Place	Shyambazar
Moisture ..	2.3	3.5	3.8	3.7
Soot, tar and other organic matters ..	19.0	26.5	25.8	24.7
Silica (as SiO ₂) ..	52.0	49.0	56.0	46.8
Iron (as Fe ₂ O ₃) ..	11.9	9.2	5.1	8.4
Aluminium (as Al ₂ O ₃) ..	0.2	trace	trace	trace
Zinc (as ZnO) ..	1.5	0.2	Nil	trace
Calcium (as CaO) ..	9.6	11.1	8.0	15.0
Copper (as Cu) ..	Nil	Nil	Nil	Nil
Lead (as Pb) ..	0.0005	0.0017	0.00176	0.0041
Arsenic (as As ₂ O ₃) ..	0.002	0.0006	0.0006	0.0014
Sulphur (as SO ₂) ..	1.4	trace	trace	0.85
Ammonia (as N) ..	0.17	—	—	0.06
Chlorides (as Cl) ..	0.16	—	—	0.15

TABLE II
COMPARATIVE STATEMENT SHOWING DIFFERENCE IN COMPOSITION OF TOXIC DUSTS FOUND IN CALCUTTA AND IN LEEDS
(Figures in milligrammes per kilo.)

	Calcutta (1943)				Leeds (1936)	
	Medical College	Amherst Street	Ballygunje Place	Shyambazar	Industrial portion	Residential portion
Copper (as Cu) ..	Nil	Nil	Nil	Nil	410	Nil
Lead (as Pb) ..	5.0	17.0	17.6	41.0	3025	1725
Arsenic (as As ₂ O ₃) ..	20.0	6.0	6.0	14.0	476	384

be much far from the truth if these metals are taken, so to say, as yardsticks to measure the progress of industrialisation. Lead, for example, is used in as many as twenty important industries, all of which are essential for the production of what we call the amenities of modern civilised life. Dust may, therefore, be considered as an index of industrialisation or in other words of civilisation, just in the same way as consumption of sulphuric acid is claimed by chemists to be an index of civilisation or more familiarly, consumption of soap is claimed by ladies to serve the same purpose.

BOOK REVIEWS

Manometric Methods.—By Malcolm Dixon. Second Edition, 1943. Pages 150. Published by Cambridge University Press.

This book deals with methods, which have come into extensive use in biological investigations, for following reactions in which gas is either absorbed or given out. As a result of repeated attempts for studying the respiration of isolated tissues and of microorganisms, the enzymic oxidation and reduction and the progress of various chemical reactions; a number of manometric methods have been evolved by different workers. Dr Dixon, who has worked extensively with these methods of investigation, removed a long felt want by presenting to the scientific world a comprehensive and critical description of the various methods, by publishing the first edition of this book in 1933. In subsequent years considerable advance took place, specially, in the improvement and refinement of the methods and their application to an ever increasing varieties of problems. Several highly sensitive manometers for ultra-micro estimations by which exchange of gas of the order of one-millionth of a cubic centimeter can be measured, have been constructed. The present thoroughly revised edition, with many new additions recording the advance made, has added considerably to the value and usefulness of the volume. In Part I of the book an account is given of the construction and theory of the various types of manometer used, while Part II supplies guidance in detail for the use of the various methods which are now available. Workers in the field will feel grateful to the author for the clear description of the improved techniques and of the micromethods. The set of protocols of actual experiments will be very helpful to inexperienced workers.

B. B. S.

An Introduction to Industrial Psychology—By May Smith, M.A., D.Sc., Cassell & Co. Ltd., London. Price 7s. 6d. net.

To many in our country Industrial Psychology is still a mystery. Even those who ought to know better often naively ask how can psychology be applied to industry? To them, the book is an effective answer. It gives a broad survey of the scope of the subject and reveals the actual nature of the many individual and social psychological problems that inevitably arise whenever many people come to work together in factories and business houses. To the enthusiast, on the other hand, who believes that high grade performance by workers in standard tests and adequate environmental factors are the only conditions necessary for bringing about the millenium in industrial sphere, the book rightly serves as a warning. It draws attention to the erroneous assumption lying behind such beliefs. The total man is not just a sum of parts, Miss Smith insists again and again. Coming from one who herself has been a worker in this field for a number of years the caution should be borne in mind by all new comers.

The book does not give details of the many tests, methods of applications, etc, and therefore cannot be recommended as a text-book. Still one would be well advised to go through it before beginning a serious study of Industrial Psychology. Laymen as well as would be specialists would both be benefited by a perusal of the book.

S. C. M.

LETTERS TO THE EDITOR

[The editors are not responsible for the views expressed in the letters.]

A MILDEW ON JUTE

In November 1942, a mildew was observed on jute specially grown in winter for crossing work. It remained on the crop up to the end of February. In August 1943, it was noticed on the main crop which was raised during the monsoon. The symptoms on this crop are not prominent as only a few greyish or whitish patches appear on the stem and very scarcely on the leaves. On the winter crop however, prominent patches of mildew appear on the upper surface of the leaves. They coalesce and cover up the entire lamina (Fig. 1a). When the infection is extensive,

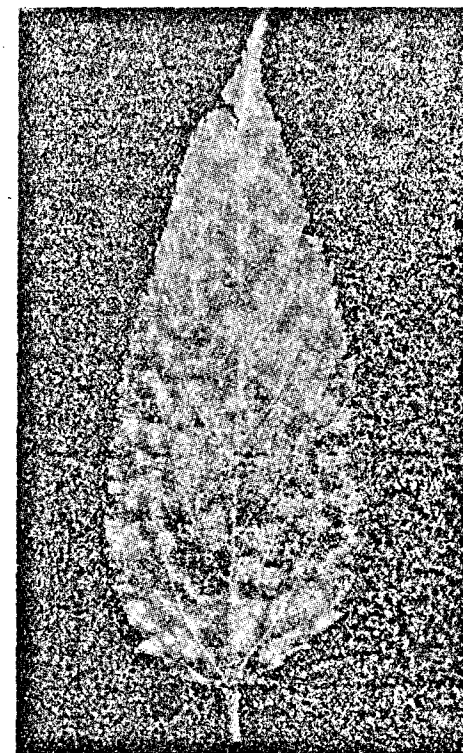


FIG. 1 (a). Leaf showing the powdery mildew.

the lower surfaces of leaves also get covered with the mycelium. In severe cases the attacked leaves become crinkled. Unlike the monsoon season, during the winter the leaves are first infected and then the stem. The entire stem, flower-bearing branches and capsules (fig. 1b) are ultimately affected. The fungus appears on the petiole, stipule, and axillary leaves

as well. The attack is superficial and if the fungus is scraped off from the seat of infection only a slight discolouration is seen. Both *C. capsularis* and *C. olitorius* recorded the infection but the disease was considerably more in the former. Wild jutes, *C. acutangulus* and *C. fascicularis*, did not show any infection.

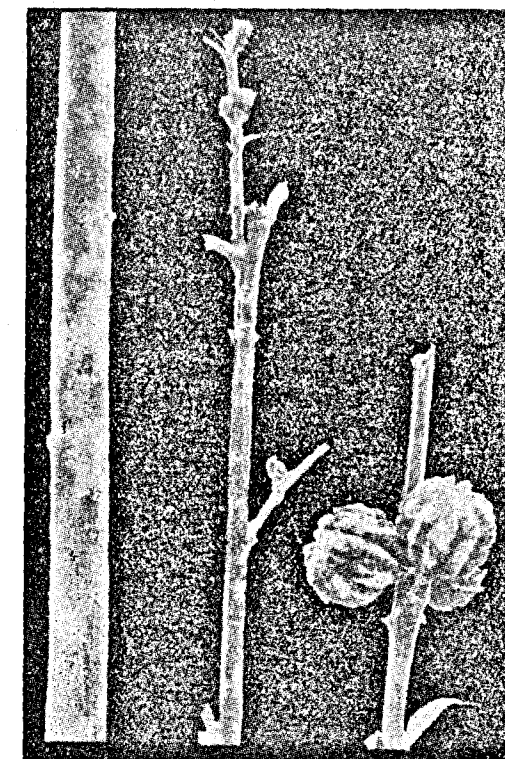


FIG. 1 (b). Stem and flower bearing branches with capsules showing the powdery mildew.

The fungus forms extensive network on all the above-ground parts. The network consists of hyaline and septate hyphae ranging in diameter from $2.9\ \mu$ to $7.8\ \mu$ which send out numerous upright conidiophores whose size and shape vary. They are either long and slender or short and stout measuring from $70.0\ \mu$ to $140.0\ \mu$, the average being $94.5\ \mu$. From the end of these, hyaline, elliptical smooth 1-celled conidia arise in basipetal succession often in chains of two or more. The size of conidia varies greatly and the frequency array of measurements of 300 conidia is given in Table I. The range of variation

in length is very large but is not much in width. On an average they measure 33.0μ by 17.4μ .

TABLE I
MEASUREMENTS OF CONIDIA OF *Oidium* sp ON *Corchorus capsularis*

Length		Diameter	
Classes in μ	frequency	Classes in μ	frequency
21.5 to 25.5	1	13.0 to 15.5	15
25.6 to 29.6	44	15.6 to 18.1	267
29.7 to 33.7	60	18.2 to 20.7	10
33.8 to 37.8	189	20.8 to 23.3	8
37.9 to 41.9	5		
42.0 to 46.0	0		
46.1 to 50.1	0		
50.2 to 54.2	1		

The conidia have been seen to germinate readily in water.

No perithecia have been seen to occur on the host.

From the foregoing descriptions, the fungus may tentatively be named as *Oidium* sp on *Corchorus capsularis* and *C. olitorius*. On perusal of literature the occurrence of this mildew on this important host appears to be the first of its kind. Both Solomon¹ and Blumer² do not record occurrence of any mildew on any genus in the family Tiliaceae.

B. S. VARADA RAJAN.

Jute Agricultural Research Laboratories,
Tejgaon, Dacca,
11-11-1943.

¹ Solomon, E. S., A monograph of the Erysiphaceae. Mem. Torrey Bot. Club, 9, 1-292, 1900.

² Blumer, S., Die Erysiphaceen, Mittel europas Zurich, 1933.

TRAMETES FLOCCOSUS BRES. IN CULTURE

Trametes floccosus is a member of the family Polyporaceae. It was first collected by Murrill in Mexico in 1910 and described as *Ganodermus areolatus*¹ which is a synonym of the species. It was also collected from Africa and was described as *Fomes intrastuppeus* by Hennings. The species had been collected from Ceylon and identified as *Formes floccosus* by Lloyd² who regarded it as synonymous with *Polyporus levisissimus*. Lloyd later on referred it correctly to the genus *Trametes*.

The fungus is widely distributed all over the tropics. It is common in tropical America including Mexico and Guatemala. It also occurs in Central and East Africa (Kenya), Ceylon and India (including Bengal, Bombay and Madras) extending upto north Australia. Pose³ first reported its occurrence from Bengal.

Fresh sporophores of *T. floccosus* were collected in large numbers from living and dead tree trunks of *Ficus religiosa* Linn. from Calcutta, in July, 1942. Spore-deposits from such a sporophore were taken on sterile agar plates in the usual way. The spores were then transferred aseptically to culture tubes ($6'' \times \frac{1}{2}''$) containing potato-dextrose agar prepared by Fritz's method.⁴ Growth in all cases started within 24 hours and several appressed and colourless mycelia were soon obtained. These cultures were kept exposed to the diffused light of the laboratory at the ordinary room temperature.

The initial growth was rather slow and the superficial mycelium soon produced a sub-felty to felty mat with narrow, appressed, and sodden advancing zones. In 15 days after inoculation, the mat in all cases invariably became felty but the character of the zone of advance was not altered. About this time the slants were completely covered and the surface of the mat, due to irregular condensation, became slightly uneven. In 30-days-old cultures the mat became much condensed but remained felty throughout. The colour of the mat was mostly white but towards the upper advancing zone, shades of pale yellow orange⁵ and pale ochraceous salmon appeared in patches. Gradually a lump was formed over the inoculum showing a resupinate patch of fruit-body with minute pore mouths (fig. 1). The

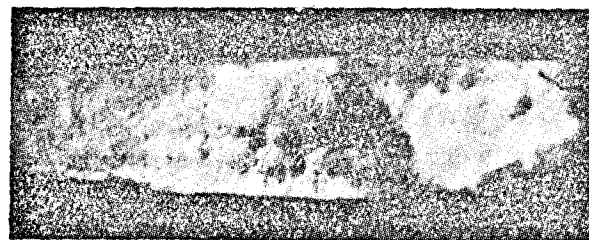


FIG. 1. *T. Floccosus* in culture showing fructification at the centre.

porous surface at first appeared pure white but later gradually acquired a tinge of lighter shade of light buff. Similar fruit-bodies were also obtained in other culture tubes. The pores on the hymenial surface in some culture tubes became slightly irregular depending on the irregular nature of the growth.

Such a fruit-body, on section, showed the presence of numerous basidia with basidiospores and a

few cystidia. The basidiospores are narrow, elliptical, hyaline, smooth walled and measure $12-14 \mu \times 6 \mu$. From one of the fruit-bodies obtained in culture spore-deposits were subsequently obtained from which new polysporous cultures were made in the usual way. Three such cultures also fructified in about a month.

For making wood-block-cultures a normal and healthy piece of wood of *Ficus religiosa*, a natural host of the fungus was cut into convenient numbered blocks ($3'' \times \frac{3}{4}'' \times \frac{3}{4}''$). The dry weights of these were determined in the following way. The blocks were placed inside a hot air oven at $45^{\circ}-50^{\circ}\text{C}$ for 24 hours. These were then taken out, cooled, separately weighed and replaced in the oven. This process was repeated for several days till they attained a final constant weight. The blocks were subsequently soaked in distilled water for about an hour. Prolonged soaking was purposely avoided in order to prevent soluble substances from being leached out and thus rendering the blocks poorer in nutrient content. After soaking, the blocks were placed in Roux tubes with some water at the base, care being taken that the blocks were not in direct contact with the water below. The tubes were then plugged and autoclaved at 15 lbs. pressure for 20 minutes. An inoculum containing 4-days-old mycelium of the fungus was put aseptically on the upper cross-sectional end of each block and tubes placed under similar conditions as stated above.

The growth was at first rather slow but later on copious vegetative growth covered the external surface of the wood-blocks. None of the cultures have as yet fructified on wood.

Observations are now being made on the loss of weight of the wood due to fungal attack in 4 months, specific action of the fungus on the wood and the type of rot produced, the results of which will be communicated later on.

Our sincere thanks are due to Prof. S. P. Agharkar, Head of the Dept., for the facilities given.

SACHINDRA NATH BANERJEE
PIMAL KUMAR BAKSHI

Department of Botany,
Calcutta University,
Calcutta, 9-12-1943.

¹ Lloyd, C. G., Mycological Notes, No. 64, p. 1010; No. 65, p. 1092; No. 72, p. 1291; Cincinnati, Ohio, 1920-24.

² ——— Index of the Mycological Writings. Synopsis of the genus *Fomes*, p. 220, Cincinnati, Ohio, 1915.

³ Bose, S. R., Polyporaceae of Bengal, Part IV, Bull. Carmichael Med. Coll., Belgachia, 1921.

⁴ Fritz, C. W., Cultural criteria for the distinction of wood-destroying fungi. Trans. Roy. Soc. of Canada, 17, 3rd Ser., 1923.

⁵ Ridgway, R., Colour standard and colour nomenclature, Washington, 1912.

ZONES OF PROGRESSIVE REGIONAL METAMORPHISM AROUND TISTA VALLEY, DARJEELING DISTRICT

THE Tista valley in the Darjeeling district lying between the hill region of Takdah, Giele and Peshoke to the west and that of Kalimpong to the east, is occupied by low grade slates, phyllites and schists of pelitic and greywackish composition. They belong to the Daling series of Mallet.¹

Up the hill slopes both to the east and the west the low grade schists etc. pass into progressively more metamorphosed schists and gneisses.

Five distinct zones of progressive metamorphism, essentially regional in nature, can be recognized and mapped within the metamorphic series, viz., a chlo-

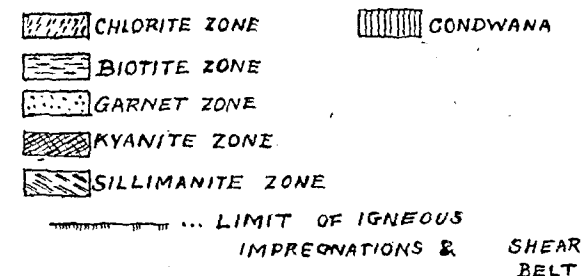
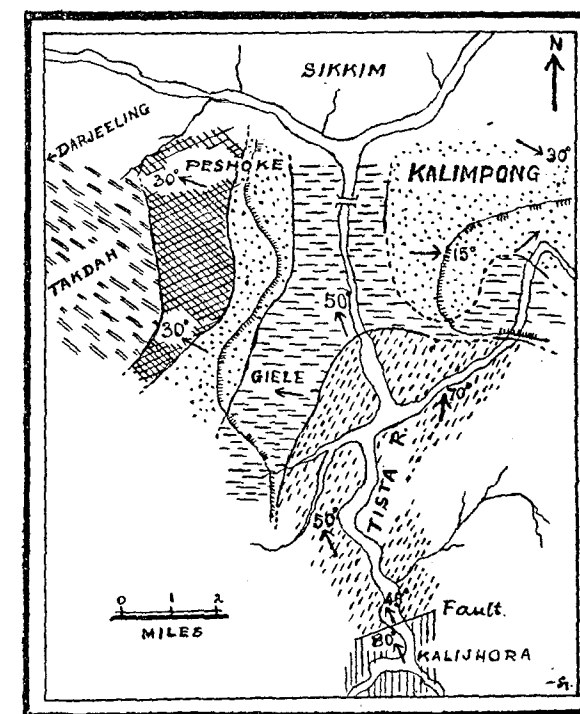


FIG. 1. Zones of Progressive Regional Metamorphism around Tista Valley, Darjeeling District.

rite, a biotite, a garnet, a kyanite and a sillimanite zone, disposed as shown in the sketch map. The Daling-Darjeeling Gneiss boundary of Mallet (*op. cit.*) runs within our kyanite zone.

The four isogradic lines bounding the five zones have been traced from the first appearance of the index minerals, biotite, garnet, kyanite and sillimanite. For this purpose pelitic schists only have been taken into consideration and microscopic examination of rock slides was always necessary; field observation often fails to reveal the index minerals. Greater precision in mapping the zones can be, therefore, attained by examining specimens taken at closer intervals across the width of the zones.

The staurolite isograd is not a separate line here. Although widespread and abundant, particularly in the Peshoke spur, staurolite is always accompanied by kyanite or/and sillimanite. The staurolite zone is here missing; the kyanite zone containing abundant staurolite, comes directly against the garnet zone.

The higher zones, from the sillimanite zone to a portion of the garnet zone, have been impregnated with quartzo-felspathic magmatic fluids and tourmalinisers. A line can be drawn (as shown in the map) demarcating the area of such impregnations from the area free from them; the line runs within the garnet zone and partly within the biotite zone. Along this line there is evidence of more localised and concentrated igneous activity. The schists occurring here show at the same time some characteristics attributable doubtfully to shearing; evidences are, however, yet inconclusive regarding positive existence of a shear or a thrust belt.

The five zones here have all the characters of corresponding zones of Barrow and Tilley.²

In the sillimanite zone near Takdah occurrence together of sillimanite, kyanite and staurolite in the same rock slide has been noted. This recalls the occurrence together of sillimanite and kyanite from some rocks of Ghoom and the Nepal frontier in the Darjeeling Hills.³

Some interest attaches also to the low grade greywacke-schists, which show, sometimes even in the garnet zone, signs of deformation by stress, such as retrogression of biotite and garnet to chlorite and granulation of albite porphyroblasts. Such effects are widespread and regional rather than local.

Detailed account of the rocks and their metamorphic and structural peculiarities will be discussed elsewhere.

S. RAY

Geology Department,
Presidency College,
Calcutta, 23-12-43.

¹ Mallet, F. R.—*Mem. Geol. Surv. Ind.*, 11, 1-96, 1874.

² Barrow, G.—*Proc. Geol. Assoc.*, 23, 274-90, 1912; Tilley, C. R.—*Q. J. Geol. Soc.*, 71, 100, 1925.

³ Ray, S. K.—*Q. J. Geol. Min. Met. Soc. Ind.*, 7, 32, 1935, Pl. IV, Fig. 1.

TEMPERATURE OF THE SOLAR REVERSING LAYER

It is well known that molecules exist in the reversing layer of the sun and that they give rise to band spectra. Determinations of the relative intensities of the lines in these bands furnish valuable information regarding the physical conditions in the reversing layer. In recent years there have been several investigations in this direction. But many of these are only of a qualitative nature. The Cynogen band at λ 3883 is very well suited for such studies. The relations that exist between the temperature of a diatomic gas in thermal equilibrium, the molecular constants and the relative intensities of the rotational lines have been applied for determining the temperature of the reversing layer. The earliest investigation was that of Pirge.¹ His determination was only from a visual comparison of the intensity distribution in the Fraunhofer Cynogen lines with those in the arc and furnace spectra obtained in the laboratory. From a knowledge of the temperatures of these terrestrial sources, he estimated the temperature of the reversing layer as about 4000°K. Later Roach² using Rowland Intensities arrived at a value of 5630°K. More recently Leon Blitzer³ for the first time attempted a quantitative study of the intensities of the lines in this band and obtained a value of 4500°K. He photographed the solar spectrum with the 75-foot tower telescope of Mt. Wilson having a linear dispersion of 3mm. per Angstrom. But his exposures for the solar spectrum were unusually long ranging from 40 minutes to 4 hours. During such long intervals the sky conditions will never be constant and it is very necessary that plates intended for photometric work should be taken under constant sky conditions particularly to avoid the uncertain influence of the varying sky conditions. Since investigations of this nature provide valuable observational material for an analysis of the physical state of the solar atmosphere, spectrograms covering the region of the CN band at λ 3883 were secured by the author at the Kodaikanal Observatory during the last ten months and from the large number of plates available, only those of the finest quality were finally selected for photometry. The spectra were secured with a glass Littrow Spectrograph giving a linear dispersion of about 2.5 mm. per Angstrom in this region. Exposures of 1 to 2 minutes were sufficient to give good pictures. The instrument is designed to minimise the systematic errors due to the scattered light in the spectrograph. Standards were impressed on each plate by a step slit. The intensities of the band lines were measured from microphotometer tracings using for this purpose the Cambridge Photoelectric Microphotometer.

It is seen from the theory of the band spectra that measurements of the position of the maximum

intensity in a band should be an excellent method for determining stellar temperatures and it can be shown that for the CN band $J_{\max} = 0.4341/T$ where 'T' is the temperature. From the photometry of this band it is found that $J_{\max}$ falls in the vicinity of 31 giving the excitation temperature in the reversing layer as 5100°K.

This result has been confirmed by an alternative method of calculation. It can be shown that " $\log I_i$ " (where 'I' is the intensity and 'i' the relative intensity factor of the rotational line) when plotted against " $J(J+1)$ " gives a straight line the slope of which involves 'T'. A least squares solution was made to determine the straight line and a value of $T = 4960 \pm 100^\circ\text{K}$ was obtained.

A detailed paper embodying these results will be published shortly elsewhere.

K. NARAHARI RAO.

Solar Physics Observatory,
Kodaikanal, 24-12-1943.

¹ Birge, A. P. J., 55, 273, 1922.

² Roach, A. P. J., 89, 99, 1939.

³ Leon Blitzer, A. P. J., 91, 421, 1940.

A COMPARISON OF THE LIMB AND DISC SPECTRA OF THE SUN

In the above note the author has described investigations undertaken for determining the excitation temperature of the solar reversing layer from a study of the intensity distribution of the CN band at λ 3883. A value of about 5000°K was obtained for the temperature of the layers at the centre of the sun's disc. It was reported by Miss M.G. Adam¹ that her investigations on the intensity distribution in the C₂ band at λ 5165 at the centre and the limb of the sun yielded a higher temperature for the layers at the limb than those at the centre. In order to examine this rather novel result obtained by Adam the writer has studied the CN band at λ 3883 with a hope of clarifying the situation. A number of limb spectra have been obtained with the high dispersion spectrograph used in the previous investigation when the seeing was 5.7 on a scale of 1-10. The plates were all calibrated from the characteristic curves. A range of intensity values were obtained for each plate which includes the limb and disc spectra. The temperature has been determined from the slope of the curve drawn between $\log(I/i)$ and $J(J+1)$ as described in the previous note. It is found that the limb temperature is in all cases definitely lower than the disc temperature, T_{limb} being $4500 \pm 100^\circ\text{K}$.

We may in this connection recall the interesting observation of Hale and Adams² viz., "... Carbon and Cynogen are particularly interesting (or a comparison of the spectra of the limb and the centre of the sun). Many lines in the violet carbon band are of unchanged intensity, or perhaps slightly strengthened, at the limb. The Cynogen fluting, which begins at λ 3884 is, on the contrary, very decidedly weakened at the limb. ..."

It is possible that the strengthening of the carbon band lines at the limb observed by Miss Adam is not due to the higher limb temperature but to some other cause. With a view to investigate this apparent anomaly, further investigation is in progress particularly as regards the relative intensities of the CH and the C₂ bands in the laboratory and solar spectra.

K. NARAHARI RAO.

Solar Physics Observatory,
Kodaikanal, 24-12-1943.

¹ Adam, M. G., R. A. S. *Monthly Notices*, 98, 546, 1937-38.
² George E. Hale and Walter S. Adams, A. P. J., 25, 310, 1907.

ASCORBIC ACID CONTENT OF CHINESE ROSE HIPS

It has been shown by Wang¹ that in 100 out of 108 healthy persons examined, the plasma ascorbic acid content was below 0.4 mg. per 100 c.c. with an average of 0.19 mg. per cent. Wang and Liao² reported the nutritional status with regard to ascorbic acid of Chungking School children in different seasons of the whole year. It was found that in 35, 65 and 4 per cent of the children in spring, autumn and winter respectively the urinary excretion of ascorbic acid never reached the saturation level on the second day after administration of the test dose. Wang³ found that in 79 per cent cases the content of ascorbic acid in breast milk was below 4 mg. per cent. This is considered to be too low to supply sufficient ascorbic acid to meet the babies' daily requirements. From the above it is clear that most of the Chinese diets are deficient in ascorbic acid. Therefore the remedy for this defect is quite an urgent problem in China, although in winter months there is sufficient supply of citrus fruits in the south-east and the south-west provinces of China.

In this letter are given the results of analyses of the ascorbic acid content of rose hips which constitute the richest source of ascorbic acid in Chinese foods.

1. *Collection and preparation.*—The rose hips were collected from the sides of fields and roads and the slopes of the hills in the region of Kolo-shan, Chungking and some other places of south-west provinces of China, at the end of August. The colour of hips varied greatly from green to yellow according to the degree of ripening. After the inedible portion had been removed, the edible portion was washed with distilled water and then dried in the air.

2. *Determination of Ascorbic acid.*—1-2 grams of fresh rose hips (E.P.) were ground in a mortar with a little acid-washed sand and 5 c.c. of 4 per cent metaphosphoric acid solution. The fine paste was poured and washed with 10 c.c. of dilute metaphosphoric acid into a centrifuge tube and centrifuged for 10 minutes. The supernatant liquid was transferred to a cylinder. The precipitate was washed three times with 15 c.c. of 4 per cent metaphosphoric acid each time. The washings and the first extract were combined and diluted to a total volume of 80 c.c. with 4 per cent metaphosphoric acid solution. The ascorbic acid content of the extract was determined by the usual titration method using 2:6 dichlorophenol indo-phenol.

TABLE I
ASCORBIC ACID CONTENT OF CHINESE ROSE HIPs (mg./g)

Sample No.	colour of fruits.	
	green	yellow
1	12.61	22.23
2	15.53	22.50
3	16.89	22.60
4	17.00	23.15
5	18.01	23.42
6	19.52	25.08
7	19.25	25.61
8	20.00	25.89
9	20.10	26.50
10	20.39	26.52
Average	17.93	24.35

3. *Results and Discussion.*—The results are shown in table I. It will be seen that the ascorbic acid content of rose hips varied greatly with the degree of ripening. The green hips contain ascorbic acid from 12.61 to 20.39 mg. per gram with an average of 17.93 mg. per gram, while the yellow ones contain 22.23—26.52 mg. per gram with an average of 24.35 mg. per gram. The average content of ascorbic acid of ripe rose hips is double that of the Emblic fruit.⁴ A comparison with the usual rich sources of ascorbic acid such as Chinese citrus fruits and vegetables is given in Table II. It is 40

TABLE II
THE COMPARISON OF ASCORBIC ACID CONTENT OF ROSE HIPs AND CITRUS FRUITS AND OTHER VEGETABLES

Names	mg. per gram or per c.c.	Reference No.
Green hips ...	17.93	
Yellow hips ...	24.35	
Emblic fruits (green) ...	9.96	
" " (yellow) ...	8.46	
Orange juice (Fu Chow) ...	0.70	
" " (Chung King) ...	0.56	
" " (Kuri Chow) ...	0.68	
Tangerine juice (Chi-Kiang) ...	0.26	
" " (Fu Chow) ...	0.47	
" " (Wen Chow) ...	0.13	
Green Amaranth ...	1.17	
Pea Sprout ...	1.04	

and 90 times more potent than the juices of orange and tangerine respectively, and about 20 times than of green amaranth. The rose hip, therefore, is the richest source of ascorbic acid among Chinese foods. It will easily meet the daily requirement if an adult weighing 60 kilograms can take one half of rose hip a day.⁵ We strongly suggest that the authorities should make this fact known to the people for adopting it as food.

The ascorbic acid content of Chinese green and yellow rose hips was determined by the usual titration method using 2:6 dichlorophenol indo-phenol as an indicator. The average content of ascorbic acid in green and yellow rose hips is 17.93 mg. and 24.35 mg. per gram respectively. It is about 2, 40 and 90 times higher than that of Emblic fruits, orange and tangerine juice respectively.

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26-12-43.

¹ Wang Cheng-Fa, The Chemical News leaflet, 6, 16, 1943.
² J. Chinese Chem. Soc., 10, 45, 1943.
³ Wang Cheng-Fa and Liao, Hsu-Chen, J. Chinese Chem. Soc. in press, 1943.
⁴ Wang Cheng-Fa, unpublished data.
⁵ Chen, T. M. Ho, S. Hsieh, K. M. and Shen, T., Biochem. Bulletin No. 27, 1943.
⁶ Wang Chen-Fa, J. Chinese Chem. Soc., 9, 97, 1942.
⁷ Wang Cheng-Fa, unpublished results.
⁸ Wang Cheng-Fa, J. Chinese Chem. Soc., 9, 141, 1942.

FISH "GOING ON HOLIDAY"

In India, people now have realised the en- vigorat- ing effect of a 'change'. So those who can afford it generally go out for a change to a health resort during vacations.

In Europe, people have gone deeper into the thing and almost everybody generally goes out annually for a change which goes by the name "going on holiday". Even labourers of factories get a leave for a fort-night annually for such a change. Experts of health are of opinion that even a change from one part of a city to another has the desired effect.

Now fish can also get the invigorating effect with a change. Even transference of fish from a big pond to a small one for a week may have the desired effect and more so on retransference to the big pond. This sort of change should be done for a week in every six months.

The effect of such change is found indirectly in rivers where fish generally get a change often as they migrate from one place to another, and for this reason their rate of growth in rivers is much more than in stagnant ponds.

We have also noted the invigorating effect of change even in small aquaria in the cases of small variety of fish, such as, *Barbus conchonioides*, *Barbus ticto*, *Amblypharingodon mola* etc. This sort of change not only gives vigour but it gives a stimulus for ready spawning mostly in fish mentioned above. On transference of mature males and females of the fish during breeding season from ponds to small aquaria we have noted on several occasions in our laboratory the immediate starting of spawning.

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Calcutta, 3-1-1944.
H. K. MOOKERJEE

Botany

Progress of Botany with Special Reference to Economic Plants

T. S. SABNIS

DURING the last three or four generations the progress made in improving the numerous plants and animals which provide us with food, clothing and ornament has been astounding. The progress achieved by the non-scientific methods in earlier centuries was no doubt good, but it could hardly have stood the strain of the modern political problems and helped to satisfy the industrial and commercial requirements of to-day.

The world was first made alive to the possibilities of the science of plant breeding by the work of Luther Burbank in the last decades of the last century. Since the year 1900, however, a fresh impetus was given to work on most of the cultivated plants all over the world. Whereas results of great economic importance were secured with wheat in America, England and India, and advances made in several other crops also, the work led to important findings of scientific interest as well.

Intensive work with selection and cross fertilization of indigenous material was followed by exploration of useful material in different parts of the world and new forms, possessing great resistance to diseases, frost and drought were introduced, specially in Russia and the United States of America. Along with the introduction of new plants has been going on the work of changing the existing forms by means of X-rays and ultra-violet rays.

Another development of botany has been plant ecology, that is, that branch of botany which deals with the effects which the various environmental factors produce upon plants. In dealing with the problem of controlling vegetation, either for agriculture, forestry or for the improvement of grassland, plant ecology, by investigating the fundamental laws concerning growth of plants in relation to the environmental factors, will be of much help.

Much attention has lately been paid to one of these factors, *viz.* light. By subjecting plants to con-

trolled illumination, and sometimes, when necessary, by artificially giving them additional illumination, the growth periods of crops have been markedly changed, thus making possible certain breeding experiments. The information secured is, besides, useful to the agriculturist and the horticulturist in their attempts to grow plants in new environments, different from those to which the plants belong.

The study of response of plants to different temperatures has led to the process originated by Russian scientists and now known as vernalization, which consists of giving to the seeds certain temperature treatments. Vernalization has enabled Russia to luxuriant crops of winter wheat in areas in which it was formerly impossible to grow it successfully. Thus the process has enabled agriculturists to triumph over Nature's climatic barriers. A great deal of work in this direction is now being done in the different countries.

Another factor which stimulates plant growth resides in the plant itself but it was discovered only recently. It is known as the growth regulator and is something like the growth hormones of the animals in nature. Preparations of plant growth regulators are now being used for stimulating the rooting of plant cuttings or seedlings which are normally found difficult to be propagated.

Researches on the nutrition of plants have led to the discovery of the important role which some of the elements play in the life of most plants. These elements are required only in traces, yet they are essential. Their deficiency was at times responsible for failure of vast crops, but with the knowledge gained the crops can now be saved by supplying the deficiency.

Not the least important researches to increase the production of economic plants are those which deal with plant diseases. Much has been done in this direction by breeding resistant varieties of plants.

Chemistry

Some Aspects of Modern Inorganic Chemistry

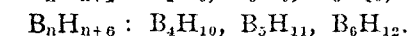
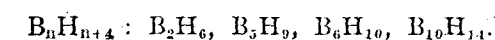
R. C. RAY

WHEN Ramsay first isolated the rare gases of the atmosphere, it seemed that chemically they would be uninteresting because of their extreme chemical inertness. In recent years, however, a large variety of compounds of these inert gases has been prepared. To-day they have received not only various industrial applications and neon lights are blazing forth their messages in all the cities of the world, but also they have been of utmost importance in the development of chemical theories.

Theoretical considerations will show that the rule of zero valency cannot be strictly true for the inert gases. In the first place, each inert gas atom has four lone pairs of electrons so that it can act as donor atoms in the formation of the co-ordinate link. Secondly, as the maximum number of electrons possible in a quantum group of n is $2n^2$, it is evident that the third and higher groups in argon, krypton, xenon and radon are capable of expansion so that they might be expected to act as acceptors of electrons. Thirdly, when the inert gas atom is suitably excited, one or more electrons may be promoted to the higher quantum level; in this state they will resemble a uni- or bi-valent element and compound formation may take place. All the three possible types of compounds have now been prepared. For example, the argon fluoroborates ($A. BF_3$; $A. 2BF_3$ etc.) of Booth and Willson, Nikitin's hexahydrates of neon and argon, and the helides of mercury, tungsten, sulphur, phosphorus etc., prepared by Manley, Boomer, Damianovich and others may be cited respectively as representatives of the three types. But little work in this line has been carried out in this country.

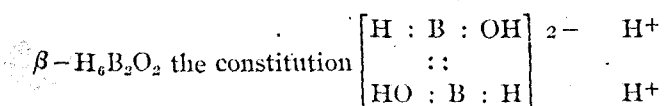
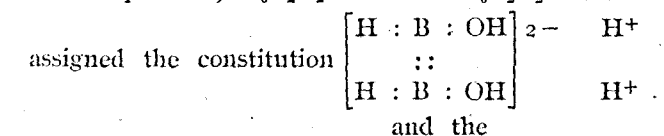
A large amount of research work has been carried out during the last 30 years in the chemistry of boron compounds. The pioneer work on boron hydrides has been done by Stock, Wiberg and their co-workers in Germany. An admirable summary of all the earlier work has been given by Stock in his Baker lectures which also contain a detailed description of the high-vacuum technique used in the isolation and manipulation of these highly reactive and volatile hydrides. Hydrides of boron described in

literature may be divided into two classes of the general formulae B_nH_{n+4} and B_nH_{n+6} .

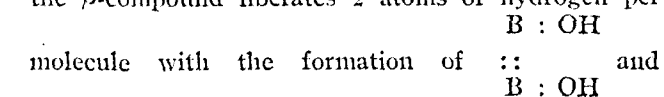


They are all colourless substances, ranging in volatility from diborane, B_2H_6 , which has a boiling point of -92.5° to $B_{10}H_{14}$ which forms characteristic crystals melting at 99.7° . Earlier work on boron hydrides has been extended by Schlesinger, Burg and others in America. They have discovered a new method of preparing diborane, by the action of hydrogen on boron trichloride (or tribromide) in a high-voltage electric discharge, and a large number of new reactions of diborane. Two of these reactions, namely, the action carbon monoxide on diborane and that of diborane on metal-alkyls resulting in the formation of borine carbonyl and metalborohydrides respectively, are extremely interesting. The work of the American School of Chemists has been fully reviewed in the Chemical Reviews of 1942.

In this country Ray (R.C.) and his collaborators have carried out a considerable amount of work on the chemistry of boron. They have studied the mechanism of hydrolysis of magnesium boride and found that the first product of hydrolysis is a compound of the formula, $H_3B_2(Mg.OH)_3$ which on further hydrolysis gives the isomeric borohydrides of the composition, $H_6B_2O_2$. The α - $H_6B_2O_2$ has been



Both the compounds liberate hydrogen by acids, but while the α -compound yields 4 atoms of hydrogen the β -compound liberates 2 atoms of hydrogen per



H : B : OH
 :: respectively. In course of these investigations, two lower oxides of boron, B_2O_2 and B_4O_5 , have been isolated in the pure state. The oxides are both acidic and give rise to the acids, $H_4B_2O_4$ and $H_2B_4O_6$. The properties of these acids and their corresponding salts have been studied.

Sufficient has been said about the hydroborons and the borohydrates to indicate that a new field of research has been opened up in which there exists considerable scope for further experimental study. The work has revealed the limitations of our knowledge of the chemical bond, and it is evident that a full understanding of the structural chemistry of this group of compounds has not yet been reached. The relationships between structure and stability of these compounds are worthy of more detailed study. Further researches on boron compounds may lead to a fuller knowledge as to the nature of resonance and its relation to chemical bonds; and the preparation of more organic derivatives may also lead to a boron-organic chemistry comparable to that of numerous silicon-organic compounds; and there is no doubt that this new field of inorganic chemistry will attract investigators for many years to come.

In order to gain a clearer insight into the nature of the chemical bond more extensive investigations of co-ordination compounds, with a view to determine the factors which determine the co-ordination number of elements, are also of great importance.

Although a considerable amount of research has centred round co-ordination compounds since the time of Werner with all the powerful physical methods at the disposal of the modern chemist, and old observations have been refurbished in the light of present-day knowledge, yet we are far from understanding fully the factors which determine co-ordination. Investigations of considerable interest and importance are being carried out in this country by Professor P. Ray and his school at the University College of Science, Calcutta.

Although the use of more powerful and exact methods are gradually advancing our knowledge of the course of many inorganic reactions and of the structure of inorganic compounds, a considerable ground still remains to be covered. While the structure of most organic compounds has been carefully worked out the same thing cannot be said about many inorganic compounds. A systematic study of these, using the tools placed at our disposal by the physical chemists, will yield fruitful results.

It will thus be seen that the future of inorganic chemistry is very bright indeed. It is evident from what has been said that a large amount of work still remains to be done on the compounds of the inert gases, compounds of boron, co-ordination compounds, structure of inorganic compounds, and the mechanism of inorganic chemical reactions and a combined attack of what were in former days separate "sciences" should be made on the various problems to produce the most prosperous harvest.



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INDUSTRIAL RESEARCH AND UNIVERSITIES

NEED FOR INDUSTRIAL RESEARCH

IT need hardly be emphasized that 'Private Industrial Producers' all over the capitalistic world have long realized the supreme importance of research work in the struggle for existence in the present ruthlessly competitive world. But the task of organising research for the benefit of the 'Private Industrial Producer' has not been easy. For, 'Industry' comprises all kinds of creative undertakings ranging, say, from the manufacture of tooth-pastes to the production of synthetic petrol, and involves all grades of capitalists having investments ranging from a few thousand to hundreds of crores of rupees. Experience has shown that there is room for improvement in almost every branch of industry, big or small. But despite this knowledge, only a handful of industrial producers are capable of finding sufficient funds for properly conducted research. Only a few mammoth undertakings* like some of the great chemical, electrical, and engineering concerns of the U. K., the U. S. A. and the European countries have been able to maintain adequately equipped research laboratories, libraries, and above all, a personnel of gifted scientists. Such research institutes have been of immense benefit to these concerns, enabling them constantly to improve old processes, introduce new ones, and extend their sphere of activity. But the smaller undertakings which cannot afford to maintain such research establishments have a different tale to tell. Before the war, they were mostly like small fish either in the process of being swallowed up by their bigger brethren, viz., the giant concerns, or, if this had not already taken place, they were simply waiting for the inexorable Fate. The econo-

mic and political consequences of such events were so serious that a national Government could hardly afford to follow a *laissez faire* policy unless it allowed itself to be a mere tool of 'Big Business'.

The dangers of such a situation have been eliminated from the very start in the U. S. S. R. by the abolition of private capital, and the conversion of all great industries to State monopolies. But however attractive and rational the Soviet methods of organisation of industrial activities might appear, the vast part of the world has to follow, under the present dispensation, some solution consistent with the existence of private capital and private enterprise. Let us therefore scrutinize the methods which have been evolved in the capitalistic countries viz., Germany, U. K., U. S. A. and in other European States, to enable the small industrialist from being swallowed up by his Big Brothers, by allowing him to share the benefits of scientific research. The question is of supreme importance to the Indian industrial producer; for, in the post-war period he will have to face a greedy and ruthlessly competitive world, and it is doubtful whether he will be able to secure any ameliorative measure from the present un-national Government. Also, let it not be forgotten that the biggest Indian industrial producer is but a tiny herring compared to some of the whales of Europe and America. Some of the giant industrial concerns of U. S. A. are said to control 30,000 million dollars, a figure which is about 100 times larger than the capital controlled by the biggest Indian industrial producer.

INDUSTRIAL RESEARCH IN GERMANY

Germany was the first country to realise the importance of industrial research and foresee its possibilities and advantages in a competitive world. This

* e.g. the Bell Telephone Co., the Du Pont du Nemours, the G. I. C. of the U. S. A., the I. G. of Germany, the Imperial Chemical Industries of England.

realisation dawned upon German industrialists and scientists in the wake of the Franco-Prussian war of 1870, and the result was the establishment by the Government of the famous Reichsanstalt in Berlin in 1886-87. The Reichsanstalt operates two divisions, one to concentrate on pure research connected with fundamental units, standards of physical measurements etc. and the other to explore ways and means for increasing application of the results of pure research to industry and manufacture. The creation of the Kaiser-Wilhelm Gesellschaft in 1911 bears testimony to German awareness of the need for co-operative research in the field of industry. It maintains several institutes to carry on investigations on natural sciences, applied chemistry and physics, and utilisation of coal, iron and steel. Kaiser-Wilhelm Institute für Eisenforschung in Düsseldorf for research in ferrous metallurgy is the most conspicuous of these institutes maintained by the Gesellschaft. The unique position and prestige German industry has commanded in the world market have been largely due to useful industrial research carried out in these institutes. The urge for complete self sufficiency and the consideration for national preparedness in the event of a war led the Reich Government to establish the *State Council for Research* in March, 1937 to supplement the activities of the Kaiser-Wilhelm Gesellschaft. The methods of organising industrial research in totalitarian Germany are, however, basically different from those practised in other capitalistic countries and nothing more than a passing reference can be made at this stage.

THE RESEARCH ASSOCIATIONS OF THE UNITED KINGDOM

Organised research for the promotion of industry is only of recent origin in the United Kingdom. Before the World War I, industrial research was sporadic and individualistic, and such distinguished manufacturing scientists as Watt, Bessemer, and Parsons, occasionally opened new lines of industrial development by the results of their own individual researches. The creation of the Department of Scientific and Industrial Research marked the beginning of a new era of industrial research which was to transform a country of commercial enterprises into one of science and technology. From the outset, the D. S. I. R. seems to have been cognisant of the need of co-operative research in industry. The difficulties and disadvantages of small and medium scale industries were realised and the idea of research associations was conceived to provide, as far as practicable, equal opportunities to industries, big or small. The research associations created under the aegis of the D. S. I. R. represent an important aspect of co-operative research on behalf of smaller

industries in the United Kingdom and as such deserve a closer examination.

A research association is an organisation established under the Companies Act, representing several firms of an industry or a group of allied industries. It is a non-profit establishment financed by the interested firms jointly and also receives annual grants from the D. S. I. R., the amount of which bears a definite proportion to the subscription income. The responsibility for the programme of work rests with a Council representing the subscribers, but in all cases the D. S. I. R. should be fully informed of the programmes, experiments and results so that the Department can judge for itself whether proper use is being made of the grants from public funds. The Associations have in most cases set up their own laboratories, and where such laboratories have not yet been built, the established laboratories of a university or Government research stations have been utilised. The members of a research association derive the following benefits:

- (a) They can obtain technical information within the scope of the research organisation and its allied associations.
- (b) The members can recommend specific subjects for research whose final undertaking by the association depends on the approval of the Board. The results of research are, however, open to all members.
- (c) They can ask for a specific research for their benefit provided they are prepared to bear the expenses.
- (d) They enjoy the privilege of using any patent or secret process without or with nominal payment.

During the initial periods of their formation the research associations* suffered from considerable confusion and a lack of clear idea as to the line of research to be undertaken. There was a definite inclination towards short time research yielding immediate commercial returns. The wasteful nature of such short-sighted policy was soon realised, and the research associations increasingly directed their attention to long-term fundamental research.

* There are at present twenty-four research associations in receipt of grants, of which the following is the list:—

- (1) Automobile Research Committee (Institute of Automobile Engineers).
- (2) British Association of Research for Cocoa, Chocolate, Sugar, Confectionery and Jam trades.
- (3) British Boot, Shoe and Allied Trade Research Association.
- (4) British Cast Iron Research Association.
- (5) British Coal Utilisation Research Association.
- (6) British Cotton Industry Research Association.
- (7) British Electrical and Allied Industrial Research Association.
- (8) British Food Manufacturers' Research Association.
- (9) British Iron and Steel Industrial Research Council.
- (10) British Launderers' Research Association.

The creation of research associations covering such a wide field of industrial investigations bears testimony to the necessity of research in almost every branch of industry and to the concern felt by the State for smaller capitalists. In 1927, there were 16 grant-aided research associations which received in that year a total subscription income of £117,000 and a grant of £58,000 from the D.S.I.R. In 1930, 1935, 1938 and 1941 the number of grant-aided associations were 18, 20, 22 and 22 respectively, whose subscription income amounted to £162,000, £233,000, £326,000 and £368,000 respectively. The corresponding D.S.I.R. grants were £93,000, £113,000, £177,000 and £192,000. Besides, the research associations have received additional donations, special contributions and grants of no mean amount from official organisations other than the D.S.I.R. The total number of subscribers to grant-aided research associations was over 7,100 in 1941. But the total number of firms taking part in such co-operative research was, however, several times this figure, as many of these subscribers are corporate groups, such as the trade associations.

When the research associations were first started they did not appear to have had much success on account of the mutual jealousies of the members of the association. Distrust and unwillingness to reveal trade secrets made difficult the much needed co-operation, and there was also lack of foresight and planning. Fortunately these difficulties now appear, to all intents and purposes, to have been solved and the British scientists and industrialists have recently come to pin ever greater faith to co-operative research through research associations. In the recent report of the Federation of British Industries (F.B.I.) Industrial Research Committee, the work of the research associations has been appreciated in the following words:

"The industrial research associations represent a well-tried means by which collective research over a wide field is carried on in this country to-day. We are convinced that the associations are playing a valuable part, their work being of direct benefit to the industries which maintain them not only through the results they directly achieve,

but also through the stimulus which they give to the individual firms in the industries concerned to undertake their own research and scientific service, particularly from the point of view of applying to their own special circumstances the broad results obtained by the associations. Since the establishment of the research associations there has been a considerable increase in the number of firms maintaining research departments.

The Committee has expressed its opinion that there is yet enough scope for expansion of the research association scheme and that the existing research associations should henceforward spend much greater amounts on research than they were spending recently. It recommended

"that every industry which has not created a collective research association should set up a co-operative research committee and take steps to create and maintain a research fund which would equitably distribute the burden over the constituent concerns in proportion to their interest in industry. The research committee would determine whether the scale and the nature of the research needs were such as to require the establishment of a research association, whether a link could satisfactorily be formed with existing research associations, or whether research problems could be dealt with extramurally through university laboratories and other research establishments."

THE INDUSTRIAL FELLOWSHIP SYSTEM IN U.S.A.

The American experiments at co-operative research represent a novel departure from the methods developed in other countries and also appear to have attained better success. To promote co-operation between industries in the common field of research a system of industrial fellowships has been evolved which has proved highly efficient and workable. The idea of introducing a system of industrial fellowships first occurred to Robert Kennedy Duncan, and the Mellon Institute of Industrial Research appears to be the most notable instance of co-operative research organisation working on this Fellowship System.

The Mellon Institute of Industrial Research is a private organisation of research workers for technical investigations and allied subjects, affiliated to the University of Pittsburgh. The Institute is essentially of the nature of an industrial experimental station undertaking 'long-range' research on industrial problems. Its purpose is to find new materials and new processes for industrial development and advance manufacturing through the application of the latest scientific methods to industry.

The Institute owes its inception to the happy combination of wealth and scientific talent. Wealth was represented by Andrew and Richard Mellon, American multi-millionaires and graduates of the University of Pittsburgh, who made money in aluminium. Andrew William Mellon, in

- (11) British Leather Manufacturers' Research Association.
- (12) British Non-Ferrous Metals Research Association.
- (13) British Pottery Research Association.
- (14) British Refractories Research Association.
- (15) British Scientific Instrument Research Association.
- (16) Gas Research Board.
- (17) Internal Combustion Engine Research Association.
- (18) Linen Industry Research Association.
- (19) Printing and Allied Trades Research Association.
- (20) Research Association of British Flour Millers.
- (21) Research Association of British Paint, Colour and Varnish Manufacturers.
- (22) Research Association of British Rubber Manufacturers.
- (23) Welding Research Council.
- (24) Wool Industries Research Association.

addition to being a great industrialist, rose high as a politician, being Secretary of the Treasury in the Cabinet of President Harding. Scientific talent was represented by Robert Kennedy Duncan who had served as a teacher of chemistry in colleges and later on as a professor in the University of Kansas. It will be difficult to describe Kennedy as a front rank scientific man; but he had a vivid imagination and possessed the art of popularising his science to the general public. In 1901, he was sent by *McClure's Magazine* to Europe to report on the discovery of Radium by Madam Curie, where he incidentally attended the Sixth International Congress of Applied Chemistry in Rome. While attending the Congress, he was impressed by the instances of Germany, France and Italy, which had all taken significant steps towards useful application of science for the promotion of industry. He realised for the first time one of the then fundamental deficiencies of American industries. American industrialists had shown wonderful efficiency as organisers, as keen business men, and in copying the industrial processes evolved mainly in Europe, and in rationalising production. But most of them depended for their success not upon intelligent application of science, but upon tariff protection, combinations for elimination of competition and the abundance of raw materials, which steadily ceased to be important factors for successful industrial ventures. They had hardly harnessed science to industry, as was being done in Europe, where the discovery of synthetic indigo in the laboratory and its production on the market leading virtually to the elimination of the natural indigo industry had produced a great impression. Duncan foresaw that what had happened to the indigo industry in India might befall other well-established industries, if the American industrialist did not move forward to take the help of science in a constant endeavour to improve his methods.

During his continental tour Duncan first conceived the idea of Industrial Fellowship, which was destined to play the most important part in the constitution of the Mellon Institute of Industrial Research. Duncan arranged for the establishment of the first Industrial Fellowship in January, 1907, in the University of Kansas where he held the chair of industrial chemistry. Started on an experimental basis, his system of Industrial Fellowship soon attracted attention in Pittsburgh, one of the leading industrial centres in U. S. A. He was invited by the Chancellor of the University of Pittsburgh to act as professor of industrial chemistry and inaugurate his system in that institution in a department of industrial research. These developments finally culminated in the establishment of the Mellon Institute of Industrial Research founded in March, 1913, at the University of Pittsburgh by Andrew William

Mellon and Richard Beatty Mellon, in memorial to their father Thomas Mellon and Robert Kennedy Duncan. The present strong position of the Institute is due to the continued financial support of the Mellons and Duncan's universally applauded system of Industrial Fellowship.

The following brief account reproduced from the annual report of the Institute will convey to our readers an exact impression as to how Kennedy Duncan's Industrial Fellowship system works:

"In accordance with the system of research, an individual industrialist, a company, or an association of manufacturers, having a suitable problem or group of problems requiring investigation, may become the donor of an Industrial Fellowship, provided that the problems are of sufficient scope to warrant the services of at least one man for a period of at least one year; and also, that there is no other investigation in progress in the Institute on the research topic which is of interest to the prospective donor.

The Industrial Fellowships of the Institute are of two general types; *viz.*, Individual and Multiple. An Individual Industrial Fellowship utilizes the services of one research chemist or engineer (with assistants when necessary), who is responsible directly to the executive staff of the Institute. A Multiple Industrial Fellowship utilizes the services of one or more research men (Junior Fellows) under the direction of a Senior Fellow, who, in turn, is responsible to the executive staff.

The Institute is not of a commercial nature, being entirely independent and deriving no financial profit from the investigations conducted under its auspices. Moreover, members of the executive staff of the Institute devote their time and ability to the interests of the Institute and of the University without outside remuneration.

The donor, on his part, provides a foundation sum which is adequate to cover the annual cost of maintenance of the Industrial Fellowship, which includes operating charges, the purchase of all necessary special apparatus or other equipment, and the salary of the research man or men selected to work on the particular problem, the solution of which is of concern to the donor.

Co-operation by sympathetic encouragement and practical suggestion is also essential on the part of the donating companies or associations for the successful conduct of the Industrial Fellowship work.

The Institute, in turn, selects the Industrial Fellow, and the investigation to be conducted is committed to this competent man, who is not otherwise preoccupied during his incumbency of the Industrial Fellowship.

The Institute provides laboratory, library, and consultative facilities, the use of its permanent research equipment, direction to the progress of the work, and an atmosphere which is conducive to productive investigation. All results obtained by the Industrial Fellowship belong exclusively to its donor.

Each Industrial Fellowship is a case of trust, and knowledge concerning its progress and subject matter is withheld from the public, if the donor so desires, in accordance with the terms of the agreement governing its operation. Further, the knowledge gained by one Industrial Fellow along one investigational line becomes available to another research man, *provided that such co-operation violates no trust.*

Reports on progress made and difficulties encountered are submitted weekly from each Industrial Fellowship to the executive staff. These private reports are considered for purposes of advice and guidance. Confidential monthly reports are prepared and placed in the archives of the Institute, to be released for publication at such a time as will not injure the interests of the donor. No scientific or technical papers are prepared for publication without the consent and approval of the donor concerned. Moreover, the donor decides as to whether patent protection will be sought for new processes or products developed.

For the benefit of donors, the Institute secures, through proper connections, systematic and prompt advices concerning improvements in American and European technical practice that may be of value in connection with its Industrial Fellowships.

The system of the Institute enables a manufacturer to obtain results in a shorter period of time and at less cost than is ordinarily possible. The co-operative and research facilities of the Institute hasten results.

All advertising or publicity matter referring to the Institute, in which the name of the Institute is mentioned, is by agreement submitted to the Director of the Institute for approval before release."

The work of an Industrial Fellow usually proceeds through three definite stages, namely preparatory, experimental and developmental. During the preparatory stage the Industrial Fellow and the executive staff have to become thoroughly acquainted with the problem the donor places before the Institute for investigation. Visits to the donor's plant, critical study of the available and most recent literature on the subject and the formulation of the future plan of action constitute the preparatory stage. A satisfactory programme of research, subject to the approval of the executive staff, being thus prepared, the Industrial Fellow enters the experimental stage embracing laboratory work. Upon the completion of the experimental stage, the developmental stage is reached. The problems tackled in this stage are essentially chemical engineering in nature.

An interesting feature of the Institute's research work is represented in the Association Fellowship which deserves more than a passing notice. Such Fellowships are created by associations of manufacturers having problems of common interest, whose solution benefits each individual member of the association. These problems are generally basic and long-range in character and are, therefore, extremely important so far as improvement of industry is concerned. The system of Association Fellowship has several important advantages in that it promotes co-operation among industries, avoids unnecessary duplication in scientific inquiries, saves time and research expenditure and above all, enables small manufacturers who cannot maintain research laboratories of their own to be equally benefited as the larger ones.

The industrial problems hitherto receiving investigation at the Mellon Institute are mostly

chemical and chemical engineering in nature. To give an idea as to the extent of the field of industrial research covered by the Institute we may mention the following as some of the most important investigations it has so far undertaken, *viz.*, bread, carbon dioxide, cellulose, citrous products, composition flooring, corrosion, edible gelatin, electrical precipitation, fertilisers, fibre containers, fish products, food and beverage flavours, fuels, galvanizing, garment cleaning, glass, glue, ink, laundering, magnesia products, matches, nickel, olefine gases, paper finishing, petroleum production, rubber compounding, sodium silicate, solvents, steel, stove enamels, sugars, vitamins, vitrified tile, wood chemicals, wrought iron, yeast, and zinc. The above list which includes only the most important subjects of investigations has been considerably extended in recent years owing to the new and fresh demands created by the war. Many of these investigations laid the foundation of a number of important industries. For instance, mention may be made of the Carbide and Carbon Chemicals Corporation which developed from researches on the synthetic products from ethylene carried out at the Mellon Institute. A new method of making sausage casings from viscose, developed at the Institute, led to the establishment of the Visking Corporation of Chicago. The "Redmanol" industry which finally merged with the well-known Bakelite Corporation had its origin in the fruitful researches of Duncan's Fellows created at Kansas.

The following Table will reflect the growth of the Industrial Fellowship System introduced at the Mellon Institute of Industrial Research. The Table presents the number of Industrial Fellowships who have been employed thereon and the total amounts of money received from the donors for research expenditure.

Institute's Fiscal Year	Number of Fellowships	Number of Fellows	Research Expenditure
1911-12 ...	11	24	£39,700
1912-13 ...	16	30	£54,300
1913-14 ...	21	37	£92,605
1914-15 ...	21	32	£73,904
1915-16 ...	36	63	£127,529
1916-17 ...	42	65	£153,391
1917-18 ...	42	64	£171,990
1918-19 ...	47	77	£233,879
1919-20 ...	47	83	£275,268
1920-21 ...	48	83	£361,140
1921-22 ...	49	75	£372,215
1922-23 ...	67	109	£616,360
1923-24 ...	66	101	£539,229
1924-25 ...	62	97	£596,938
1925-26 ...	66	102	£632,547
1926-27 ...	69	125	£816,315
1927-28 ...	72	142	£1,062,830
1928-29 ...	86	161	£1,104,405
1929-30 ...	91	167	£1,181,639
1930-31 ...	93	187	£1,258,866

OTHER ANALOGOUS INDUSTRIAL RESEARCH ORGANISATIONS OF U. S. A.

Duncan's ideas and Industrial Fellowship System have to-day received wide appreciation in U. S. A. A number of new industrial research organisations working more or less on plans followed in the Mellon Institute of Industrial Research have recently sprung up throughout the length and breadth of the country to meet American industry's growing need for scientific research. The Battelle Memorial Institute in Columbus, Ohio, founded by Gordon Battelle, has introduced an industrial sponsorship plan which operates in much the same way as Duncan's industrial fellowship system. The Institute's research divisions at present cover the following fields, *viz.*, metallurgy, ceramics, beneficiation of raw materials, chemistry and physics, and each is under the direction of a technical supervisor. There is a supreme executive department to co-relate and co-ordinate the activities of the various research divisions. The Purdue Research Foundation at Purdue University, West Lafayette, incorporated in 1930, the Ohio State Research Foundation at Columbus, Ohio, established in 1936 and the Armour Research Foundation, a separate research department to the Armour Institute of Technology at Chicago, created in 1936, are other notable instances of industrial research organisations affiliated to a university or some educational institution, which are largely responsible for the strong and unchallenged position the American industries enjoy to-day in the world market.

The idea of carrying on industrial research through universities on the American Fellowship System is new in India. It appears, however, as the

only suitable form of industrial research which can be conveniently followed in India under her present conditions. It may be noted that, in the 31st Session of the Indian Science Congress, Mr J. J. Ghandy, while presiding over the section of Engineering and Metallurgy, referred to this fellowship system in his presidential address on 'Industrial Research' and advocated the desirability of introducing the same in India. The same idea, though in a different form, was also expressed by Sir S. S. Bhatnagar, in his presidential address at the Conference of Manufacturers of Chemical and Pharmaceutical Products and Representatives of Universities and Research Institutes, held at Bombay in November, 1943. All these are good signs. Several universities in India maintain laboratories for the promotion of pure research in various branches of science, and some library facilities are also available. In many of them research in applied sciences, though on a modest scale, is also being carried on. So, with certain additions and extension, the library and laboratories of a university can be utilised for the investigation of industrial problems. This procedure will eliminate the necessity of large initial expenditure involved in the building of a separate industrial laboratory. The industrialists who so desire to derive the benefit of scientific research will be required to bear the expenses incurred for this purpose, while the university will supply the scientific personnel, and the industrial fellowship system can be effectively introduced to give effect to this plan. What is more important, work can be started immediately in this arrangement. Such possibilities have hardly occurred to our industrialists who may, therefore, do well to give serious consideration to the practicability of this new form of industrial research through universities.

ORGANISATION OF SCIENTIFIC RESEARCH IN THE U.S.S.R.

K. G. NAIK, BARODA

SCIENTIFIC Research in the U.S.S.R. is organised on the principle of 'Unity of Theory and Practice'. All the sciences grew out of practice. Theoretical problems are raised and solved in connection with general practical problems and *vice versa, viz.*, the solution of practical problems are illuminated by theory. Hence in the U. S. S. R., all the Scientific Research establishments are brought close to industry and are utilized to work out a plan of activity answering the needs of industry. Economic growth and economic independence, it was realised in the U. S. S. R., demanded the solution of a number of technical problems, which in turn raised the whole series of important theoretical scientific problems. "Great practice calls for great theory".

The planning of scientific work according to a clear perspective of technical and economical developments, results in a 'Social Synthesis' of Science and Practice. The main groups of national problems would embrace (i) prospecting for natural wealth (deposits), (ii) finding the best methods and means (machines etc.) of utilization, (iii) devising the best forms of organization for such utilization, (iv) rationalizing production and (v) problems of labour (study of the working man as the subject of the process of labour). All these presuppose the development of all branches of both *natural* and *social* sciences. In the U. S. S. R. "The Academic Studio" has thus been supplanted by the huge laboratories and the lone scientists by huge scientific organisations. Planning no doubt implies a certain amount of restriction, but a planned attack from various aspects brings the solution of problems quicker than by unorganised individual grappling. Consequently, the Soviet Government came to the decision that if they must overtake and even surpass, both technically and economically, the advanced capitalist countries, the network of scientific research institutions must grow at a colossal speed. In planning, the themes should embrace current economic problems as well as problems of to-morrow, even simultaneously. This is carried out through the system of "Head" and "Branch" institutions and factory laboratories, and by rational apportionment of these themes, among different research establishments. Mutual competition and secrecy had to be replaced by mutual information and joint elaboration of plans—the planning of *Construction* and *Means* had to become the product of the planning of *thematics*. The planning of scientific forces followed immediately. Vast reconstruction

needed hundreds of thousands of qualified workers who had to be trained and distributed according to different branches of themes of scientific research work; and this was followed by the problem of securing a sufficient influx of reinforcements of all degrees of scientific qualifications. Naturally, all the problems enumerated above are inter-connected forming an organic whole—a functional part of the general *National Plan*.

Experience led to the necessity of establishing three basic types of institutes for research in the U. S. S. R. *Viz.*, (a) Subsidiary points, (b) Branch Institutes, (c) Head Institutes.

(a) The Subsidiary points serve industrial enterprises such as factories, mills, mines, farms, hospitals etc. Besides fulfilling the elementary technical tasks, they include the elaboration of new methods, improvement of old methods, and so on. The subsidiary points, form an integral part of (b) the Branch Institutes which latter serve the interests of entire branches of industry, agriculture etc., and carry out direct tasks given to them by the industrial organisations. Further, on their part, they raise a series of prospective problems of more general and profound importance, growing into the theoretical problems of a fundamental character, and thereby maintain contact with (c) the Head Institutes. The Head Institutes solve the more general scientific questions arising from the whole complexity of the techno-economic plans. They also raise and elaborate the great fundamental problems of science—"problems of to-morrow". Such is the line of connections, traced from bottom up. The return road is also perfectly clear. The Head Institutes advise the Branch Institutions and help them in solving problems. The technical results of problems handled by the Head Institutes are passed on to the Branch Institutes for detailed technological treatment. The Branch Institutes in their return, advise the subsidiary points and through these latter, they carry out the adoption of new technical methods and improved models in industry. Thus a rational form of subdivision of labour, between different categories of research institutes, is created, assuring *certain* unity between the theoretical and applied problems of scientific work. Experience has shown that such a form of organisation has proved wholly successful. The gigantic growth of the scientific institutions in the Soviet Union, both qualitatively and quantitatively, irrefutably demonstrates that the fear of the debasing

of science, to result from deliberate association of Science with Industry, is utterly unfounded.

Before the present war, the number of large institutes was about 80. The Lenin Academy of Agriculture includes a net-work of some 50 establishments. The Commissariat for Public Health embraces nearly 30. Over 40 are maintained by the Peoples' Commissariat of Education; over 10, by the Peoples' Commissariat of Ways and Communications. The Peoples' Commissariat of Heavy Industry alone has 126 units with 163 branches, besides a net-work of over 800 factory laboratories. Over and above these, whole net-work of institutions are incorporated in the Academy of Sciences, the Communist Academy etc. Closely connected with these large institutes, is a wide net-work of subsidiary research institutions and factory laboratories and add to this the Zonal Experimental Stations, and the total number of scientific research points reaches well over several thousands, besides laboratories attached to Higher Technical Schools, Technicums, Museums, etc.

The actual working of these institutes, can be illustrated by that of the All-Union Lenin Academy of Agriculture with an annual research grant of 100,000,000 roubles. This Academy has 14 big Institutes under it; the working in these, is co-ordinated and controlled by it. These are:—

1. The All-Union Institute of Plant Cultivation;
2. The All-Union Institute of Horticulture;
3. The All-Union Institute of Mechanisation and Electrification in Agriculture;
4. The Fodder Institute;
5. The Veterinary Institute;
6. The Institute of Aviation;
7. The Institute of Fertilizers;
8. The Soil Institute;
9. The Institute of Genetics;
10. The Institute of Agricultural Engineering;
11. The Institute of Animal Husbandry and three

others, besides 70 Branch Institutes. Now let us take one of them—The Institute of Animal Husbandry—and let us see how it works. It has 15 departments and it controls some 150 Sub-stations, spread over the Soviet Union. Special research work is carried out at the Central Institute of Animal Husbandry in theoretical problems and the main practical problems and the work in local problems is co-ordinated at the Central Institute. The Sub-stations collect data after putting into practice the applications of the researches carried out at the Central Institute. Thus, the Central Institute always looks ahead for future work and the importance of such work to the Soviet Union. The annual, budget

of the Central Institute of Animal Husbandry is 4,000,000 roubles. The same holds true of the remaining big institutes. Under such a planning, the several branches of pure Science such as Mathematics, Physics, Chemistry, Botany, Zoology, Geology etc. have achieved monumental progress which is evident in the applications of these to Agriculture, Engineering, Mining, Metallurgy, Aviation, Warfare etc., in short, in all the spheres of National existence.

The 900 Technical Institutes and Technicums and 400 Universities, supply a constant flow of artisans, technicians, technical foremen and engineers, as well as trained industrial workers of all classes. The Academy of Sciences is mainly responsible for a supply of the major portion of highly trained research workers, trained directly under the academicians and professors who are, as a rule, consultants to one or more factories also.

The Academy of Sciences is the centre of scientific activity, which synthesises the co-ordination of work going on in the Soviet Institutions, Laboratories, Experimental Stations, Commissions and Museums. The Academy has under its purview, problems relating to (i) Structure of Matter, (ii) Study and utilization of the natural resources of the Soviet Union, (iii) the Systematic investigation of the power resources in the U. S. S. R. including distant power transmission and electrification in industry, transport and agriculture, (iv) new construction, questions of distribution of productive forces, health, protection etc., (v) Chemification of the country, (vi) Harvest, drought, new crops, cattle raising etc. and (vii) The task of the overcoming of capitalism etc. In virtue of a special statute, the U. S. S. R. Academy of Sciences constitutes the highest research institution in the Soviet Union. It has set itself the task—"to study the country's productive forces and contribute to their utilisation" and "to elaborate the methods of applying the scientific theories and the results of scientific experiments and observations to the task of Socialist construction in the U. S. S. R." The Academy of Sciences plans its activities in close co-ordination with the planning of economic reconstruction by the Soviet State in close consultation with other Institutes, such as, the Department of Social Sciences, the Institute of Economics, the Agrarian Institute etc. and thus helps the State Planning Commission. It helps the All-Union Lenin Academy of Agriculture which does the synthesis and collaboration of all plans of work for Agriculture, under the Peoples' Commissariat of Agriculture. It controls and plans the work pertaining to Heavy Industry, under the Peoples' Commissariat of Heavy Industry and so on. It also remains in close touch with various conferences, and reports on large enterprises in big centres.

The net-work of Scientific research as carried out in (a) Subsidiary points, factory laboratories, etc., (b) Branch Institutes and (c) Head Institutes brings the Academy of Sciences in close touch with the needs of industry, creating as it were a continuous flow from the most abstract theoretical considerations to the minutest details of practical work. It is

difficult to demarcate between Pure and Applied Sciences so happily interwoven together in the U. S. S. R.*

* Abridged from the talk given at the Special Symposium on 'Organisation of Post-war Scientific Research' under the auspices of the National Institute of Sciences, Calcutta, on 26th and 27th September, 1943.

WATER POLLUTION RESEARCH

GILBERT J. FOWLER

IT is with a certain mischievous satisfaction that memory recalls a short exchange which took place between Sir John now Lord Simon and the Principal of the Harcourt Butler Technological Institute on the occasion of a garden party in Cawnpore held in honour of the Simon Commission, now as it seems, so many years ago. In reply to the friendly inquiry, "What is your work here?" came the answer: "We try to teach these lads to do something useful, instead of all being lawyers."! "Some of us" came the gentle retort, "think that even lawyers have their uses"!

Meditating on the incident recalls former experience which does not associate lawyers with questionable politics or criminal litigation but with helpful creative activity concerned with the framing of new laws and by-laws designed to facilitate the public good. How much thought and care goes to the drafting of a clause in a Municipal Bill, few who have not worked in that field can fully realize. To be associated closely with such a wise watcher of the public welfare as the dear and charming veteran Sir William Talbot, Town Clerk of Manchester, controlling an expenditure greater than that of many an important Indian State, was indeed a most valuable education in the conduct of affairs. An early incident comes to mind. Called in to the august presence the young and newly appointed chemist in the City Surveyor's Department was happily surprised at the geniality of his reception. Commenting on it afterwards to the Head Clerk in the outer office, the information came: "You must remember that the Town Clerk is a very old bird, and you do not suppose that when he wished to glean some information from you that he would begin by putting you ill at ease."! And so it continued through many interviews and hours spent in drafting clauses and letters so that the exact meaning and proper phrasing should be distilled out from the possible confusion.

Some times this was troublesome owing to inherent scarcity of available words, and care was needed in the reading aloud of a phrase as thus: "no dam, (pause here) weir or other obstruction."

It may be asked what have these reminiscences to do with Water Pollution Research? The reply is that law making and litigation over Water Pollution have gone on throughout history. In England it was Edward III who in 1358 issued a royal order prohibiting the deposit of filth in the Thames. 30 years later came the first Rivers Pollution Prevention Act designed to prevent the deposit of solid filth in rivers. No very great changes are to be recorded in this field until the Industrial Revolution had set in and in addition to an increasing burden of sewage, the rivers were called upon to receive all manner of pollution from the multiplying factories, especially those producing heavy chemicals. Then came the Towns Improvement Clauses Act of 1847 permitting what we now know as "water carriage" and the discharge of sewage into sewers. What happened to the rivers into which the sewers discharged their contents was not apparently much thought of. Sir Robert Rawlinson appointed in 1852 as the first Chief Inspector of the Local Government Board questioned whether it was not better to pollute rivers than to pollute towns and houses, to kill fish than to kill men. Nevertheless increasingly restrictive Acts were passed at intervals until we come to the Public Health Act of 1875 and the Public Health Act Amendment Act of 1890. These were preceded by numerous Royal Commissions, the general conclusions of which were that sewage should be purified before discharge into rivers and that the best means of purification was treatment on land either by broad irrigation and the growing of crops, or by so-called intermittent downward filtration.

Little progress was made until County Councils were formed under the Local Government Act 1888.

To these Councils were given powers to administer the Rivers Pollution Prevention Act of 1876. Under Section 14 of the Local Government Act of 1888 the Local Government Board (now Ministry of Health) was empowered upon the application of any County Council concerned, to constitute Joint Committees representing County and County Borough Councils for the sole purpose of enforcing the Rivers Pollution Prevention Act in regard to the rivers and streams flowing through or by their combined administrative areas.

After much public discussion and tentative legislation several Joint Committees and important Rivers Boards came into being. Among these may be mentioned the West Riding of Yorkshire Rivers Board, the Mersey and Irwell Joint Committee and the Ribble Joint Committee. These Joint Committees as well as authorities such as the Thames Conservancy, Port of London Authority and others, are accustomed to lay down certain standards of purity, or limits of impurity, to which all sewage discharges, either with or without previous purification, have to conform.

The attainment of these standards by the approved method of land treatment was handicapped by the increasing difficulty in obtaining the necessary large areas of land. An era of experimental work on various methods of artificial treatment set in. These may be broadly comprised within two categories, chemical and bacteriological. Among the many varieties of chemical treatment perhaps the most permanently successful was what was known as the A. B. C. (Alum, Blood and Clay) process for many years in operation at Kingston on Thames and the sludge from which was commercially disposed of as a valuable fertiliser. The recovery of grease from sewage containing large quantities of wool scouring refuse, as at Bradford, has been successful as a preliminary process. In most cases final purification of dissolved impurities has to depend on bacteriological or biological treatment either through the agency of land or otherwise. Among the workers of this time in England the name of W. J. Dibdin, Chemist to the London County Council stands out, as he was the first to bring into permanent use what has come to be known as the Contact Bed, which comprised a concrete tank filled with broken clinker or any suitable resistant material affording a large surface on which the necessary organisms can grow. At this period other methods depending on biological activity were developed, notably the Septic Tank operating under anaerobic (absence of air) conditions, and the percolating filter, upon which the effluent from the septic tank or other preliminary treatment was distributed by spraying.

The development of these alternatives to land treatment resulted in the appointment of another

Royal Commission, the well known Iddesleigh Commission of 1898. The strenuous activities of this Commission found expression in the issue of 10 reports between 1901 and 1915. They demonstrated quite clearly the possibility of purifying sewage by intensive bacterial action operating on extended surfaces of artificial filtering materials other than land.

Prior to and during the investigations leading to these findings an era of great activity set in for the legal profession and for the expert witness, in the frequent local inquiries which were held in those days by the officers of the Local Government Board, before sanction could be given for public expenditure on the numerous novel schemes put forward in lieu of the now old fashioned land treatment. One of the most important of these was held in Manchester to consider the proposal to put down a large area of contact beds on the basis of experiments carried out under the supervision of a trio of Experts of the highest standing consulted by the Manchester Corporation. Bacteriology was represented by Prof. Percy Frankland, Chemistry by Prof. W. H. Perkin, (Jun.) and Engineering by Mr Baldwin Latham. The Inquiry was held in the Town Hall, the public and press being admitted. The Local Government Board was represented by two responsible Inspectors. The case was opened by one of the most brilliant members of the Parliamentary Bar, Mr Balfour Browne, K.C. It was then that the present writer was impressed by the quickness of the lawyer mind at its best. Coming new to the subject the previous day the good man was able to give an opening speech of an hour's duration and conduct a whole day's examination and cross-examination of witnesses with only one small technical mistake. In after years further opportunities occurred to meet him and other distinguished members of the legal profession at numerous local inquiries, and in the Committee Rooms of the Houses of Parliament at Westminster. It would be entertaining to recount many humorous incidents which occurred on these occasions but the fact that a member of the public during an inquiry in a little country town, when the proceedings tended to dullness, called out: "Mr Chairman, may we smoke?", is sufficient to indicate the democratic character of the whole procedure.

Such inquiries also were not infrequently occasions for the uncovering of "backdoors" and other devices for the disposal of sewage when legitimate methods became difficult. As one "old-fashioned" sewage works manager remarked to his engineer chief, when confronted with some ingenious hidden outlets, "You see, Sir, we 'ad no other eternity." So far as is known this priceless Belcherism has not yet appeared in *Punch*.

As one of Mr H. G. Wells' characters remarks—"This yer progress it keeps on keepin' on", and in due course the one-time new artificial filter beds became outmoded and the "Activated Sludge" period began, with a whole new series of research problems. The need for some Central Authority, which should not only adjudicate but should itself investigate the apparently endless new paths of research opening out in connection with modern water supply and sewage purification problems, had been adumbrated by the Iddesleigh Commission, but it was not until 1927 after much urging from the British Waterworks Association and others that Lord Balfour, Lord President of the Council, stated that Government had decided to provide money for research.

In June 1927 the Water Pollution Research Board was appointed with the following terms of reference:

- (1) To submit to the Committee of the Privy Council for Scientific and Industrial Research from time to time, schemes for research on the prevention of the pollution of rivers and other sources of water supply by industrial effluents and sewage and on any relevant matters affecting the purity of water supplies.
- (2) To supervise the execution of approved investigations.

An Advisory Committee on River Pollution was subsequently set up by the Ministries of Health and of Agriculture and Fisheries to deal with the legislative and administrative aspects of the question.

The Royal Commission on Sewage Disposal of 1898-1915 had recommended the establishment of a Central Authority charged among other duties with the investigation of problems in the purification of polluting discharges. In accordance with this recommendation as detailed by the Royal Commission the newly appointed Water Pollution Research Board conceived their task to be threefold:—

- (1) To collect and collate all pertinent scientific and technical information so that it may be readily available for practical application by those who are concerned with water supply and the disposal of polluting liquids;
- (2) To encourage and co-ordinate relevant scientific research in this country; and
- (3) To undertake such investigations as are necessary in the public interest and not otherwise provided for.

Although the problems of water supply and sewage disposal in India differ considerably from those encountered in Great Britain there can be no doubt that the formation of a Board with similar terms of reference but modified to meet Indian problems, would be of the greatest benefit to the country. At present responsibility for recommending schemes of water supply or sewage or refuse disposal rests mainly with a few permanent officials, engineering and medical, who, although individually competent, are burdened with many other duties and

have not ready access to the accumulated experience which would be collected and filed during many years by such a body as the Water Pollution Research Board.

One of the first activities of the Water Pollution Research Board in Great Britain was to issue periodical summaries of all the published work concerned with their terms of reference. These appear every month under the title "Water Pollution Research Summary of Current Literature," and can be purchased by the public for an annual subscription of 24 shillings. The volume for 1941, the third year of the war, contained 1439 abstracts, the number being larger in pre-war years. It is true that ultimately research in this field published in India finds its mention in these abstracts but only after a considerable delay. A similar publication appearing monthly in India and concerned solely with researches directly bearing on Indian conditions could not fail to be of the greatest interest and would be of special value if ably edited in awakening the interest of the general public in the whole wide field of sanitation as distinct from curative medicine and the more purely physiological aspects of nutrition.

Apart from the publication of these summaries, the Water Pollution Research Board has itself been responsible for the carrying out of researches of wide scope calling for team work and expenditure beyond the means of individuals or minor local authorities. The results of these investigations have been published in volumes of great importance and interest to all concerned with activities which have their bearing not only on the immediate question of *e.g.* river pollution and sewage and refuse disposal but of fisheries and agriculture, as well as irrigation and river conservation. Among these publications may be mentioned: Technical Paper No. 2, Survey of the River Tees, Part I, Hydrographical, H. M. Stationery Office, 1931, Price 5s. 6d. net; Technical Paper No. 3, Richards E. H. and Cutler D. W. The Purification of Waste Waters from Beet Sugar Factories, H. M. Stationery Office, 1933, Price 7s. 6d. net; Technical Paper No. 5, Survey of the River Tees, Part II, The Estuary—Chemical and Biological, Price 9s.; Technical Paper No. 7, Estuary of the River Mersey, Price 20s.

An account of this last very important Report was given in a short article by the present writer in *Current Science*, 1939, 8, No. 1. An investigation of this character was shown to require the joint labours of specialists in a number of professions—engineering, hydrographical, sanitary, legal, as well as the chemist, the biologist and the fisheries expert.

Such estuarial studies would be of great value to India, more particularly to Bengal.

In the first place there is the immediate question of the Calcutta Water supply. It was the advent of industrialism into India which first called this into consideration. Just as the mill wastes alarmed the owners of fishery rights in England, so the discharge into the Hooghly of the effluents from numerous septic tanks serving the riparian Jute mill population caused apprehension concerning the purity of Calcutta's water supply. A careful and prolonged research into this problem in its various aspects laid the foundation of the chemistry and bacteriology of Indian sewage disposal. Compared with the overwhelming pollution of English rivers, the water of one of which was used instead of ink to indite a letter of protest to the Rivers Authorities, there was little to be seen on the vast silently moving expanse of the Hooghly above Calcutta. Careful sampling however revealed the presence of *B. Coli* skimming the smooth surface of the stream, away into the centre of the river far from the actual outfall. Percolating sewage filters and a small dose of chlorine were sufficient to remedy this. The main discharge of Calcutta sewage was not involved since this was directed away from the Hooghly into one of the many streams comprised in the delta of the Ganges, viz., the river Bidyadari. Even at that date (1906) the present writer was informed by high authority, that this outlet was becoming loaded up with silt and sewage deposit. It was not however until 1913 that serious notice was taken of this dangerous state of affairs and only in 1923 were dredging operations undertaken. Much discussion and some investigation followed and eventually Dr Dey's Kulti Scheme was adopted in 1936 according to which the sewage would be screened and settled and the effluent and storm-water would be discharged ultimately into the river Kulti 17 miles from the existing outfall. Two circular sedimentation tanks have been constructed at Bantola on waterlogged land which is some distance from habitations and where there is space for final disposal of sludge. Sludge will be pumped to lagoons for partial digestion and then transferred to drying beds. Dried sludge can be used for manure or for land fill.

There are thus two channels, one for normal sewage and one for stormwater uniting at the final outlet into the Kulti. The Kulti connects up at about the point of sewage discharge with the Raimangal series of rivers emptying finally into the Bay of Bengal.

The final decision to adopt the Kulti Scheme was arrived at after many years of discussion and a certain amount of experimentation mainly of an engineering character. Some of the interim decisions arrived at are now realised to have been unfortunate, but in spite of mistakes the experience gained and the study

necessitated will prove of great value in future planning.

Among the numerous responsible engineers consulted or whose opinions have been quoted was Sir William Wilcocks, a name enduringly famous in relation to the control of the waters of the Nile.

"Once the Ganges is trained", he says, "and the Nadia barrage built there will be ample water for irrigation by pumping scores of miles above and below Calcutta. The dirty and grubby slums and environs of the city will have had their place taken by such a landscape as we see around Cairo."

The need for specialist engineering studies has been clearly recognised in the appointment of various Research Boards such as the Water Resources Conservation Board recommended by the National Planning Committee, the Central Hydrodynamic Research Station, Poona, founded in 1925 where the training of rivers and silt deposit conditions are investigated by models covering an area of 6 acres with 14 experimental channels, and the Rivers Research Institute recently established in Calcutta particularly for the study of the river problems in Bengal. All of these important bodies are mainly concerned with the engineering aspects of river conservation. Up to the present it would appear that the chemical and biological studies, which would be the main concern of a Water Pollution Research Board, have not received the attention which they demand. One very important fact e.g., which governs the deposit of silt in sewage polluted rivers has not been fully recognised in the public discussions. In a study of the Yangtse, carrying as it does vast quantities of sewage polluted silt from the agricultural lands of China, it was found that on separation of the silt the water was remarkably pure. Laboratory studies showed that if raw sewage was mixed with such silt-laden water under natural conditions of aeration, the silt and the sewage would mutually precipitate, resulting in a heavy and readily settling deposit. This has evidently been taking place in the Bidyadari and other polluted rivers of Bengal, and the deposited "slime", as it is described, is not easily removable by ordinary tidal action. The mutual reaction therefore of silt and sewage deserves careful biochemical and physical study. The phenomenon is so well recognised among water pollution engineers that the addition of a certain proportion of silt to the sewage or water and aerating the mixture has been employed as a method both for sewage and water purification. In addition to the purely physico-chemical effect of clarification the silt particles form a suitable nidus for bacterial growth and so the actual oxidation of suspended and dissolved impurities is effected.

The subject of Calcutta water supply, though it has received intermittent attention has only comparatively recently awakened the public interest

which it deserves. A Technical Advisory Board made important recommendations, among others the re-conditioning of the Pulta Water Works Laboratory. The inauguration of this new era was celebrated by an opening ceremony attended by the Mayor of Calcutta with prominent guests and officers. Excellent speeches were made, and the expectation was expressed that the Laboratory would now take its place with the world famous Laboratory of the Metropolitan Water Board of London whose Annual Reports have for many years been a source of inspiration to all responsible students of water supply and purification. Doubtless owing in part to the difficult war conditions no publications of this order have so far appeared, but at any rate it may be hoped that the foundational possibilities are not forgotten.

Further questions still remain. What becomes of the potential fertilizing value of the whole of the solid and liquid contents of Calcutta sewage and what effect have this and other discharges on the fish life of the estuary. It is stated that at one outfall the fish are destroyed for a mile round.

Thus it would appear that the three great cities of India—Calcutta, Bombay and Madras—discharge the greater proportion of their sewage into the sea and thus the wastes of some 5 million people do not return to fertilize the barren acres of the countryside. It may be argued that at any rate the benefit to health from the removal of sewage from the congested city dwellings compensates for the loss of food values, and that at any rate even this may ultimately return as fish. There is room for careful and prolonged research on the part of a body like the Water Pollution Research Board to obtain real factual data on this question. The Report on the Pollution of Estuaries and Tidal Waters by E. A. Letts and W. E. Adeney published as Appendix VI to the 5th Report of the Iddesleigh Commission will serve as an excellent model of the kind of investigation required more particularly from the biochemical point of view which largely controls the biological factors on which successful fisheries depend.

Such investigation would also have its bearing on inland sewage disposal. The chronic difficulty with any method of treatment of sewage on land is that the crop only requires ample water at certain seasons whereas the sewage comes down without intermission. Even if artificial methods such as percolating filters or activated sludge are employed the value of the dissolved compounds of nitrogen and other useful elements is lost. The possibility of recovery of these elements in artificial fishponds deserves careful investigation. Shallow lagoons have indeed been proposed in which both rice and fish could flourish. Already there is a Fish Committee of the Imperial Council of Agricultural Research.

Valuable papers have recently appeared in SCIENCE AND CULTURE on the general subject of fishery development and control. Two are concerned with the relation between plant growth and fish nutrition, the main controlling factor of inland fish ponds. Two valuable papers on the technique of deep sea fishing in different parts of the world are contributed by B. Sunderaraj, formerly Director of Fisheries, Madras. In a number of *Chemistry & Industry* which has just come to hand the important question of the relation between plankton development and fish life is considered. From the point of view of water pollution this is of special interest, since important fishing grounds, e.g., in the Arctic circles are necessarily far from the discharge of human waste of any description.

In considering the degree of waste of valuable plant food arising from the discharge of sewage into the sea, the question of the relation, if any, of such discharges to plankton increase or decrease needs much closer study. It is clear in fact that much of the work now undertaken by the Imperial Council of Agricultural Research would form part of the purview of a Water Pollution Research Board.

The great need is that although individual aspects of such researches may particularly concern the agriculturist, the irrigation engineer, the fisheries controller or the sanitary specialist, it should be easily possible for all relevant information to be available at one centre so that qualified workers, either officers of the Board or available outside specialists, with the necessary experience, could be deputed by the Department of Government concerned to take up any given problem as it arose. Their reports and researches should be published in the same way as the technical papers of the Water Pollution Research Board in England and all copies of publications elsewhere which are of special interest should be available in the library of the Board. Any large scheme of public expenditure involving special knowledge should be passed upon by experienced officers of the Government Department concerned, advised by the specialist officers of the Board.

Apart from Reports and Researches, the essentials of which have found their way into text-books, many valuable investigations are buried in the archives of Municipalities, or Provincial Governments. The need for a Central Reference Library is evident.

At present Reports prepared by direction of Provincial Governments or by Municipalities rapidly become unavailable either through being out of print or never having been at the disposal of the public. Among such publications in India may be mentioned those concerned with the pollution of the Hooghly, with the removal of silt from the

Calcutta water at the Pulta Water Works, Experiments on the treatment of the sewage of Nagpur, of Madras and of Bombay and on Sewage Farms in the U. P.

A visit to the Ministry of Health at Whitehall would impress the observant caller with the store of recorded information available when he sees rows upon rows of volumes filling the shelves which line the corridors of the Ministerial environment. The more important Reports remain available for purchase by inquirers from H. M. Stationery Office.

A Water Pollution Research Board, if formed, would have in addition to the important duties outlined in the foregoing paragraphs many other lines of research. Among these the following may be particularly considered:—

Trade Effluents.—Until recent years the problem of trade effluents in relation to sewage purification has not played such an outstanding part in India as in the industrial towns of England. Nevertheless important instances of trade effluent pollution of rivers are met with. As long ago as 1906 the discharge from the *lac factories* of Mirzapur into the Ganges was receiving attention. The consequent investigation led later to important technical and scientific developments in the lac industry. Other trade effluents which have been examined are those proceeding from the textile industry, effluents from bleach and dye works and from a certain number of wool scouring factories. The problem connected with bleach works is the high saline content which interferes with the use of the effluent for agricultural purposes, at the same time creating possible serious pollution of wells in the neighbouring countryside. Sulphur dye works effluents raise a special problem in public health owing to the possibility of the evolution of sulphuretted hydrogen in poisonous quantities. More than one fatality occurred in the past in Manchester through the evolution of this gas in the sewers. The proper treatment of tannery waste has needed attention in Cawnpore and Madras. Lahore has had to consider the effect of the effluent from chrome plating works on the treatment of sewage. Recently the treatment of brewery waste and distillery waste has become an urgent problem in view of the increasing production of power alcohol from molasses. Slaughter house effluent has increased with the demands of the army for dried meat. Complaints have been received by the fishing communities both in the Darjeeling and in the Nilgiris districts that the discharge of waste from the quinine factories has an injurious effect on fish life. Special problems, partly of a mechanical nature, arise in connection with the treatment of effluents from paper mills and cardboard factories.

It is clear that with the industrialisation of India and the simultaneous improvement in sanitary conditions the problem of the effect of trade effluents on sewage treatment will become of greater urgency. It will have to be fully realized by factory owners that proper treatment of the effluent must always be reckoned as one of the necessary costs of manufacture. If the effluent is discharged into the public sewer to be treated at the public expense at the local works, then an equitable charge will have to be paid for this service as is provided for in the most recent legislation on this subject in England. It is clear that a Water Pollution Research Board, as an impartial authority, will find work of great value in the equitable adjustment of difficulties both scientific and social which may arise in this connection.

Agricultural Value of Sewage.—The whole subject of the treatment of sewage from Indian Municipalities still requires very careful study in view of the state of things revealed by an official report, *e.g.*, that most of the numerous towns in the U. P. alone are without proper sanitation. Doubtless similar conditions prevail in other less closely populated regions of India. How far, in view of the inherent difficulties involved in the direct treatment of sewage on land, artificial methods can usefully and economically be adopted is a matter for impartial investigation. In this connection important contingent objectives will arise such as the possibilities of fixation of nitrogen from the atmosphere both in the soil and in the compost heap. The work of Dr N. R. Dhar in which he draws attention to the possibilities of induced oxidation apart from bacterial action has given a new impetus to this enquiry. It would even seem that the old theories of Liebig in pre-bacterial days contained a certain element of truth.

The bacteriologists of the Water Pollution Research Board might well devote their attention to an examination of the theory of mycorrhizal association of plant and soil, powerfully supported by Sir Albert Howard and others, but on which there is still a considerable difference of opinion in competent quarters.

Finally, in addition to these lines of inquiry which affect all India, it may perhaps be permitted to look forward to a future when the dream of Sir William Wilcocks and others concerning particularly the Bengal River Problem will come to fulfilment. With the embodied experience of the great canalisation works in the past as well as such vast war-undertakings as the present-day Alaska Road, many things appear no longer impossible. Not only are mechanical inventions available, but also one may perhaps add, modern ideas on finance. The war has at last revealed to many, *e.g.*, the Governor of the Bank of Canada among others, that anything which

is physically possible and desirable can be made financially possible.

May it be that the Water Pollution Research Board will lend its assistance to the engineers to bring about the dream of Sir William Wilcocks, when the rivers of Bengal will be tamed by suitable dams, when the crooked streams will have been made straight, when the water-hyacinth will have been

cleared and composted for the fertilization of land, and instead of a malaria-infested jungle there shall be a happy and beautiful countryside?*

*The writer's cordial thanks are due to Dr S. L. Hora who has supplied him with valuable information concerning Bengal fisheries, and to the officers of the Calcutta Corporation who at Dr Hora's request have made freely available reports and maps concerned particularly with the problem of Bengal rivers.

THE INDIAN HISTORY CONGRESS

BISHESHWAR PRASAD,

JOINT SECRETARY, INDIAN HISTORY CONGRESS

THE Indian History Congress was founded in the year 1935 with the object of supplying the long-felt want for an association* which dealt with the problems of Indian History as a whole. The objects of the Congress as laid down in the Constitution are:—

1. Promotion and encouragement of the scientific study of Indian History.
2. Holding of Congresses and publishing of the proceedings, bulletins, memoirs, journals and other works.
3. Co-operation with other organisations in India and abroad holding similar objects.
4. Encouragement to the formation of provincial and State organisations, affiliated to the Central Body.
5. The securing, management and disposal of funds, property and endowments for the purposes stated above.
6. Performance of all other acts conducive to the fulfilment of the objects of the association.

The work of the Congress is divided into six sections, *viz.*,

- (1) Ancient India, Part I, up to 711 A.D. ;
- (2) Ancient India, Part II, 711 to 1206 A.D. ;
- (3) Early Medieval India, 1206 to 1526 A.D. ;
- (4) Later Medieval India, 1526 to 1764 A.D. ;
- (5) Modern India, 1764 onwards ;
- (6) Local History, where necessary.

The administration of the Congress is in the hands of an Executive Committee.†

*The Indian History Congress Association is a registered body under the Societies Registration Act of 1860. It has a democratic constitution and the Congress is representative of the various areas and interests in the country. The membership of the Congress is open to all persons interested in the study of Indian History.

†Its present office-bearers are:—

President—Rao Bahadur K. N. Dikshit.
Vice-Presidents—Dr R. C. Majumdar and Rao Bahadur Prof. C. S. Srinivasachari.
General Secretary—Dr Tara Chand.
Joint Secretary—Dr Bisheshwar Prasad.
Treasurer—Dr Benarsi Prasad Saxena.

The first session of the Indian History Congress was held at Poona in 1935. The second session was held at Allahabad in 1938. The next three sessions were held annually at Calcutta, Lahore and Hyderabad respectively in 1939, 1940 and 1941. The last session of the Congress was held at Aligarh from December 26th to 28th, 1943. The sessions of the Congress have been attended by an ever increasing number of scholars from all over the country, thus testifying to its growing popularity. The Congress has been fortunate in securing the whole-hearted co-operation of the Government of India, the Provincial and State Governments, the Universities and the learned societies, who have been sending their representatives to participate in its deliberations and to further its objects.

The Aligarh session was a great success and it reached another milestone in furthering the objects for which the Congress stands. The Congress met under the Presidentship of Rao Bahadur K. N. Dikshit, Director-General of Archaeology in India. In his inaugural address, he dwelt upon the need for a comprehensive history of India, and made valuable suggestions with regard to the manner in which that need might be met. He pointed out that "for over a decade now there has been a considerable amount of feeling among historians and orientologists that with the enormous and ever-growing material and an increasing number of scholars of real merit, India urgently stood in need of a Comprehensive Scheme of Indian History brought out by the co-operative efforts of Indian scholars". He appealed to all who have the interests of India at heart and who believe in the supreme necessity of the appearance at the earliest practicable moment of a Comprehensive Indian History, to rally round the banner of the Congress, so as to accelerate the progress of the project."

The emphasis laid upon the project for a Comprehensive History of India by the President was most timely for the consideration of the project was one of the most important items on the agenda of the Congress for the Aligarh Session. Editorial Committees had been appointed at the Hyderabad session for the selection of scholars who would write the various chapters of the History in 12 volumes, planned by the Congress. The final draft of the list of contributors was discussed at the Aligarh session and adopted. Thus an important stage has been reached in the preparation of the Comprehensive History of India and it is hoped that the first volume will be ready before the year 1944 is over.

The various Sections of the Congress did most valuable work. The Sectional Presidents delivered opening addresses and these were followed by the reading of papers written by scholars for their respective sections.

Dr P. C. Bagchi, President of Section 1, delivered a very arresting address containing many original ideas. He emphasised certain problems of Central Asiatic races, viz., Sakas, the Tukharas, the Murangas and the Hunas. Following Dr Sylvain Levy, he seemed inclined to identify the Tukharas with the Kushans. In this he followed also the references in the Puranas, which put the Tukharas as reigning after the Sungas and the Andhras. It was a very instructive and comprehensive survey of some of the most important problems of Ancient Indian History.

Dr Rama Shankar Tripathi presided over Section 2. He made an exhaustive survey of the main currents of the period and gave many new interpretations of some of the facts. He reviewed the work done so far and made valuable suggestions regarding the manner in which the existing gaps in Ancient Indian History should be filled up.

Prof. H. K. Sherwani presided over Section 3. He emphasised the study of the Early Medieval period, which, he said, is so rich in materials and which has been so sadly neglected. He pointed out that it was in this period that various movements for the cultural rapprochement in India developed. He said that their reaction on political life had not attracted the attention of scholars; nor had the activities of Muslim saints been fully appreciated in relation to their influence on contemporary life.

Prof. S. R. Sharma presided over Section 4. He drew attention to the various dark nooks and corners in the study of the history of the Moghul Period and emphasised that more intensive search should be made for the documents and the Akhbārāt as also for the recorded decisions in Courts of Law. He

said that they should be studied with a view to solving many intricate problems of administration. He considered it desirable to draw greater attention to the activities and lives of Muslim saints and was very keen about more light being thrown on the life of the people as distinct from the kings and the nobles.

Prof. K. K. Datta presided over Section 5. He surveyed the work done in the History of British India during recent years and pointed out the gaps that remain to be filled. He referred to the problems that confront the researcher in studying the history of this period.

The papers read before the Congress dealt with numerous problems of the utmost importance in the History of India. More than 100 papers were submitted. The papers for Section 1 covered a wide range from the Mohenjodaro Civilisation to the reign of Harsha and dealt with social, political, economic and cultural problems. The papers for Section 2 dealt with biographical and administrative problems especially relating to the history of the dynasties that arose in Central India and Rajputana after the death of Harsha. The papers for Section 3 dealt with the sources and the interpretation of certain important historical documents relating to the Early Medieval period. They discussed also with important cultural and economic problems. The papers for Section 4 dealt with the sources and with several important problems relating to the political, economic and administrative history of the Moghul Empire and the Provincial Dynasties that arose during that period. The papers for Section 5 were the largest as compared with any other single section. More than 35 papers were submitted dealing principally with the political history of the British period. A few papers of great value were written on economic and constitutional problems also. Section 6, dealing with the local history of Koil (Aligarh), was well represented. A number of papers were written dealing with the historical importance of Aligarh.

An exhibition of original manuscripts, historical documents, seals and ancient weapons was organised by the authorities of the Aligarh Muslim University on the occasion of the Congress. A number of learned discourses were delivered by distinguished scholars. A debate was also organised in which the delegates as well as the students took part. The social life of the Congress was marked by the greatest good-will and harmony.

It has been decided to hold the next session of the Congress at Madras at the invitation of the University of Madras. Dr S. N. Sen, Keeper of the Records of the Government of India has been elected as the President of the next session of the Congress.

PLANNING FOR NUTRITION*

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PLANNING should be directed towards securing optimum nutrition, so far as present knowledge goes, for our entire population within a reasonable space of time, as is being done in the more progressive countries. As that plan is given effect to stage by stage, steady improvement in the nutrition level of the people will follow.

Before, however, such a tentative plan is given the following points may be borne in mind.

(1) A higher level of nutrition goes in general *pari passu* with a higher income level. The question of malnutrition therefore resolves itself principally into an economic one. The planning of optimum nutrition must therefore be an integral part of a comprehensive plan for an all-round industrial and agricultural development, which can be elaborated only by a State Planning Commission.

(2) Though population is an important feature of the problem of nutrition, the so-called over-population of India is not the major reason of her poverty and malnutrition. The increase in population in Britain has far out-run her food-production without causing famine or semi-starvation. It should be obvious that India can produce all the food she needs for optimum nutrition if science and technology are fully utilised according to a planned economy.

(3) At present there is practically no margin of safety for the bulk of the population. The Secretary of State for India stated recently that the "Government of India on the basis of the present information consider that the total abnormal mortality due to famine and to disease in the last five months of 1943 have not exceeded one million." This is apparently more than the number of persons killed in the present war in the whole of the British Empire. Efforts must, therefore, by preference be directed towards an immediate increase in food production based on nutritional considerations so that such a catastrophe might not recur.

(4) The trend of the future in the field of nutrition is that natural diets affording good nutrition will be increasingly supplemented as a routine measure by synthetic vitamins and vitamin concentrates in tablets or capsules in order to ensure optimum vitamin consumption. This may also be supplemented by mineral tablets supplying the physiological requirements of important minerals in an assimilable form. The routine food of the future is likely to consist of (1) natural food-stuffs, (2) pro-

cessed food-stuffs, such as dehydrated, refrigerated, canned, concentrated and otherwise preserved materials, (3) synthetic vitamins and vitamin concentrates in tablets and capsules and (4) physiologically important minerals also in tablets. It is expected that such scientific feeding would greatly improve the general state of nutrition and minimise the chance of malnutrition.

A FOOD-PRODUCTION PLAN ACCORDING TO NUTRITIONAL REQUIREMENTS

(a) Production of natural food-stuffs.

An optimum or nearly optimum daily diet, which we may aim at for an average adult of ordinary active habits may consist generally of the following ingredients:

Unmilled or lightly milled rice	10 oz.
Whole wheat	6 oz.
Pulses	4 oz.
Eggs	one or two
Sugar	2 oz.
Milk and milk products	10 oz.
Fish and meat (or extra milk products for vegetarians)	4 oz.
Non-leafy vegetables	5 oz.
Green leafy vegetables	5 oz.
Fats and Oils	2 oz.
Fruits	3 oz.

Such a diet would supply roughly the following:

Carbohydrates	470 g.
Fat	75 g.
Protein	96 g.
Calcium	1.1 g.
Phosphorus	2 g.
Iron	34 m.g.
Carotene	4 m.g.
Vitamin A	1.6 m.g.
Thiamin	2 m.g.
Riboflavin	1 m.g.
Vitamin C	90 m.g.
Calories	2,780

This diet would naturally have variations according to occupation, age, habits, sex, taste, etc. But this or a similar diet may be made the over-all basis of a long-term plan of food production for the entire population of 400 millions, considering that persons in heavy occupations will eat more and children will eat less. The implications of such a daily diet in an annual food-production scheme are the following:

Annual Production Required:

Cereal grains (mostly rice and wheat)	65 million tons
Pulses	16 billion "
Eggs	15 billion "
Sugar and "gur"	8 million tons
Milk	40 million tons
Fish and meat	16 billion "
Non-leafy vegetables	20 billion "
Edible oils	7½ billion "
Fruits	12½ billion "

* Adapted from an evening lecture delivered at the Indian Science Congress at Delhi on January 6, 1943.

The present production figures for some of these items are not available with any degree of accuracy. But the above production scheme would mean, to take some rough examples, that cereal production would have to go up by 30 per cent, pulses production by 200 per cent, milk production by 100 per cent, egg production by 400 per cent and so on. Such a scheme can be carried through in less than five years, if it is tackled comprehensively with the fullest use of science and technology. It may be pointed out that India at present uses barely one lakh tons of ammonium sulphate, while at least 50 lakhs of tons are needed. All of this could be produced in this country partly by fixing nitrogen of the air and partly as a by-product in the scientific utilisation of coal. With (1) the supply of fertilisers, (2) better irrigation, (3) better seeds, (4) bringing of culturable waste under cultivation, (5) crop-rotation and (6) the development of animal husbandry, poultry and fisheries, the production of cereals and other food-stuffs could be greatly stepped up. Such a production plan requires, of course, a co-ordinated and comprehensive handling as it has far-reaching implications in many aspects of our land system and economic life.

(b) *Production of synthetic vitamins and vitamin concentrates and physiologically important minerals.*

As indicated above, a scheme should be set on foot for the production of synthetic vitamins (aneurin, riboflavin, nicotinic acid, pyridoxin, ascorbic acid, etc.) and of pure vitamin A from rich liver oils by molecular distillation. Pure vitamins are now being produced in tons and hundred-weights elsewhere and their manufacture in this country should start as soon as possible. Their production is related to other chemical industries, whose co-ordinated development is urgently required. All this development is perfectly feasible with the scientific and technical knowledge available in this country. The annual production of the following quantities of the vitamins may be aimed at.

Annual Production of Vitamins:

Carotene	...	...	300 tons
Vitamin A	...	...	150 "
Riboflavin	...	...	300 "
Thiamin	...	...	300 "
Vitamin C	...	...	7,500 "
Calciferol	...	...	1,500 "

Similarly the production of physiologically important minerals in an assimilable form, particularly calcium lactate, calcium gluconate, dicalcium phosphate and iron salts should be undertaken on a planned basis. The annual production of calcium and phosphorus compounds calculated as calcium

and phosphorus should be 1.2 and 2 lakhs of tons respectively and that of iron salts as iron should be 2,300 tons roughly.

ORGANISATIONAL PLAN

(1) The food and nutrition problem naturally impinges on so many other problems that, if a plan like the one outlined above is to be implemented, a Central Food and Nutrition Planning Board representing all the facets of the problem, such as agriculture, animal husbandry, fisheries, food-technology, nutrition, public health, marketing, etc., will have to work out the co-ordinated details of the plan, which requires to be carried through by the State in a specified period of time.

(2) In the matter of food, it is desirable to aim at regional self-sufficiency as far as possible. In the light of the comprehensive All-India plan, every Province or State should, therefore, work out and carry through its own programme of co-ordinated food production (including technological production of synthetic vitamins, processed food-stuffs, etc.), food distribution, including institutional feeding, nutritional education and propaganda, nutritional and food-technological research, etc. For this purpose the creation of a permanent Food Ministry and Food Department in every Province or State is essential, which alone can deal effectively with such a many-sided problem as nutrition. The Ministry and Department should be advised by a permanent Provincial Nutrition Board, which should be constituted in a way similar to that of the Central Board representing all aspects of the nutrition problem. The lack of such a department has meant disaster to us in the past and would mean continued disaster in future. Its creation is therefore most strongly to be urged.

FEEDING PLAN

All the above planning would be largely infructuous if the food so produced is not made available to all people, *irrespective of income*. This requires that even in peace time *laissez faire* regarding food should not be restored. (1) Some form of rationing on a scientific but liberal basis should be continued in all cities and towns. (2) The distribution of food in the villages should also be under scientific and administrative supervision, if not under control. (3) All institutions, schools, orphanages, factories, etc., are specially suitable for institutional feeding, which should be made compulsory. (4) Community feeding through large restaurants under State control or supervision should be encouraged.

Notes and News

MANUFACTURE OF INTERNAL COMBUSTION ENGINES IN INDIA

THE final report of the Exploratory Committee on Internal Combustion Engines, for which we have been eagerly waiting for all these months, has at last been submitted to the Board of Scientific and Industrial Research. A summary account of this by Mr H. S. Murti, Secretary of the Committee, containing the important results of investigation has appeared in the *Journal of Scientific and Industrial Research*, January, 1944.

The Board of Scientific and Industrial Research, it may be recalled, appointed in March 1941 the Exploratory Committee on Internal Combustion Engines, with Mr J. C. Mahindra as Chairman, to investigate the possibilities of (1) the production of components or complete engines offering prospects of immediate development with particular reference to war demands and (2) the future development of Internal Combustion Engine Industry in this country.

With a view to obtain the necessary information, the Committee approached the Director General of Supply, Vehicles Directorate, New Delhi, and the Secretary, Department of Supply, Government of India, Simla and established contact with Directors of Industries of the Provincial Governments and several parties interested in internal combustion engines. The Committee has come to learn, as a result of these contacts, that 4 firms are at present manufacturing internal combustion engines in India and a very large number of workshops are engaged in the manufacture of various component parts in ferrous and non-ferrous materials for standard engines. These firms are, however, experiencing difficulties in obtaining special steels and component parts, normally imported from abroad, to build complete engines. Some of the steel industries in India, notably the Tata Iron and Steel Co. Ltd., are making alloy steels, such as high speed tool steel, nickel and nickel-chrome steels, etc.; but the production of such special steels falls far short of the demand.

With regard to the question of importing special machine tools, such as power hammers, crank turning lathes, etc., the Committee is of opinion that it will not be difficult of solution. It is suggested that the problem can be solved in much the same way as it is being done by the newly established Hindusthan Air Craft Factory at Bangalore. Supply of such machine tools and also of trained technicians may be available from the United States of America under the

Lease-lend Act, as recommended some time ago by the U. S. Technical Mission to India.

The Committee also investigated the problem of meeting the requirements of fuels and lubricating oils from indigenous sources. Experiments on the utilisation of Indian vegetable oils as fuels and lubricants for internal combustion engines (*Indian Industrial Research Bulletin*, Nos. 19 and 20) have already yielded encouraging results. For instance, the cotton seed oil gives an exceptional performance in that its consumption is definitely less than that of mineral oils and its efficiency appreciably higher, while the power output is equal to that obtained in the case of mineral oils. It is stated that further research bids fair to develop suitable substitutes to cover the whole field of engine lubricants from vegetable oil blends. Then the bright prospect for production of fuel oil from coal by low temperature carbonisation was pointed out, and a reference was made to the investigations of Dr H. K. Sen, Chairman, Fuel Research Committee, who tried the neutral fractions of the low-temperature tar produced in the gas works in 27 H.P. National Engine with successful results. The use of pulverised coal, according to Dr Forrester of the Indian School of Mines, does not appear to be a practical proposition at this stage owing to the high ash content of Indian coals. Attention was also drawn to the possibility of using power alcohol and other fermentation products as fuel. A reference was made to the Industrial Fermentation Committee which reported that the use of power alcohol for internal combustion engines to the extent of at least 20 per cent of the petrol used should have been encouraged and even made compulsory.

The need for setting up a properly equipped workshop for testing the results of research on a sufficiently large scale for obtaining the data necessary for industrial development was emphasised by the Chairman of the Committee. Difficulties have been experienced in testing the findings of research committees under actual manufacturing conditions. It was further suggested that the workshop should be financed by the Board of Scientific and Industrial Research and staffed by persons with experience in the manufacture of pilot plants.

But the most interesting and important part of the report is the reaction of a number of British manufacturing associations, such as the Diesel Engine Users' Association, Society of Motor Manufacturers and Traders, Ltd., and Internal Combustion

Engines Manufacturers' Association, London, who were approached, through the High Commissioner for India, to ascertain whether they were prepared to offer their standard makes of engines for manufacture in India under license. Though the subject greatly interested these associations, they expressed their inability to do anything in the matter in the face of the official statement made by Mr Amery, Secretary of State for India, in the House of Commons on 9th October, 1941, in reply to a question relating to the manufacture of internal combustion engines in India, which runs as follows:—

"As I have already explained, the manufacture of internal combustion engines in India is not a practical proposition so far as the present war is concerned".

The disappointment was, however, a foregone conclusion. But the whole procedure has served the useful purpose of exposing the policy of His Majesty's Government towards any developmental programme relating to industry in India. Under this policy, the manufacture of internal combustion engines, nay the development of any heavy industry, in India will never be a practical proposition. In this connection we may also recall Lord Beaverbrooke's reply when Mr Arthur Moor, Editor of the *Statesman*, pleaded with him in London to let India have machine tools and experts to build up belated war industry in the East and also to send her aircraft for training on a large scale. He said, "I'd be mad to do it". Never was the attitude of the British Government towards industrialisation in India more clearly explained than on that occasion, through a short sentence of only six words and thirteen letters. Against such official statements, therefore, Indian manufacturers and industrialists should not have any illusion regarding foreign co-operation and help in the matter of any major industrial development in this country.

GEOLOGICAL STRUCTURE OF MOUNTAIN ROOTS

THE problem of the earth's crust immediately below high mountains always constitutes an important study from the view point of earthquakes and other related seismological phenomena. According to a report in *Nature*, an interesting account of the present knowledge of the roots of mountains throughout the world has been given by Prof. Beno Gutenberg of Pasadena, California, in his recent paper on "Seismological Evidence for Roots of Mountains" (*Bull. Geol. Soc. Amer.*, 54, 473-498; 1943). Prof. Gutenberg is a distinguished geologist who has studied the structure of Southern California in great detail, and much of the present knowledge of the structure of mountain roots is the outcome of his own investigations.

Prof. Gutenberg writes that seismological evidences of nearby continental earthquakes strongly suggest the existence, below the sediments, of a layer, called the granitic layer, in which the longitudinal waves are propagated with a velocity lying between 5.55 to 5.60 km./sec. The intermediate layers which show definite regional differences appear below the granitic layer and have their lower boundary in the Mohorovicic discontinuity. Below the Mohorovicic discontinuity the geologists recognise another layer, the ultra-basic layer, in which the velocity of propagation is about 8.0 km./sec. It has further been found that the velocities of longitudinal waves in granitic and ultra-basic layers are the same in different regions of the earth, the variations remaining within 0.4 km./sec.

The 'continental layers' above the Mohorovicic discontinuity have the maximum thickness of about 60-70 km. below the Southern Alps and the Sierra Nevada. The thickness of this continental layer generally amounts to about 50 km. under areas with moderately high mountains and to about 40 km. in the vicinity of oceanic coasts. In New Zealand the Mohorovicic discontinuity appears only at a depth of 30 km while it probably begins at a still lower depth under the Atlantic and Indian oceans and practically starts from the basin in the Pacific ocean. The thickness of the granitic layer is more important under the Alps, while that of the intermediate layer is thicker and more important below the Sierra Nevada.

X-RAY ANALYSIS GROUP

ACCORDING to a report in *Nature*, the Institute of Physics has recently sponsored the formation of X-ray Analysis Group with Sir Lawrence Bragg as its Chairman. The formation of the X-ray Analysis Group has been actuated by the growing need for a closer co-operation between the users of X-ray diffraction methods in industry and for theoretical research. The methods of X-ray analysis are at present receiving such wide application in industry that a sound understanding of the theoretical basis involved in the routine procedure is considered imperative on the part of industrial workers. The practical workers are sometimes confronted with unusual problems which could not be adequately tackled without a good theoretical knowledge of the methods of analysis employed. It is also necessary that the academic circles engaged in pure research should also be aware of industrial problems in which the application of the X-ray methods is sought.

Previously the Institute of Physics arranged a number of X-ray conferences in 1942 and 1943 to give opportunities to the industrial workers as well

as the academic circles to learn the problems and results of investigation of each other's province. But such conferences were of limited value, and accordingly the X-ray Analysis Group has now been formed under the auspices of the Institute of Physics to place this co-operation on a solid basis so that a more effective and intelligent use of X-ray methods may be made in industry in future.

AGRICULTURAL DEVELOPMENTS IN THE SOVIET UNION

It is well-known that success in agricultural developments in the U. S. S. R. according to the new planning introduced after the Revolution was the last to be achieved. Frequent changes had to be made in the farming system before the desired co-ordination and development could be in sight. In a recent issue of *Nature*, Sir John Russell has given an illuminating account of the development of farming system in U. S. S. R., to which our attention has been drawn.

Sir John states that before the Soviet regime the Russians used to practise three systems of farming: (1) large estates; (2) small peasant farms; (3) peasant land farmed by the peasants under the *Mir*, the village council or commune of very ancient origin. Under the third system, peasant land belonged to the body of peasants and not to any individuals. The land was parcelled out in several strips which were periodically distributed by the *Mir* among the peasants according to the size of the family, etc. It was estimated that before the Revolution as much as 45 per cent of the cultivated lands belonged to the peasants. The first two systems worked on the basis of private ownership and the third suffered from grave inefficiency. Moreover, the fragmentation of land rendered impossible the application of the modern methods of cultivation.

State farms were introduced after the Revolution, in which arrangement the peasants were employed like factory workers and given weekly wages and dwelling facilities. But this arrangement was hardly acceptable to the peasants, and in 1938 only about 10 per cent of the cultivated land was worked as State farms. The peasants have a strong feeling for land ownership, and the idea of working in masses like workers was simply repugnant to them. The *artel* organisation, an old Russian method, was adopted, in which the workers were required to feed and house themselves. The workers were paid in actual produce, mostly grain, potatoes and vegetables. This arrangement, after suitable modification, proved workable and a very large percentage of the cultivated land was farmed in 1939 in this way. The farms generally varying from 1,000 to 4,000 acres in size were called "collectives". Before the War the plan of working used to be sent from the

headquarters. The plan had to be previously discussed and submitted for criticism before it could be finally adopted, but once adopted it could not be further discussed. The workers elected a committee from among themselves to execute the plan. As the Party always insisted on keeping its hold upon the farms the Chairman of the Committee had to be accepted by the Party and the Government and was generally taken from outside for short terms. The payment was always by the piece. The worker could eat his share of the produce or sell it to the farms, the co-operative or in the peasant market. The workers' share of the produce, however, varied with the yields and the outgoings.

The great change in the peasant outlook and organisation was largely the consequence of the constitution of 1936, which gave the collective farms the use of their land for ever, and also gave each member the use of his cottage and its gardens and holding varying from $\frac{1}{2}$ acre to $2\frac{1}{2}$ acres, on which he could maintain livestock according to his capacity. This arrangement became very popular with the peasants who by 1939 came to own in their private capacity a large proportion of the livestock of the U. S. S. R. The tendency of the peasants to devote more time to their small holdings later on led to the passing of a decree by which they are compelled to put in a minimum of hundred days per annum on the farm.

Agriculture in the U. S. S. R. has shown a steady development and progress since the introduction of the system of collective farms. Sir John states that with the return of peace this system, after some modifications, will provide the Soviet Union with food necessary for a rising standard of living. The policy followed in the present farming system is not, however, in keeping with the theoretical principles of the Party and the 'Peasant Mindedness', with its sharp contrast with the proletariat mentality, is still widely prevalent. But doctrinaire differences, as we have often seen, have hardly stood in the way of evolving a realistic solution in Russia, and we have reasons to suppose that the present theoretical inconsistency will not prevent the natural development of agriculture in the U. S. S. R.

THE INSTITUTE OF AGRICULTURE, ANAND

THE third annual report of the governing body of the Institute of Agriculture, Animal Husbandry and Dairying, Anand, for the year 1942-43, indicates a steady progress in the Institute's various activities. The Institute is still in the process of making and has, within the brief period of its existence, done useful work in animal breeding and genetics, reproductive physiology, animal nutrition and dairy science, plant breeding, agronomy, horticulture, etc. It may be recalled that the origin of the

Institute was due to the generous donations of 9 and 6 lakhs of rupees respectively by the Trustees of Sheth Mansukhlal Chhaganlal Trust and the Trustees of Seth Munglal Goenka Trust to the Government of Bombay to establish and maintain a school called the Mansukhlal Chhaganlal Institute of Animal Husbandry, Dairying and Agriculture and an institute called the Munglal Goenka Institute of Animal Genetics and Animal Nutrition. The objects of these institutions are (1) to import education and training in animal husbandry and dairying, animal genetics and nutrition, science and practice of agriculture, rural hygiene and in the development of village industries; (2) to develop and maintain pedigree herds of the best milch cows and draft cattle and to provide for the multiplication and distribution thereof; (3) to carry on research in animal husbandry, dairying, animal breeding, animal nutrition and in agriculture; and (4) to popularise improved methods of agriculture and animal husbandry. It has been estimated that about 1,000 acres of land are necessary to carry out these objects, and this area is being acquired mainly through the effort of the Government of Bombay. The Northcote cattle Farm at Chharodi, comprising an area of 2,200 acres, a pedigree herd of 450 heads of Kankry cowstock and buildings and equipment worth Rs. 1½ lakhs was also transferred to the Institute.

The main activities of the Institute, in the year under review, were directed towards the construction of buildings and roads costing about Rs. 1,19,000, organisation of the second year course of the Mansukhlal Chhaganlal Institute, planning and carrying out research work including animal nutrition, agronomy and plant breeding. The Government of Bombay, during the year, transferred to the Institute 40 acres and 26 gunthas of grass land at Surat and also acquired 3 acres and 6 gunthas at Anand for the Institute. It is stated that the Government also decided to acquire an additional area of 150 acres and hand it over to the Institute and the action in respect thereof is in progress.

MINERALOGICAL PROGRESS IN CEYLON

CEYLON'S mineralogical progress for the year 1942 has been outlined in the administration report of the Government Mineralogist, issued in November, 1943. So far as economic geology is concerned, progress is noted in the production of kaolin, mica, graphite, iron-ore and other minerals of economic importance. A number of prospecting pits were sunk in the vicinity of Kalutara for a rough preliminary examination of the industrial clays, specially of the kaolin resources of this area with promising results. Very superior quality of amber mica is being pro-

duced in the Matale and Kandy Districts and at one or two other places. Much of the larger number of remaining pits produce inferior quality, but still serviceable, mica for use in the electrical industries. With the understanding that the Government would purchase the entire output of phlogopite mica (Ceylon amber mica) for the Joint Anglo-American Mica Mission, there was a tendency to open up a number of new pits. It is suggested that prospects of exploring a 'Micanite' (synthetic sheet-mica) making plant in Ceylon should be explored. New occurrences of graphite have been recently reported in the North-Central Province, North-Western Province, and Northern Province, but no private company has so far undertaken any excavation work. The Government Mineralogist is of opinion that the Government Department should take up initial prospecting work at likely localities and then invite private enterprise on auction or tender basis. The present total reserves of surface iron-ore in sight have been estimated at 5 to 6 million tons. This quantity is inadequate to maintain an iron and steel making plant working on the blast furnace principle, but is quite sufficient for the iron and steel requirements of Ceylon, for over 100 years, if the manufacture be carried on the electro-smelting principle in modern small-scale ovens. Investigations for new sources of peat have resulted in the discovery of its existence in fairly large quantity in the Maturaja Swamp, which is estimated at over 50 million tons. During the year under review, geological survey was carried out in the following areas: West part of North-Western Province, North part of the Central Province, South-East of the Southern Province and adjoining portion of the Eastern Province, Eastern sector of the Province of Uva, and South-Central parts of the Northern Province. It is further reported that the geological boundary between the Khodalites and the basal gneiss, the principal feature in the stratigraphy of Ceylon, is at present being mapped in some detail, from which structural relationship between the major formations is becoming somewhat clearer.

CORRIGENDUM

In lines 33 and 34 of the left column of p. 305 of Vol. IX read 310°-320°C and 330°-350°C for 210°-220°C and 230°-250°C.

ACKNOWLEDGMENT

We acknowledge with thanks the receipt of the following:—

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Nos. 71, 73. 3. Bulletin of the American Meteorological Society, Vol. 24, Nos. 2, 3, 4, 5, 8, 11. 4. Chemical Age, Vols. XLVIII-XLIX, Nos. 1249-52, 1255, 1258-59. 5. Indian Art & Letters, Vol. 17, No. 1. 6. Journal of the Chemical Education, Vol. 20, Nos. 5, 6, 8, 9, 10, 11, 12. 7. Meccano Magazine, Vol. XXVIII, Nos. 11 and 12. 8. Nature, Vol. 152, Nos. 3846, 3857-63, 36864-69. 9. Publications of the Astronomical Society of the Pacific, Oct., 1943. 10. Science, Vol. 98, Nos. 2529, 2535, 2545-46, 2550-51. 11. Science and Society, Vol. VII, Nos. 3, 4. 12. Science News Letter, Vol. 43, August 21, Sept. 25, Oct. 2, 9, 30, Nov. 6, 27, Dec. 4, Vol. 44, July 3, 17, 24. 13. Scientific American, December 1943. 14. Scientific Monthly, Dec. 1943. 15. Sky and Telescope, Sept. 1943. 16. Terrestrial Magnetism & Atmospheric Electricity, Vol. 48, No. 2. 17. The School Science Review, Nov. 1943. 18. Endeavour, Oct. 1943.

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1. An Introduction to Historical Plant Geography—E. V. Wulff. 2. Beyond the Microscope—Kenneth M. Smith. 3. Education and the University—F. R. Leavis. 4. Education Through Art—Herbert Read. 5. Habit and Heritage—Frederick Wood Jones. 6. History of Bengal, Vol. I. 7. Human Physiology—Kenneth Walker. 8. Social Studies and World Citizenship—L. J. F. Briamblé and F. J. May. 9. Stellar Dynamics and Galactic Rotation—S. W. Shivesh Warkar. 10. The Aborigines—"So-called" and their future—G. S. Ghurye. 11. The Art of Discipline and Leadership—Abul Hasanat. 12. The Living Soil—E. B. Balfour. 13. The Peckham Experiment (a study of the living structure of society)—Innes H. Pearse and Lucy H. Crocker. 14. The Traveller's Journey is done—Dilys Powel. 15. Technical Education—J. C. Ghosh. 16. Thomas Barnes of the Times—Derek Hudson and Harold Child. 17. Time and Chance—Joan Evans.

SCIENCE IN INDUSTRY

BUTYLENE GLYCOL FROM WHEAT

CANADIAN scientists of the National Research Council, according to a report of the *Chemical and Engineering News*, have recently developed two new processes of producing butylene glycol from wheat. In one of the processes, the starch in the wheat is first converted into sugar by melting or by acid hydrolysis. A type of bacteria, called 'Aerobacter', obtained from the soil, is employed to ferment the sugar to produce mesoglycol, a liquid which freezes at about 60°F.

In the other process, the conversion of wheat starch into sugar is not necessary. For, the soil organism known as 'Aerobacillus' which is employed for bringing about fermentation, works directly on the starch to produce l-glycol. Wheat is, however,

cooked before fermentation. l-glycol can be used as an anti-freeze and be made to freeze at a temperature of 40°F below zero, in proper mixtures with water.

The glycol yield of the first method is greater than the second, and the product also contains less alcohol. Thus produced, glycol may be used to make butadiene and finally Buna-S rubber, through the addition of styrene in the polymerisation process.

Canada is a chief wheat producing country. Her storage of wheat in March 31, 1943, amounted to 798,000,000 bushels. It has been estimated that no more than 20,000,000 bushels would be required if all feasible Canadian rubber requirements were to be met from a wheat base and this is easily available from Canada's wheat granary.

RANCIDITY OF DRIED MILK PREVENTED

THERE has been in recent years a large increase in the use of dehydrated milk. The dehydrated milk, however, suffers from one serious drawback that the butterfat content of the milk does not keep well for a reasonably long time, but turns rancid. This limited the advantage of dried milk and as such research was directed to find out a suitable agent which would extend the usable life of the whole milk powder. It is reported in *Science News Letter*, October 9, 1943, that Dr W. D. McFarlane, a Canadian chemist of MacDonald College, McGill University, has recently succeeded in arresting the development of rancidity by adding wheat germ oil and edible acids in milk before dehydration. It is stated that this treatment doubles the life of milk powder.

Wheat germ oil has long been known to improve the keeping quality of less stable fats. The oil is generally extracted at low temperature. Dr McFarlane finds that the use of edible "hydroxy" acids along with wheat germ oil greatly increases its efficiency. The mixture of oil and the edible acids is simply homogenized into a small amount of skim milk, which in turn is poured into the whole liquid milk to be dehydrated. The amount required is so small that it does not bring about any change in colour or taste of the milk powder. In the presence of the germ oil the oxidation of the butterfat is greatly retarded and consequently the development of rancidity is also delayed. This further helps the retention of the vitamin A content. It is stated that the wheat germ oil treatment of whole milk does not necessitate any new machinery.

RECENT WORK ON STAINLESS SILVER ALLOYS

ACCORDING to a report in the *Chemical Age*, W. N. Baker, of the State University of Iowa, has recently carried out some interesting work on silver alloys. He has particularly investigated the "tarnish-resistant" silver alloys. According to this authority, several patents have been issued for making tarnish resistant alloys of silver, including one in which silver is exposed to mercury vapours, by which means a surface amalgam containing at least 90 per cent silver is obtained. This alloy is widely used for tableware. Another method is to expose silver to chlorine, bromine, or iodine vapours. Patents have also been granted for an alloy containing, in addition to silver, about 1.5 per cent silicon, together with cadmium, aluminium, zinc, and antimony; and for another alloy of 93 per cent silver, 6.5 per cent zinc, and 0.25 to 0.5 per cent sodium.

Baker, in conjunction with K. W. Ray, studied the alloys of silver with the various metals which are claimed to yield a tarnish-resistant combination, and obtained the following results:—

(1) None of the metals studied gave binary alloys with silver that were satisfactory in every respect as regards hardness, malleability, and tarnish resistance.

(2) Aluminium alone did not increase the tarnish resistance. It hardened the alloys materially and made them brittle when present in amounts beyond 4 per cent. Its malleable alloys were not as hard as sterling silver (92.5 per cent silver, 7.5 per cent copper).

(3) Zinc had the greatest tarnish resisting effect of any of the metals studied, the resistance being nearly proportional to the amount of zinc present. Zinc, however, did not increase the hardness sufficiently to be used alone. Alloys containing up to 25 per cent zinc were malleable.

(4) Chromium did not alloy with silver in amounts sufficient to have much effect upon its resistance to tarnish.

(5) The barium-silver and strontium-silver alloys studied were brittle and tarnished as easily as sterling silver.

(6) Silicon had a marked hardening effect, but could not be used in amounts much above 0.5 per cent for brittleness resulted. It had no marked effect on tarnish resistance.

(7) Tin-silver alloys containing 5 per cent tin were the most tarnish-resistant of any 95 per cent silver alloy studied, although only slightly better than the corresponding silver-zinc alloy. Increasing the amount of tin beyond 5 per cent did not increase tarnish-resistance materially, whereas increasing the amount of zinc in silver-zinc alloys did increase tarnish-resistance.

(8) Appreciable amounts of beryllium rendered silver alloys hard and brittle and decreased tarnish-resistance.

(9) Nitriding with ammonia at either 500° or 650°C was of no value for case-hardening or increasing the tarnish-resistance. Alloys containing aluminium and silicon were darkened, owing to the formation of aluminium nitride and silicon nitride case, while the colour of the other alloys was not materially affected. Cast alloys were softened because of the high temperature.

(10) While many of the alloys studied were more tarnish-resistant than sterling silver and had sufficient hardness and malleability, none was found that would be considered entirely non-tarnishing or stainless.

MANUFACTURE OF FERRO-SILICON IN MYSORE

ACCORDING to a report of the *Journal of Scientific and Industrial Research*, the Mysore Iron and Steel Works have recently started manufacturing ferro-silicon with silicon content of 70-80 per cent. For this purpose they have installed two electric smelting furnaces, the first of which was put into operation in April, 1942 and the second in April, 1943. Each furnace is reported to have a capacity for turning out about 80 tons of ferro-silicon. The furnace employs

electrodes of amorphous carbon in which the current density is about 35 amp. per sq. inch at the full load of about 11,000 amps. The raw materials used are quartz (98 per cent SiO₂ content), charcoal and iron scrap, which are mixed in the required proportions and charged in the furnace. The molten ferro-silicon collects at the bottom of the furnace and is tapped off at regular intervals. For details as to the constructional design of the furnace and methods of manufacture, the readers may be referred to *Electro-technics* (1943, Nos. 15, 16, 27).

ELECTRO-CHEMICAL INDUSTRIES

G. C. MITTER

BOMBAY MINT

THE TECHNIQUE

ELECTRO-CHEMICAL industries can be divided into three broad headings on the basis of methods of production, viz., (1) Electrolytical, (2) Electro-thermal and (3) Electric furnace. A rough list of the more important electro-chemical industries has been drawn up in the form of a table shown on the next page.

The technique of manufacture of some of the products by electrolytical method is simple enough to find a place in the post-war reconstruction scheme for the development of chemical industries in India. It is these industries which are dealt with in the present article and those manufacturing electro-thermal or electric furnace products have been left out from this review.

A Light Alloy Industry:—In electrolytical method two distinct sub-divisions are made, (1) those using aqueous solution as the electrolyte and (2) those in which an electrolytic bath of fused salt of the metal to be extracted or its double salt is used. In non-aqueous or fused electrolyte besides the salt or the double salt of the metal, a fusible salt such as an alkali fluoride or chloride is invariably added to improve the electrical conductivity and fusibility of the bath. Base metals of lower order such as Al, Mg, Be and alkali metals and also lead and sulphur are extracted by following this process. This method has thus a war-time significance because of the possibility of manufacture of metals viz., Al, Mg, and Beryllium which form important constituents of light

alloys now brought prominently in use in the construction of air-planes, automobiles and trucks. From India's point of view, a light alloy industry may be considered as one of strategic importance not only for its war-time needs but because of its many peace-time applications in industrial and domestic uses. For, we must not forget that India is, as at present known, deficient in raw products for the manufacture of copper, zinc and tin. Aluminium and alloys of aluminium and magnesium, indigenous ore reserves of which are happily enormous, must necessarily be made to replace copper and copper base alloys. To-day such replacements are being made not only as substitutes but in many cases as better alternatives for copper or copper-base alloys.

Aluminium and Magnesium:—Electrolytic manufacture of aluminium has recently been started under war impetus. It follows the orthodox line so far as its technique is concerned. Its fabrication is already an established practice in this country and it has a ready market as well. There is also the bright prospect of its use as a deoxidising agent for steel (about 400 tons a year), in aluminothermic reactions, in explosive (Ammonal), for acid containers and as electric power transmission cables. But the same cannot be said of magnesium. The electrolytic process of manufacture of magnesium as developed by the Dow Chemical Co. at its works at Midland (Michigan) and Freeport (Texas) in U. S. A. has no doubt been a remarkable success. But it is a complicated and expensive process involving the preparation of a suitable electrolyte of fused anhydrous magnesium chloride from sea water. The foundry

and fabrication practice of magnesium are again a new technique and require expert supervision. To add to this difficulty is the uncertain financial prospect of the project, as it is known to-day that the magnesium development programme of U. S. A. aims at the gigantic production of 362,500 tons of the metal at the end of 1943 at a total cost of \$339,000,000. But it can be assumed with a degree of confidence that the aviation and air-craft industry which absorbs most of the metal at present is not going to be eclipsed, with the return of peace. It is also certain that the metal will be increasingly in requisition in various non-aircraft industries, most notable of which is the automobile industries and those manufacturing portable machines, equipments and tools, textile and stationery machinery; besides it has its use in pyro-technics and flash-light photography. With us to-day the important consideration is that the development of its use as an alloy with aluminium and titanium in place of copper-base alloys is essential in the national interest of this country for it is certain that in a crisis like the present one it will be unwise to depend upon imports of such metals as copper, zinc and tin, the present indigenous ore reserves of which are either insignificant or nil. There is no reason therefore not to investigate possibilities of manufacture of the metal by using a modified Dow process at places like Mithapur where magnesium chloride is obtained as a by-product and at a price considered to be the cheapest in the world. The metal can be obtained by other non-electrical methods the most notable of which is the Pidgeon's process developed by L. M. Pidgeon of the Canadian National Research Council where ferro-silicon is used to reduce magnesia obtained from

the mineral magnesite. But the electrolytic method is to be given preference because in that case magnesite may be left for other essential uses, viz., for refractories and special cements irrespective of the cost of production which in the latter case involves the production of the costly ferro-alloy.

Beryllium:—This metal has recently attracted considerable scientific attention. The raw product for the manufacture of beryllium and its alloy is the mineral beryl and India can be said to hold substantial reserves of the ore. It is not mined for itself but is picked out from the accumulation of mica mines. The resources of this metal are considered by some to be uncertain. In the opinion of Mr Ghandy and Sir C. S. Fox to whom the subject was referred by the Board of Scientific and Industrial Research, its exploitation is necessary because, as has been pointed out, the metal and its alloys have extraordinary properties, viz., their acoustic application, their uses in X-ray equipments and specially as springs which are almost fatigueless. The metal and the beryllium copper alloy with 2-3% Be can be manufactured by the electrolysis of fused double salts of fluoride or chloride in a specially designed furnace. Talking of manufacture of such "misch" metal as Be-Cu alloy by electrolysis the possibility of manufacturing by similar methods other alloys of industrial importance such as Al and Ti need also be explored.

New Method of Manufacture of Sulphur and Lead:—Owing to its novelty but more for the importance of the recovery of sulphur in which India is badly deficient, the new electrolytic process which produces lead and elemental sulphur by the electrolysis of a solution of galena (or natural lead-sulphide)

in a bath of fused lead chloride deserves special mention. The fused lead chloride taking part in the electrolysis, is constantly reformed as the result of secondary reactions.* In this process unlike the aluminium process, the electrodes do not deteriorate during the electrolysis, but may be used efficiently for long periods as sulphur, and not oxygen, is liberated at the anode surface. The ore, galena is separated from the greater part of the waste matter before use. A concentrate containing 80 per cent lead and 13 per cent sulphur is used but there is no reason to suppose that ore of lower grade cannot be used with equal success. The most important factor in the process is the employment of bipolar electrodes. As for reasons, both practical and economic, it is desirable to set up individual cell units of large output, a very large current (approx. 100,000 amp.) will have to be employed and the use of single-coupled electrodes normally adopted in electrolysis of this kind will give rise to serious difficulties from the point of view of electrical supply. But by employing a bi-polar arrangement, a very much lower current can be used at a considerably higher pressure, because by inserting intermediate electrodes in the path of the current between the true anode and the true cathode, the same current can be used over and over again, whilst the pressure increases according to the number of additional gaps which are formed. (*The Industrial Chemist*, May 1938, Newal A. P.)

Aqueous Electrolyte:—We find in the case of aqueous electrolyte, a long line of electro-chemical industries is already in existence, the most important of which are, (1) the manufacture of caustic soda and chloride and their derivatives classified in the category of electrolytic separation, (2) the electrolytic oxidation and reduction products sub-divided as under, (a) per-acids and per-salts, (b) hydrogen peroxide and ozone and (c) organic products, e.g., iodoform, bromoform, sorbitol, etc. The third most important industry under this head is the electro-winning of metals straight from the ore; fourth is the allied industry of electro-refining and lastly comes electro-deposition and forming. These industries are to-day well-established abroad. In this country in some cases a start has been made only recently. The I. C. I., the Tata Chemicals and Mettur Chemicals are to-day manufacturing caustic liquor and chlorine on a scale large enough to meet a good part of the country's demands. The question of manufacture of hydrogen peroxide and hydrogen is being solved at Bangalore under the direction of Sir J. C. Ghosh and Dr B. B. Dey in Madras is actively engaged in the electrolytic preparation of several organic compounds such as benzidine etc. which are important inter-

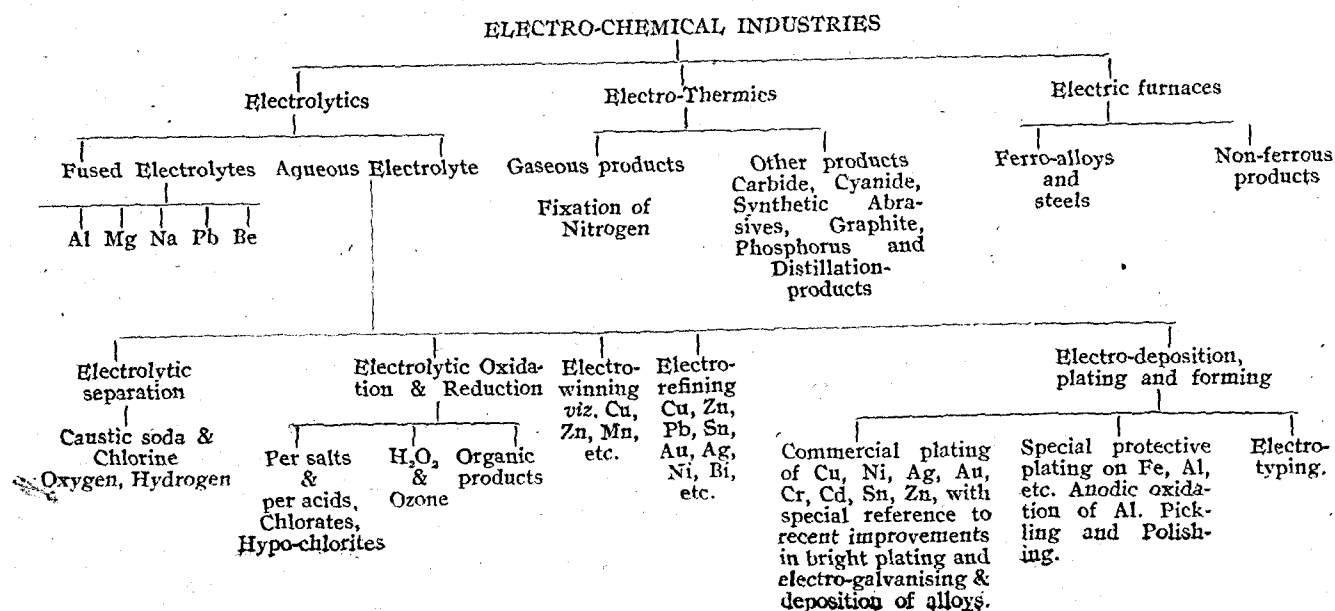
mediates in the plan of preparation of dyestuffs. Earlier attempts mostly by private industrialists made in this country for large-scale manufacture of hydrogen peroxide and certain per-salts are reported to have met with little success—their chief causes of failure were the difficulty (a) in maintaining a sufficiently low temperature at moderate cost and (b) of getting a supply of insoluble electrodes of the right quality. In almost all cases under this head a high anodic potential is necessary along with a high current density whilst the temperature would in most cases have to be kept low and in some cases addition of an oxidiser (e.g., chromate) to the electrolyte was necessary to eliminate excessive cathodic reduction. Under these conditions of work ordinary electrodes give way. Electrodes quality of "magnetite" or "chilex" (copper silicide) will have to be either imported or manufactured in this country in order to tackle successfully the problem of manufacture of the above chemicals.

Electro-winning:—Electro-winning technique has been fairly largely exploited in the case of metals such as copper, zinc and lately of manganese. In the case of copper, the main object which prompted the application of hydro-metallurgical method followed subsequently by electro-winning, was the low metal value of the ore. But in the case of zinc and manganese it was more due to the fact that the ores were complex and were not readily amenable to pyrometallurgical methods.

The general principle consists in leaching or dissolving with the help of a solution which in turn becomes an electrolyte which is then stripped of a portion of its metal by electrolytic precipitation, the stripped or spent electrolyte being returned for leaching fresh ores. It is thus a cyclic process. In the case of copper and zinc, a preliminary roasting is necessary if ores containing sulphides are the raw material so as to obtain acid soluble oxides or sulphates, the acid used being sulphuric acid manufactured usually from the SO_2 escaping through the flues of the roasting furnaces. Manganese, however, is leached from reduced manganese ores by sulphate solutions which are electrolysed in multi-compartment cells to produce pure metals. The future of high purity manganese, which can only be obtained by this method appears to be full of possibilities and therefore deserves more than customary notice. High purity manganese¹ obtained by electrolysis is considered, by analogy with the technical development of other high purity metals such as copper, zinc and aluminium, to be a potential source of valuable alloys. Both in the United States of America and in Canada

¹ Manganese and Its Alloys, U. S. Bureau of Mines publication 1939; Metallurgist (Supp. to Engineer) April 26, 1940, p. 108.

* $\text{PbCl}_2 + \text{Pbs} = \text{PbCl}_2 + \text{Pb} + \text{S}$.



patents of interesting manganese alloys using high purity manganese of electrolytic origin have been taken which are reported to give amongst other properties such as high modulus of elasticity, the property of being hardened by cold work and by heat treatment, high co-efficient of expansion, high electrical resistance with extremely low temperature co-efficient and remarkable vibration-damping capacity. The prospect of an industry involving the production and use of such a metal, ore reserves of which are practically inexhaustible, is worth investigation.

In an electro-winning process the power consumption per unit of metal recovered is much higher than in electro-refining because of the greater voltage across the cells. Selection of suitable insoluble electrodes in these cases is, as indicated earlier, a very important consideration.

Electro-refining:—The electro-refining industry started its fruitful career as early as 1865, the discovery of dynamo making it possible. To-day it has taken deep root in countries abroad due to the fact (1) that with the growing knowledge of the properties of pure metals leading to efficient services in their respective spheres of use, there came a steady demand for manufacture of pure metals and (2) that some of the foreign constituents specially the precious metals did not only pay for the process of refining but actually could be manufactured economically for making them marketable at reasonable prices, e.g., platinum metal in the case of nickel refining.

The demands for electrolytic copper for the electrical trade which consumes nearly half of the world production of the metal, for munitions and railway departments are such that an electrolytic copper industry can be called a national industry of strategic importance. High purity zinc, nickel, and recently manganese have such extraordinary properties as metals and also in the form of their alloys that many new uses have been found for them in Engineering, Chemical, Automobile and Aircraft Industries.

The principle involved in the process is no doubt simple but the technique of manufacture has undergone interesting modifications. This is more true in the case of reclaiming these metals from alloy scraps. In countries such as ours deficient in metals of strategic importance, viz., copper, zinc, tin, reclamation from scraps takes an important place in the plan for the conservation of metals. To-day the technique, still intriguing, has actually been developed and worked successfully in countries like Germany, Austria and U. S. A. (vide SCIENCE AND CULTURE, Vol. VIII, pp. 177—180, 1942-43). Details are woefully lacking and the best that can be extracted is as follows:—

An electrolytic method of refining copper directly from scrap (brass and bronze) is said to work suc-

cessfully in Austria and U. S. A. In one of the methods referred to in the case of brass, bronze and monel metals, the electrolyte was cuprous chloride, cathode was a sheet of pure copper and the anode was the brass to be refined. During the electrolysis the electrolyte was circulated through reaction towers which were packed with the scrap material to be treated. This was necessary as the electrolyte was rapidly stripped of its copper content in the refining cell because more copper was deposited at the cathode than was dissolved at the anode.²

A method for refining bronze was developed by P. Weise in 1922.³ He used a modified copper sulphate electrolyte in which the electrolyte was circulated over copper scales to reformat the electrolyte with copper, the tin content of the scrap being collected as SnO₂ in the slimes. This process is also known as the Lewin process and is protected by a U. S. A. patent.⁴

A. Hollard refined bronze electrolytically in a modified electrolyte of the customary type but in order to maintain the proper cell condition steam and air were blown into it.⁵

The electrolytic refining of the lead-bearing copper has been simplified by Kühle who eliminated dense coating of PbO₂ by adding HNO₃ and keeping the temperature at 50°C.⁶

Electro-deposition:—Electro-plating is concerned with the production of metallic coatings on metallic objects and to a limited extent on non-metallic objects with the primary idea of producing high quality finishes on the surface. But when it came to the question of preventing formation of scales or rust it assumed an importance of a different character. Here also the principle is so simple that an electroplater is tempted to take no consideration of certain important technical facts regarding (1) the setting up of a plating bath, (2) conditions governing the quality and character of the deposit such as current, temperature, concentration etc. The poor quality which is generally obtained in this country of electroplated articles is mainly due to complete disregard to the above factors. They are enumerated in detail as under:—

(a) **Plating baths:** It may be considered to consist of the following—

(1) the salt containing the metallic ion or radical,

² M. Hosenfeld and G. Hansel, U. S. Pat., 1,757,047, May 6, 1930.

³ Z. Electrochemi., 28, 327-41, 1922 and German Pat., 312,941 (1917).

⁴ U. S. Pat., 1,574,043 (Feb. 23, 1920) and 1,890,856 (Dec. 13, 1932).

⁵ U. S. Pat., 2,016,718 (Oct. 8, 1935).

⁶ Ph.D. Thesis, Tech. Hochschule, Breslau, Germany (1931).

- (2) additional salt whose function is to increase the conductivity of the bath,
- (3) a material to effect the anode corrosion and prevent passivity of anode,
- (4) addition agent to effect the type of deposit produced (organic),
- (5) a buffer material to maintain the proper pH of the solution.

(b) **Concentration and type of Electrolyte:** For the production of fine grained or so-called amorphous deposits, which are readily polishable, plating bath should show low ionic metallic concentration produced not by using dilute solutions but either by the use of salts showing low ionization or salts whose ionization is depressed by the addition of another salt having a common ion, or by secondary ionization or by reduction at the cathode. This explains the widespread use of double salts such as NiSO₄(NH₄)₂SO₄·6H₂O, complex compounds such as the double cyanides and in the specific case of chromium, chromic acid.

(c) **Current density, voltages, overvoltages, etc.:** Plating baths are operated within definite current density ranges beyond which poor type of deposits result. Deposition potentials in general are lower than the decomposition voltage of water, but in the case of chromium and alloys such as brass, the deposition potential is above that of the decomposition of water and hydrogen is evolved at the cathode. This latter condition is essential for the deposition of chromium. 70% of the current is consumed in this case in hydrogen evolution. (Ordinarily, however, current efficiency of plating baths is as high as 90 per cent).

Special Protective Plating:—While the above general principle holds good for plating of the ordinary type, the protective plating on rust forming materials such as iron calls for technique of a different character. Plating on iron or aluminium is difficult owing to the poor adhesive quality of the materials concerned due to their being not favourably placed in the electro-chemical series. The technique of throwing an adhesive splash of brass, zinc or copper from the cyanide bath followed by the normal process of plating with silver, nickel or chromium is to-day fairly well-known.

Anodic Oxidation of Aluminium:—The protection from corrosion by the electro-chemical method of throwing an oxide film on the surface of a metal or an alloy has its best application in the case of aluminium and its alloys known as the Anodic Oxidation Process. The resistance of aluminium to corrosion varies with the thickness of this oxide (or hydroxide) film. The anodic oxidation in a bath

containing a chromate, bichromate or chromic acid gives a coating of protective film nearly 100 times thicker than the natural oxide film due to the atmosphere. The Guertler Process which consists in the immersion of the aluminium for 2 hours in a bath maintained at 90 to 95 C of the following composition:

Pot. carbonate	...	25 grammes.
Sod. bicarbonate	...	25 grammes.
Pot. dichromate	...	10 grammes.
Distilled water	...	1 litre.

showed that some protection was afforded in the case of commercial aluminium, but little or no protection was obtained in the case of the various aluminium alloys as it gives a much thinner film and moreover owing to its nature the immersion method fails to develop a resistant film in pores and cavities of the metal.

The Anodic Oxidation Process may be described thus:

After thoroughly cleaning the surface of the aluminium it is immersed in a dilute chromic acid bath along with a carbon rod; a small external E. M. F. is applied so as to make the aluminium the anode and the carbon, the cathode. The applied E. M. F. is gradually raised to a value depending on the nature of the alloy and on the composition of the bath. Thus, with duralumin in a chromic acid bath the voltage may be safely raised to 50 volts. After sometime the surface of the treated metal becomes covered with a semi-opaque, uniform, white coating. Two practical points need be noted here. The immersed material must consist only of aluminium or suitable aluminium alloys since most other commercial metals are attacked by the treatment and prevent the raising of the voltage; also the bath should be large compared with the material otherwise the heat produced affects the temperature of the bath. In such case a cooling coil is used.

As the result of the anodic oxidation, the surface assumes a silvery white matt appearance and is thus admirably adapted to painting and varnishing and can also take a variety of tints or colours by simple immersion in a suitable dye solution. This is in accordance with the common practice of aluminium hydroxide being used as a mordant.

Electro-typing and Forming.—Electro-typing has as its object the reproduction of the printer's type set up, of engravings and medals, while electro-forming produces or reproduces an object by electro-deposition. The mould of the object to be reproduced is first made either in soft metal by pressure or by impressing the object in wax. In the latter

case the mould is a non-conductor but its surface is made conducting by coating it with graphite. In ordinary electro-typing works the electrolytes used are 8 to 10 per cent H_2SO_4 solutions saturated with $CuSO_4$ at room temperature. Current densities are relatively low.

MATERIALS OF CONSTRUCTION

Mention has often been made earlier of the difficulty of procuring the right type of electrodes, etc. It is not to electrode alone that our attention is particularly invited in an electro-chemical enterprise. There are other equipments in electro-chemical machinery which need as much consideration. The nature of these equipments depends broadly upon (1) Those employed in electrolytic cells in which aqueous electrolytes are used; (2) Those finding application in fused electrolytes, and (3) Those in electro-thermic operations.

The principal items under (1) and (2) are

- (a) Anodes (d) Tank materials
- (b) Cathodes (e) Circulating systems
- (c) Diaphragms (f) Bush bars and power lines.

In the case of (3) besides some of the items mentioned above the choice of furnace body and its linings and charging equipments are important considerations. The selection of suitable insoluble electrodes especially anodes not readily attacked by gases evolved or the corroding electrolyte, is limited to a few known imported articles, e.g., chilex or fused magnesite for electro-winning for copper. Iron-silicon alloy is now obtainable in India and can form a tolerably good electrode in an electrolytic bath containing nitric acid. Lead and antimonial lead form the major part of electrodes used in a sulphuric acid bath. Graphite and platinum, however, owing to their insolubility have a general application in all electrolytic processes—their uses are being limited due to disintegration in the case of graphite and high cost in the case of platinum. Diaphragms which will resist corrosive bath tolerably permeable to electrolyte with little electrical resistance are as yet difficult to procure.

POWER

The subject of power is a major one and deserves very careful consideration. It is, however, recog-

nised that a proper survey of the existing power at the disposal of industries and an idea of the extent of its development should be made at an early date. On such a basis a chart requires to be made showing total power available for existing and future industries of this country. On the basis of this information power allotments to industries should be made in the order of their importance, basically important and industries of strategic importance coming first and others following in the order carefully regulated according to plan and requirements.

CONCLUSION

Attempt has been made in the course of describing the technique of manufacture of some electro-chemical industrial products obtained by electrolysis to indicate the nature of the problems that are confronting us to-day. Briefly they are (1) the production of magnesium from magnesium chloride and a study of its fabrication and foundry practice, (2) the preparation of certain alloys by electrolysis, viz., Be-Cu, Al-Ti which have important uses in light alloy industries, (3) production of high purity metals, specially manganese whose future prospects yet lie unravelled, (4) electrolytic reclamation of metals from scrap especially with regard to metals of strategic importance, viz., Cu, Zn, tin and lead as a necessary step in the plan for conservation of metals in which our country is relatively deficient. More problems will be cropping up with the progress of electro-chemical ventures in this country and if they are to flourish and remain efficient, the need for a properly equipped research institution where research could be undertaken to guide industries in the right direction is evident. The authorities guiding the destiny of scientific researches in this country and planning at the moment for the establishment of research institution should move for the creation of an Institute of Electro-chemical Research in India, properly equipped and with adequate resources, so that it might tackle these and many similar problems which are bound to arise as we proceed onwards to the goal of progressive industrialisation of India.*

* Summary of the opening address of Mr G. C. Mitter, at the symposium on "Electro-Chemical Industries" held under the auspices of the 31st Indian Science Congress at Delhi on 4th January, 1944. Mr J. J. Ghandy, General Manager, Tata Iron & Steel Co., and President of the Section of Engineering & Metallurgy, presided.

MEDICINE AND PUBLIC HEALTH

TOOTH DECAY

In their recent report (*Science*, November 5, 1943) Dr H. Trendley, Dean of the U. S. Public Health Service, and Raymond J. Faust, assistant engineer of the Michigan State Department of Public Health have shown that tooth decay can be effectively arrested through use of fluorides in drinking water. Epidemiological studies by the U. S. Public Health Service indicate that school children using domestic waters containing as little as one part per million of fluoride experience only half to a third as much dental decay as comparable groupings using water containing no fluoride. The amount of fluorine necessary to stop dental decay is not enough to cause the disfiguring of the mottled enamel that is found among users of water with higher fluorine concentrations. On the practical side, adding fluorine to public water supplies should not prove difficult or expensive, according to Mr Faust. It could be done with chemical feeding equipment of the type already in use and familiar to water plant operators. The cost per person per year would be about seven and one-half cents. For a family of four the cost per year would be about 30 cents (1 cent=half anna nearly). A simple, accurate colour test must be developed, so that water plant operators with little technical education can ascertain the right amount of fluorine in water. It should be noted that great caution should be exercised in the use of right amount of fluorine as its thoughtless use in large quantities may bring about serious consequences.

PENICILLIN IN VENEREAL DISEASES

Science News Letter, October 23, 1943, reports the important news that penicillin, the germ-killing chemical from a common mould has been used in

venereal diseases, such as syphilis and gonorrhea with successful results.

Apparent cures of four cases of early syphilis by penicillin were reported by Dr John F. Mahoney, Dr R. C. Arnold and A. Harris of the U. S. Public Health Service's Marine Hospital on Staten Island. Other patients are now being treated, but in only four cases has enough time elapsed for the doctors to be sure the disease has been cured. The penicillin is injected into the patient's muscles every four hours, day and night, for nine days. At the end of the first seven hours of this treatment, the spirochetes that cause syphilis can no longer be found in the syphilitic sores. Blood tests are strongly positive at the start, negative by the 15th day. By the 10th day after treatment had been stopped, no trace of the disease could be detected in the patient's blood by any of the ten most delicate tests for this disease now known.

This speedy cure of syphilis can also be achieved, but not so safely, by the intensive treatment methods devised in recent years. These methods all depend on giving the patient massive doses of arsenic in some form and are consequently dangerous. Penicillin seems to be absolutely safe. No one using it has yet discovered any sign of a poisonous effect from this mould chemical. Some of the patients getting it for syphilis felt a little sick and feverish the first day but that was due to the large scale destruction of syphilis spirochetes and not to the penicillin itself.

Gonorrhea is also yielding to attack by penicillin but that is not so surprising. The germs that cause gonorrhea belong very far down in the scale of living organisms. The spirochetes of syphilis are much higher in the biological scale, close to the protozoa which are not far from animal forms of life.

POST-WAR HOUSING AND TOWN PLANNING IN INDIA

"RUSTIC"

INTRODUCTION

HOUSING conditions are intimately associated with the health of a community. Overcrowded and insanitary houses are a menace to public health. They result in high morbidity and mortality rates; high prevalence of tuberculosis; easy transmission of small-pox, measles, whooping cough, colds, diphtheria and other communicable diseases; and high infantile mortality rates. Further, persons living in an environment where sunlight and fresh air are not freely available; elementary necessities like water, bathing facilities and latrines are not provided; where dirt and disorder prevail; where people are perpetually forced to face strangers and misery in all forms; have their hygienic, aesthetic and ethical values gradually undermined. Incentive for progress is killed, and callousness, apathy and delinquency increase.

Such conditions are found in every country. They are found in urban as well as rural areas. Gradually slums grow in the early stages of the growth of towns and in the course of the rapid growth of industries. Western countries have enacted housing laws and regulations to ensure certain minimum standards of healthy housing. These have been partially successful. The present war has brought an opportunity to those countries to plan and rebuild their bombed cities on a better basis. Town planning and housing are important items in the post-war national planning of Great Britain. London, Southampton, Coventry, Sheffield, and many other cities are to be rebuilt avoiding the mistakes of the past. Two Committees, known as the Scott Committee and the Uthwatt Committee, have already reported to the British Government on housing and town-planning in Britain, stressing the need for a ministry for coordination of town planning, and pointing out ways of utilising land, etc. Some of their recommendations have been accepted by the Government. Discussions are going on in the press about the nature of post-war housing,—about the need for dispersion of industry, preservation of rural features, transport coordination, zoning of industry, and minimum standards of housing.

In India too, we have to plan for the peace that will follow the war. Our problems are different, but not less urgent. Every one realises that we have to plan from now. It is reported that Government committees have been set up in the provinces and at Delhi to go into problems of post-war reconstruction. Unlike other countries, we have to commence

from the foundation in many cases. These committees must conceive their plans on a really large and constructive basis, and not rest content with suggesting temporary palliatives. The Committee dealing with public health will perhaps take up housing and town planning; but, if there are other committees considering industrial expansion and industrial housing, or rural development, or electrification, they must work in collaboration and produce unified plans.

The problems of post-war housing and town planning in India may be considered broadly under four heads:—

- (a) Minimum housing standards, and how far existing laws and procedures are operative in securing these standards.
- (b) Improvement of urban and industrial housing.
- (c) Improvement of rural housing.
- (d) Whether and how industries may be zoned.

MINIMUM HOUSING STANDARDS

The basic principles of healthful housing have been set out by the American Public Health Association in their report of May, 1939. Most of these are applicable to all countries and in all conditions. It is perhaps easier to indicate the factors that constitute an unsatisfactory or insanitary house, in order to clarify those that constitute a healthy house. An insanitary house may have any of the following defects:—

- (1) Structural defects such as poor foundations, dampness, leaky roofs, crumbling plaster, unsound walls and floor that offer inadequate protection against sun, rain, wind, rats, vermin etc.; or defective plumbing endangering the safety of the water-supply. Some of these defects may cause physical injury, others may injure health;
- (2) Inadequate light for reading, domestic work and playing;
- (3) Inadequate ventilation, using ventilation in its modern sense;
- (4) Inadequate protection against excessive noise;
- (5) Inadequate or impure water-supply;
- (6) Absence of a proper kitchen for preparation of food;
- (7) Absence, inadequacy, or inaccessibility of latrines and bathing facilities, so as to militate against the maintenance of personal cleanliness or privacy of people;
- (8) Improper drainage, sewage disposal or excreta and waste disposal,—so as to offend against sight and smell and pollute food and water in the neighbourhood;
- (9) Overcrowding; and
- (10) Unhealthy, marshy, or dusty site.

Of these ten defects, some are controlled in many countries by building bye-laws. They cover the defects under 2, 3, 9 and 10. Sometimes defects 1, 5 and 8 are also covered in a few large municipalities. Building bye-laws are not in force even in every municipality in India. They apply to buildings within the large Corporations of Calcutta, Bombay, Madras etc., and to those places where town planning acts apply. They are theoretically applicable in all the municipalities of Bengal and Madras etc. But in Bengal bye-laws have not been framed by many municipalities. The bulk of building operations taking place in small municipalities, union boards, etc. escapes rigid control.

In Great Britain such laws exist. In Ceylon such laws are applicable to all municipal areas, urban districts, local boards and sanitary boards and such other areas as may be declared. Only the small village which is not paying any tax is usually exempted.

The procedure in places where such laws apply is as follows. The person who wants to erect a new house or alter an existing one has to apply to the authority named in the Act,—municipal chairman, president, local board, Government Agent, etc., for permission, submitting plans and specifications. These are scrutinised by the health officer, or the building inspector, and if the standards laid down in the law are complied with, the plans are approved. A copy of the approved plan is returned to the applicant, who can then commence construction. On completion, the building must again be inspected by the building inspector or health officer, to see if there are any unauthorised and unacceptable deviations from the approved plan. If that plan has been followed, a certificate of "Conformity to sanctioned plan" is issued. The building may be occupied thereafter.

Existing house laws in most countries may be summarised as follows:—

- (1) The minimum width of streets and roads is laid down for new housing projects;
- (2) Maximum limits are fixed for heights of buildings in the front, sides, and rear, with respect to the width of available open space from which ventilation and light may be derived without let or hindrance. These limits are covered by rules regarding "Standard light planes" at various angles;
- (3) The minimum area of windows alone, and doors and windows together are fixed as a proportion of the floor area of the room which they are intended to ventilate and illuminate;
- (4) Minimum sizes are fixed for habitable rooms;
- (5) Minimum floor space and cubic space of air are fixed for human occupation, and these together with the number of rooms in which the inmates of a house are distributed with respect to their numbers, sex

and age form the basis for determining conditions of overcrowding. Such standards of floor space and cubic space are not found in the Bengal Municipalities Act, where overcrowding is left to be determined by the municipal commissioners; (6) The maximum proportion of a building site that may be built upon is limited, to secure openness. In town planning, there are standards for the minimum area to be allotted for parks, roads, etc.; (7) The site is required to be well drained, and the floor must be raised above the surrounding land.

Such laws have on the whole been effective in producing open, airy, bright and pleasing houses. They ought to be made applicable to all new construction in cities, municipalities, union and panchayat boards, estates, and industrial colonies, in India. The rules of the first two categories are sometimes not stringent enough.

The rules of the third category are intended to ensure good natural ventilation and lighting. But they are open to a few criticisms. Natural light indoors depends upon the brightness of the source of illumination, and also on the colour of the walls, ceiling, and floor; on the distance from the source, i.e., the depth of the room from the window; on the amount of visible sky and its brightness. A neighbour's high wall or a tree may cut out the sky. Lighting at night depends on artificial sources. With the increasing complexity of modern life, artificial light is used more and more in the day-time also. The windowless factories of modern armament manufacturers are located underground, and are well lit and ventilated. The two requirements, lighting and ventilation must be separated in housing laws. The provision of a certain window space is not sufficient to ensure good light or ventilation in all cases. One has only to peep into the dingy, smoky coolies' lines and slums of mill hands to realise this. The proportion of window space required by law has been provided. The living room is used as kitchen, smoke and soot blacken the walls, and the interior is dark and ill ventilated. On the other hand windows are not necessary in the windowless factories mentioned above. Housing laws must lay down minimum standards of lighting for houses, whether by natural means or artificial sources. When natural lighting is used for part of the time, the laws may embody suggestions for ensuring these standards, such as the size and orientation of windows, their height to secure the maximum visible sky, the interior finish of walls, ceilings and floor to reduce absorption of light, and the maximum depth of a room with respect to the window. But the laws must lay down the ultimate requirement, viz., an illumination of about 2 foot candles in all parts of a room with the windows open, etc. Similar standards must be laid

down for passages, kitchens, etc. The local building inspector must have the means of checking the actual illumination, and must take all factors into account, such as the possibility of soot, the depth of room, the finish of walls etc., before approving plans.

Regarding ventilation too, housing laws must be based on a better appreciation of the physiological requirements of ventilation and the prevailing weather conditions. Ventilation is not only intended to keep the proportion of carbon-dioxide below a limit, and exclude poisonous fumes and dust. It is not intended merely to prevent the occurrence of body odours in a place subject to human occupation. The heat produced by the human beings and other sources of energy must be dissipated at a rate suitable for physiological comfort. Perspiration is Nature's attempt to accelerate the rate of dissipation of heat by evaporative cooling. High humidity in the atmosphere retards the rate of cooling, but too low a humidity is not conducive to comfort. All these concepts are included in the term ventilation, —the effectiveness of which is controlled by the quality, temperature, humidity and movement of air. These modern concepts are not taken cognisance of in the housing laws and bye-laws. All-weather air-conditioning is the only way to ensure effective ventilation at all times, and it requires no windows to do it. But it is impracticable to air-condition private houses of the great majority of people, and in the rural areas it is unknown. Housing laws must be framed separately for natural and artificial ventilation.

In natural ventilation, windows must be so oriented as to exclude fumes, smoke, etc. The area of windows must be large enough to admit fresh air at a velocity of say 30 ft. per minute. The temperature and humidity of air cannot be controlled in natural ventilation, but the movement of air depends on (1) uncontrollable outdoor air currents, and (2) the density, pressure or temperature gradient between the indoor atmosphere and outdoor atmosphere. If the inlet and out-let for air are located suitably, and the walls of the room are built of such materials that changes of temperature outdoor will not be readily transmitted indoors, the indoor atmosphere will be nearer the average diurnal temperature than the outdoor atmosphere. Thus there will be a temperature and density gradient which will urge the air to move. On the other hand, in a house with thin concrete walls and corrugated iron or tiled roof, heat will be exchanged very quickly between the indoor and outdoor atmosphere, and there will be little movement of air inspite of large windows. Consequently ventilation will be poor. Building research laboratories must take up this question and evolve the minimum thickness of walls for the various regions of India for this kind of air

movement and ventilation comfort. Cheap and suitable materials must be evolved for the different regions of India. The old fashioned mud huts with walls 18 inches thick and thatched roofs are often more comfortable than the modern concrete buildings with thin walls, wide windows, and corrugated iron roof. Housing laws must incorporate the results of research in this direction.

The criteria for overcrowding are not entirely rational, if they are based only on a minimum floor space and air space for a person, without regard to weather conditions, efficiency of ventilation, the nature of the work on which he or she is employed, and whether the person is occupying the space temporarily or permanently. In a running train passengers are generally comfortable with a smaller floor space and air space than that prescribed in housing laws. But these standards are too low for permanent occupation, as in tenements and labourer's quarters, because very little additional space is provided for cooking, eating, etc. Standards of floor space and air space must vary according to circumstances. More liberal minima must be prescribed for housing schemes for people of low socio-economic status. 36 or 50 square feet of floor space per capita is sufficient for a room in a house with more than one room, but taking the house as a whole, including the kitchen, store etc., the floor space must be 75 to 100 square feet, per capita. A child under 10 years requires as much air as an adult if not more, and there is no justification for considering a child to be half an adult in judging overcrowding.

The concept of moral overcrowding found in the English Acts may be unnecessary for India. Morals may be taken care of by other laws than those relating to housing.

In all municipal areas housing bye-laws must control structural defects, such as poor foundations; unsafe design of floors, beams, roofs, leaky roofs, combustible building materials, dampness, and faulty plumbing.

In tenements and houses for the poorer classes, the use of building materials that will not readily transmit noise, and the use of partitions up to the roof to secure privacy must be insisted upon through bye-laws.

The provision of a satisfactory water-supply, a satisfactory kitchen, and a satisfactory latrine must be insisted upon through housing laws applicable to all houses built in municipal, union and panchayat board areas, and in all houses for industrial workers, whether these are situated within these areas or outside. The laws may contain schedules to explain the types of water-supply, kitchen and latrine that may be considered satisfactory in different areas in

various stages of civic development. In municipal areas, it may be desirable to insist on the provision of a satisfactory bath room also in each house.

IMPROVEMENT OF URBAN AND INDUSTRIAL HOUSING

Improvements are more urgently required in urban and industrial housing than in rural housing.

The growth of towns is inevitable with the growth of industries. A town has an organised local Government, and is able to provide organised sanitary services for the community. Hence the growth of towns is not to be discouraged or regretted. But the worst slum conditions arise when a town is allowed to rise overnight and grow without a plan, and when it gathers industrial workers drawn from villages who are neither housed satisfactorily nor paid well enough by their employers.

In the early stages of the growth of a town, speculation in land is probable. Capitalists may get control of the land, and may try to get the maximum return for the minimum outlay, or inflate prices. Vested interests develop, and at a later stage it becomes very expensive for the municipality or Government to clear the slums and build decent houses.

The horrible conditions of housing found in the bustees of Calcutta and Howrah, the chawls of Bombay and other mill cities, the cheris of Madras, etc., have been described in the report of the Royal Commission on Industrial Labour in 1931 (known as the Whitley Commission). The report contains exhaustive recommendations on industrial housing, some of which have been acted upon, but others have yet to be implemented.

The growth of heavy industries and cottage industries is very necessary for post-war India, and nothing must be done to arrest it. But the social evils incidental to the growth of industry, such as the creation of slums, must be suppressed by the Government.

State legislation and State assistance both directly and indirectly can ensure the proper housing of the majority of industrial workers in all organised business activities within ten years. With such a constructive programme, most slums can be eliminated. All industries and business organisations employing more than 500 workers at one town, city, or factory may be required to proceed with schemes for housing at least 70% of their staff in a period of ten years, and details may be called for by Government. The schemes must be subject to approval by Government. They must be planned to ensure certain minimum housing standards for the worker, on the lines discussed already,—viz.,—accommoda-

tion, water-supply, drainage, lighting and ventilation, kitchens, baths and latrines, streets, parks, schooling and hospital facilities, and quick transport to the factory. State aid may be given to such schemes in three ways,—(1) Making land available for the scheme, either through land acquisition and leasing, or leasing of Government or municipal land, (2) Making water, sewer, and electricity mains available by negotiation with the municipality, and (3) advancing loans to the value of 60% of the cost of the scheme in deserving cases, on suitable terms of repayment spread over 50 years, and on suitable security. The law by which such industries will be compelled to house their staff within ten years as mentioned above must also lay down the rents to be charged from occupants of houses. 5% of the family income may be the upper limit where the income is below Rs. 100 per month. Employers of labour must be made to recognise their responsibility for housing their employees in comfort, and must not look upon the housing project as an independent investment for profit, but as part of the outlay on the industry. Whether they wish to pay their employees more and take back a part of it as rent for houses, or whether they would prefer to provide free housing as part of the remuneration for service, it is for them to decide. But the industrial worker must no longer live in slums of a subhuman standard, and a time limit must be given to the employer to rectify this state of affairs. Minimum standards of housing for such schemes must be laid down by Government. There must also be suitable administrative machinery for controlling industrial housing, for making land available, for granting loans and supervising the expenditure of loan funds, and for ensuring the standards of housing and maintenance. The health department, industries department, lands department, and finance department will have to work together for creating this machinery.

Further, the town planning acts recommended by the Whitley Commission must be brought into force in all municipalities above a certain size. Minimum standards of housing must be enforced in all municipalities, so as to include in their scope structural safety, roads and approaches, lighting and ventilation, habitable rooms, their dimensions, colour, materials, etc., the condition of floors, kitchens, bathrooms, water supply, latrines, drainage, and refuse collection. The utilisation of un-built land within and around a municipal area should be subject to the control of a town planning administration or department. Health must be adequately represented and emphasised in this department.

Every municipality or group of municipalities must have an engineer or inspector free from local and municipal politics, to administer housing laws,

suggest slum clearance, abate overcrowding, recommend zoning, provision of parks etc. in consultation with the health department. He must also exercise strict control over safety, sanitation, ventilation etc. in places of amusement, such as cinemas and theatres, parks, swimming pools etc.

IMPROVEMENT OF RURAL HOUSING

The commonest defects in rural houses are the absence of water-supply and absence of latrines. Approaches are generally difficult. There are very few good roads. In many parts of India village houses have few or no windows, and are built attached. The interior is dark. But defective ventilation is not of such great public health importance in rural life. People live out-doors most of the day, and come home only to eat and sleep. Overcrowding is not so common.

Yet, even in these areas, some sort of loose Government control will produce more healthy houses.

Housing laws (of a lower standard than in municipal towns) must be made applicable to all union boards and panchayet boards. It may be made obligatory on those who wish to build new houses or alter old ones to apply to the Chairman, Union Board, who should refer it to the sanitary inspector of the area before passing orders. The housing standards may tentatively consist of the following :—

(1) Width of new streets to be not less than 40 ft. (2) Site—not more than 60% to be built upon. (3) Windows to be provided for living rooms, at not less than 10% of the floor area, and to open directly or through a veranda into free external space. (4) Interior of houses to be at least lime washed and to be so finished as to make it possible to read a newspaper at 8 A.M. in the morning or 4 P.M. in the afternoon. (5) Minimum size of living rooms to be not less than 100 sq. ft. (6) The floor to be raised, free from damp, and to be of brick, concrete etc. Exceptions may be made and mud floors may be permitted at the discretion of the sanitary inspector. (7) A kitchen to be built with smoke outlet, separate from the living room, or a portion of a veranda to be set apart for cooking. (8) A latrine to be built specially for the house, of any approved type. (9) A drinking water supply to be available within 200 yards from the house, from a well, tube well or tap, public or private. If a private supply not belonging to the applicant is used, permission for using it must be registered.

If housing in union boards is improved in the above manner, rural areas not under union boards will follow the example gradually. After 4 or 5 years, a law may be enacted requiring the provision of latrines in new houses in rural areas also. The provision of water supplies in rural areas is a matter for executive action by Government.

The improvement of rural communications and rural electrification will produce a silent revolution in rural India. Standards of living and housing will rise gradually.

ZONING OF INDUSTRY

In England, the public is concerned about the concentration of heavy industries in particular areas. They want to disperse industry as a measure of prudence and safety in war, and as a means of preserving the healthy features of rural England in many places. They want particular zones to be allocated for particular industries.

There are some who think that similar zoning will be necessary in India also. But India is just undergoing industrial expansion, and such interference with its natural growth may be harmful to our national interest.

Apart from the question of capital and machinery, the growth of industry in India at a particular place depends on (1) the availability of raw materials, (2) availability of power,—electricity or coal, (3) availability of cheap transport to the markets.

Heavy industries and subsidiary industries can develop naturally in the mining districts, and around great ports and railways centres. Textiles will develop in the cotton districts, and around ports and places where power is available, as for example at Nagpur, Bombay, Coimbatore, Sholapur, etc.

The best way to disperse industry away from the ports over a wide area is to improve rural communications and electrify rural areas. Thus new industries can develop in the interior districts, and cottage industries can thrive. At the same time, industry will be dispersed without compulsion. The industrial development in post-war years will depend to some extent on post-war policies with regard to (1) power expansion and rural electrification, and (2) improvement of communications—road, rail, and waterway, telegraph and telephone.

Where industry develops, industrial housing has to be taken special care of, and public health has to receive special attention.

Hence, the post-war policies for improvement of industrial housing have to be co-ordinated with those relating to rural electrification and power expansion, improvement of communications, and industrial development.

LETTERS TO THE EDITOR

[The editors are not responsible for the views expressed in the letters.]

HIPAROL

Jute, coconut, hemp and other fibres are usually obtained by retting in stagnant water, the treatment extending from 4 to 6 weeks. The process is a source of pollution of the pond water, which become breeding places for mosquitoes, and from which unsavoury stench is given out. Any method by which the period of retting can be considerably reduced and which is also reasonably cheap will be of great benefit both to the fibre industry and to the country side.

We have recently succeeded in isolating a highly active substance to which the name Hiparol has been given, by which it is possible to ret jute and coconut fibres in 8 to 10 hours. Further experiments are in progress with a view to reducing the cost of production and of simplifying the procedure for the treatment of fibres and it is hoped that this method would enable the grower to obtain the finished fibre products in course of a day.

We are grateful to Dr D. M. Bose for his kind interest and helpful criticisms.

MRS PARUKUTTY BARUAH
DR H. K. BARUAH

Bose Research Institute,
Calcutta, 7-2-1943.

RAINFALL IN PATIALA STATE

In 1863 Mr Edward Prinsep¹ when he was the Commissioner of Settlements in the Amritsar Division, found that the gradations of rainfall in the Punjab are susceptible of being ranged into zones running parallel with the Himalayas. But Mr Prinsep based his conclusions on observations extending over an average of five years with a minimum of 1¼ years, and maximum of ten years. This was a great drawback in his conclusions. In 1924, Dr Gilbert Walker² of the India Meteorological Department, published a paper giving the average rainfall of 197 stations in the Punjab, computed upto 1920. The maximum number of years for which an average has been

recorded is 55 years and the minimum being nine years.

In 1940, Professor J. B. Seth³ of the Government College, Lahore found that quite a number of the Prinsep stations were not found in the Walker's ones, and there was great disparity between the two sets of figures as the Prinsep's figures are lower than the Walker's figures for the stations near Multan and Rohtak and higher for the stations near Pathankote and Batala (Gurdaspur District) and Ajnala (Amritsar District). He further found that the zone divisions according to rainfall in round numbers from Walker's figures and Prinsep's figures are not exactly the same in the two cases though in both cases they are roughly parallel to each other and to the Himalayas. But the zone divisions in the South East of the Punjab are very markedly different in the two cases. In the South East Punjab, they are not parallel to the same degree in the Walker's map as in the Prinsep's map. In view of this disparity between these two sets of figures (the Prinsep's and the Walker's figures) and the marked difference of the zones in the South East of the Punjab the author studied the rainfall of the Patiala State which forms the major part of the South East Punjab. The statements of Prinsep and Walker have also been verified.

Patiala State gets its major rainfall of the year from the South Eastern monsoons in the summer months, the rainfall in winter being very scanty. In order to study the rainfall in different parts of the State, the rainfall data has been collected from the old records of the State, such as, the offices of the Revenue and Irrigation Departments and the Meteorological Observatory at the Mahendra College, Patiala. The records available from the former two offices are dated from 1900 A.D. and 1922 A.D. respectively. Thus the data has been collected for 22 canal sub-stations and 12 Tehsil headquarters, besides the Meteorological Observatory at Patiala. Out of these 35 stations, five are discarded for the double entry by different departments or discontinuous periods. Thus the remaining 30 stations have been located in the map of the State (Fig. 1). The value of the average annual rainfall of all these stations, the duration of the period and the years for which these average values have been calculated are given in the table on the next page. The annual rainfall means the rainfall of

the meteorological year i.e., from 1st April of the year to 31st March of the next year. The last column of the table represents the average annual rainfall in

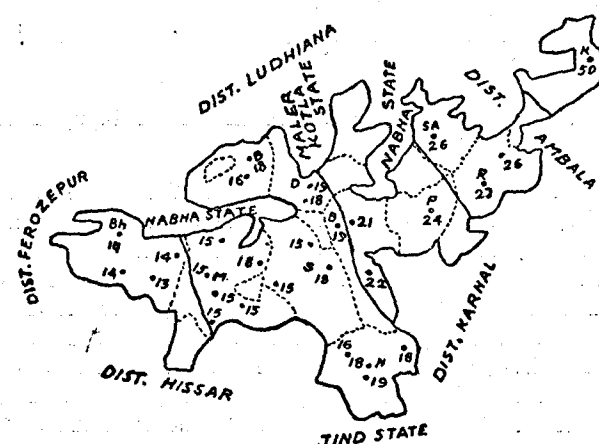


FIG. 1.

round numbers which are plotted in place of the stations in the map.

TABLE I

No.	Station	Period of record	Average annual rain-fall in inches	Round numbers
1.	Patiala	(1902-42) 40 years	23.9 "	24"
2.	Kandaghat	(1906-42) 37 "	50.4 "	50"
3.	Rajpura	(1903-42) 39 "	26.63 "	27"
4.	Sirhand	(1903-42) 39 "	25.74 "	26"
5.	Dhuri	(1902-42) 40 "	18.95 "	19"
6.	Bhawanigarh	(1902-42) 40 "	18.60 "	19"
7.	Sunam	(1902-42) 40 "	18.15 "	18"
8.	Narwana	(1903-42) 39 "	18.75 "	19"
9.	Barnala	(1902-42) 40 "	17.61 "	18"
10.	Mansa	(1903-42) 39 "	15.20 "	15"
11.	Bhatinda	(1903-42) 39 "	13.99 "	14"
12.	Narnaul	(1905-42) 37 "	19.40 "	19"
13.	Ladha	(1930-42) 12 "	17.63 "	18"
14.	Sheron	(1930-42) 12 "	14.49 "	15"
15.	Bhiki	(1931-42) 11 "	17.68 "	18"
16.	Joga	(1931-42) 11 "	15.44 "	15"
17.	Hadiaya	(1930-42) 12 "	15.62 "	16"
18.	Raman	(1930-42) 12 "	13.68 "	14"
19.	Talwandi	(1931-42) 11 "	13.44 "	13"
20.	Ramnagar (Qaziwara)	(1933-42) 9 "	13.98 "	14"
21.	Jawaharke	(1930-42) 12 "	14.67 "	15"
22.	Balad	(1930-42) 12 "	20.85 "	21"
23.	Dedna	(1931-42) 11 "	21.48 "	22"
24.	Ramnagar Bhatian	(1930-42) 12 "	14.63 "	15"
25.	Phulera	(1932-42) 10 "	14.99 "	15"
26.	Hingua	(1932-42) 10 "	15.39 "	15"
27.	Banur	(1925-42) 17 "	25.77 "	26"
28.	Dhakal	(1921-42) 21 "	19.44 "	19"
29.	Bata	(1921-42) 21 "	17.94 "	18"
30.	Kharal	(1921-42) 21 "	15.88 "	16"

The study of the table of average annual rainfall and the map of the State shows that the area of the whole State can be easily divided up into five distinct zones according to the average annual rainfall of various stations in round numbers. The maximum average annual rainfall at any station in the State is 50.4" and the minimum being 13.4". This whole range of rainfall is divided into five classes, each having a sub-range of five inches only. The rainfall zones so formed are given below:—

Zone I.—It is a zone having average annual rainfall above 30". This zone extends in the district of Kohistan and its surroundings. The rainfall is high. It is possibly much higher than 50" at most of the places situated to the North and East of Kandaghat.

Zone II.—It is a zone having average annual rainfall of 25" or more than 25" but less than 30". This zone extends in the tehsils of Rajpura and Sirhand.

Zone III.—It is a zone having average annual rainfall of 20" or more than 20" but less than 25". This zone extends in the tehsils of Patiala, Bhawanigarh, Dhuri (East) and sub-tehsil Pial.

Zone IV.—It is a zone having average annual rainfall of 15" or more than 15" but less than 20". This zone covers the largest area of the State, and extends in the tehsils of Dhuri (West), Bhawanigarh (West), Sunam, Narwana, Barnala, Mansa (East) and Narnaul. The last one (one of the districts of the State) lies to the South-West of Delhi.

Zone V.—It is a zone having average annual rainfall of 10" or more than 10" but less than 15". It extends in the tehsils of Mansa (West) and Bhatinda. It is the driest part of the State.

These average annual rainfall zones are marked with thick lines in the map of the State (Fig. 1). The district and tehsil boundaries of the State are shown there by thin dotted lines.

A careful study of these zones indicates that these zone divisions are roughly parallel to the Himalayas. The zones which are nearer to the Himalayas have higher rainfall than those which are farther away. They are very roughly parallel to one another and run from North West to South East direction. They roughly face the North East ranges of Himalayas. The rainfall goes on decreasing from the N-E to S-W direction. Thus all stations to N-E have higher rainfall than those to the S-W.

Moreover the study of the map⁴ of the State shows that these rainfall zones are also very roughly parallel to the contour lines as shown in the map.

Besides the above results, the comparison of these zones with the zones obtained from the Prinsep's figures and the Walker's figures clearly shows that they are more similar to the Walker's zones produced

by Professor J. B. Seth from the Walker's figures, than the Prinsep's zones. This confirms the results of Professor Seth and also throws light on the works of Mr Edward Prinsep and Dr Gilbert Walker on the rainfall zones of the Punjab.

The author is indebted to His Highness' Government, Patiala, for providing facilities to carry out this work in the Physics Research Laboratory,

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Patiala, 13-5-1943.

¹ "Report to the Punjab Government on the Rainfall in the Punjab", by Mr Edward Prinsep, *Supplement to the Punjab Government Gazette*, dated Saturday, the 19th December, 1863.

² "Memoirs of the Indian Meteorological Department, Poona", by Dr Gilbert Walker, Vol. XXIII, part 7, 1924.

³ J. B. Seth, "Rainfall in the Punjab", *SCIENCE AND CULTURE*, 5, 679-682, 1940.

⁴ Oxford School Atlas by John Bartholomew, p. 22.

ON THE BOUNDARY VALUE PROBLEMS OF LAPLACE'S EQUATION RELATING TO TWO SPHERES. A NEW METHOD OF SOLUTION

THE boundary value problems of Laplace's equation relating to two spheres have engaged the attention of eminent mathematicians for more than hundred years.¹ Two general methods have so far been developed to treat this class of problems, viz., the method of successive images, first employed by Thomson² (Lord Kelvin), and the method of transforming Laplace's equation into suitable curvilinear co-ordinates, termed bipolar co-ordinates by C. Neumann³, who developed this latter method extensively. The method of images is applicable with ease only to axial symmetric problems, but it has the advantage over the second method that the results arrived at through it are directly physically interpretable. The advantages of the present method are (i) that one can directly arrive at the results given by the method of images, avoiding the round-about process inherent in it; (ii) that it succeeds where the method of images either fails or becomes unmanageably cumbersome, as for example, in those problems where there is no axial symmetry;⁴ and (iii) that it can be very easily extended to the cases involving three or more spheres, where the method of bipolar co-ordinates fails.

In this short note I have tried to present the outlines of this new method by briefly treating the well-known problem of determining the potential due to two charged spheres. The potential ψ at any point can be expressed in the form,

$$(1) \quad \psi = 2\pi a \sum_{n=0}^{\infty} A_n \left(\frac{a}{r}\right)^{n+1} P_n(\cos \theta) + 2\pi b \sum_{n=0}^{\infty} B_n \left(\frac{b}{r'}\right)^{n+1} P_n(\cos \theta')$$

where a and b are the radii of the two spheres; (r, θ, φ) are the polar co-ordinates of the point with respect to the centre of the first sphere as pole, and (r', θ', φ') are the polar co-ordinates of the same point with respect to the centre of the second sphere as pole, the polar axis being the line joining the centres; A_n s and B_n s are unknown constants to be determined. The boundary conditions that $\psi = \text{constant} = V_a$, on the first sphere, $r = a$, and $\psi = V_b$, on the second sphere, $r' = b$, lead to the following sets of infinite recurrence equations,

$$(2) \quad A_0 = \frac{V_a}{2\pi a} - \frac{b}{a} \sum_{n=0}^{\infty} (-)^n B_n q^{n+1}$$

$$(3) \quad A_m = -\frac{b}{a} p^m \sum_{n=0}^{\infty} (-)^n \frac{(m+n)!}{m! n!} B_n q^{n+1}; \quad m=1, 2, 3, \dots$$

$$(2') \quad B_0 = \frac{V_b}{2\pi b} - \frac{a}{b} \sum_{n=0}^{\infty} A_n p^{n+1}$$

$$(3') \quad B_m = -\frac{a}{b} (-)^m q^m \sum_{n=0}^{\infty} \frac{(m+n)!}{m! n!} A_n p^{n+1}; \quad m=1, 2, 3, \dots$$

where $p = \frac{a}{c}$, $q = \frac{b}{c}$, c being the distance between the centres. An exact solution of these equations is the thing sought for. Let

$$(4) \quad f(z) = \sum_{m=0}^{\infty} A_m z^m;$$

$$(4') \quad g(z) = \sum_{m=0}^{\infty} (-)^m B_m z^m; \text{ and } |z| < 1$$

From the above recurrence equations it is easy to find that

$$(5) \quad f(z) = \frac{V_a}{2\pi a} - \frac{b}{a} \frac{q}{1-pz} g\left(\frac{q}{1-pz}\right)$$

$$(5') \quad g(z) = \frac{V_b}{2\pi b} - \frac{a}{b} \frac{p}{1-qz} f\left(\frac{p}{1-qz}\right)$$

These simultaneous functional equations can be easily solved, the solution being

$$\begin{aligned} f(z) &= \frac{V_a}{2\pi a} \sum_{s=0}^{\infty} \frac{q \sinh \lambda}{q \sinh(s+1)\lambda + (p-z) \sinh s\lambda} \\ &\quad - \frac{V_b}{2\pi a} \sum_{s=0}^{\infty} \frac{q \sinh \lambda}{(1-pz) \sinh(s+1)\lambda - zq \sinh s\lambda} \\ (6) \quad &= \frac{V_a}{2\pi a} \sum_{s=0}^{\infty} \frac{\sinh \mu}{\sinh(s\lambda + \mu) - z \sinh s\lambda} \\ &\quad - \frac{V_b}{2\pi b} \sum_{s=0}^{\infty} \frac{\sinh \mu}{\sinh(s+1)\lambda - z \sinh(s\lambda + \mu')} \\ g(z) &= \frac{V_b}{2\pi b} \sum_{s=0}^{\infty} \frac{p \sinh \lambda}{p \sinh(s+1)\lambda + (q-z) \sinh s\lambda} \\ &\quad - \frac{V_a}{2\pi b} \sum_{s=0}^{\infty} \frac{p \sinh \lambda}{(1-qz) \sinh(s+1)\lambda - zp \sinh s\lambda} \\ (6') \quad &= \frac{V_b}{2\pi b} \sum_{s=0}^{\infty} \frac{\sinh \mu'}{\sinh(s\lambda + \mu') - z \sinh s\lambda} \\ &\quad - \frac{V_a}{2\pi b} \sum_{s=0}^{\infty} \frac{\sinh \mu'}{\sinh(s+1)\lambda - z \sinh(s\lambda + \mu)} \end{aligned}$$

where

$$\cosh \lambda = \frac{1-p^2-q^2}{2pq} = \frac{c^2-a^2-b^2}{2ab};$$

$$\sinh \mu = q \sinh \lambda; \sinh \mu' = p \sinh \lambda$$

Thus,

$$\begin{aligned} A_m &= \frac{\sinh \mu}{2\pi a} \left[V_a \sum_{s=0}^{\infty} \frac{\sinh^m s\lambda}{\sinh^{m+1}(s\lambda + \mu)} \right. \\ m=0, 1, 2, \dots &\quad \left. - V_b \sum_{s=0}^{\infty} \frac{\sinh^m(s\lambda + \mu')}{\sinh^{m+1}(s+1)\lambda} \right] \end{aligned}$$

$$B_m = \frac{\sinh \mu'}{2\pi b} \left[V_b \sum_{s=0}^{\infty} \frac{\sinh^m s\lambda}{\sinh^{m+1}(s\lambda + \mu')} \right. \\ m=0, 1, 2, \dots \quad \left. - V_a \sum_{s=0}^{\infty} \frac{\sinh^m(s\lambda + \mu)}{\sinh^{m+1}(s+1)\lambda} \right]$$

The problem is thus completely solved. It can be easily shown from exp. (1) that the total charge carried by the first sphere is $2\pi a^2 A_0$ and the same carried by the second sphere is $2b^2 B_0$. Consequently, the coefficients of capacity and induction are

$$\begin{aligned} q_{aa} &= a \sinh \mu \sum_{s=0}^{\infty} \frac{1}{\sinh(s\lambda + \mu)} \\ q_{bb} &= b \sinh \mu' \sum_{s=0}^{\infty} \frac{1}{\sinh(s\lambda + \mu')} \\ q_{ab} &= -\frac{ab}{c} \sum_{s=1}^{\infty} \frac{\sinh \lambda}{\sinh s\lambda} \end{aligned}$$

These expressions, of course, agree with the usual ones.⁵ Other problems can be treated in exactly similar manner. Mathematical details concerning the solution of the simultaneous functional equations (5) and (5') and the convergence of their solution etc., will be given in the detailed work to be published shortly. A general type of problem, viz., the Green's function for two spheres, will be treated by this method in that detailed work.

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The Indian Association for the Cultivation of Science,
210, Bowbazar Street,
Calcutta, 18-10-1943.

¹ *Encyclopädie der mathematischen Wissenschaften*, Bd. V, section 13, p. 319.

² Thomson—Reprint of Papers on Electrostatics and Magnetism, Art. VI, p. 86, 1872.

³ C. Neumann—Stationär Temperaturzustand, Halle, 1862. Hydrodynamische Untersuchungen, Leipzig, p. 283, 1883.

⁴ Hicks—*Phil. Trans.*, Lond., 171, part II, p. 455, 1880; Hargreaves—*Quarterly Journal of Mathematics*, 41, p. 308-24, 1910.

⁵ *Handbuch der Physik*, Bd. XII, Kap 4, p. 443.

A NOTE ON THE CHEMICAL COMPOSITIONS OF CHINESE ROSE HIPS

In a previous communication, one of us¹ reported the higher content of ascorbic acid in the green and yellow rose hips. The Chinese rose hips are flatly spherical in shape, 1-3 cm. in diameter, and covered with small spikes. They grow abundantly in the mountains and fields and ripen in July and August every year. The country people take them as fruits and sell them in the markets but the people in the cities seldom take them. These fruits were described in ancient Chinese books and were used as rheumatism tinctures. So far as we are aware, there has been no report concerning the chemical composition other than the content of ascorbic acid of this fruit. Thus the writers would like to present the following results of analyses of these Chinese rose hips.

The method of collection and preparation of the hips for these experiments has been described in the previous communication. The content of water, solid and ash in hips was determined by the usual methods. The total acidity in the juice of the edible portion of hips was titrated with 0.1 N NaOH solution. The content of calcium, phosphorus and iron in the ash was determined by the methods of McCrudden, Briggs and Elvehjem respectively. After the complete hydrolysis of the dried hip powder with 15 per cent HCl, the hydrolysate was immediately neutralized with 40 per cent NaOH solution and filtered. The reducing sugar content in the filtrate was estimated by Shaffer's method. The content of proteins, fat and tannic acid was determined by Kjeldahl, Soxhlet and A. O. A. C. methods respectively.

THE CHEMICAL COMPOSITION OF CHINESE ROSE HIPS
(g. per 100 g.)

Composition	Samples			
	Yellow		Green	
	Fresh	Dried	Fresh	Dried
Edible portions ...	72.62		72.07	
Water ...	85.21		84.77	
Solid ...	14.79		15.23	
Total acid* ...	21.60		25.60	
Ash ...	0.64	4.33	0.68	4.52
Calcium ...	0.008	0.050	0.009	0.062
Phosphorus ...	0.027	0.184	0.032	0.213
Iron ...	0.0019	0.0130	0.0018	0.0124
Carbohydrate ...	3.72	25.18	3.11	20.48
Protein ...	0.61	4.09	0.70	4.58
Fat ...	0.95	6.43	0.94	6.19
Crude fibre ...	7.23	52.87	8.27	54.14
Tannic acid ...	1.64	11.10	1.53	10.09

* The total acid is indicated by c.c. of N NaOH standard solution required to neutralize 100 c.c. of juice.

Thus this fruit contains 85 parts of water and 15 parts of solid per 100 gram. The solid matter consists chiefly of crude fibre and carbohydrate. The content of total acid is very high. It is higher in the unripe hip than in the ripe. But the content of carbohydrate and tannic acid is higher in the latter than in the former. The fruit has got, in general, a high content of acid, crude fibre, carbohydrate and tannic acid.

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National Institute of Health,
Chungking, China, 26-12-1943.

¹ Wang Cheng-Fa, *SCIENCE AND CULTURE*, 8, 355, 1944.

DISTRIBUTION OF TANNIN IN DIFFERENT PARTS OF THE MYROBALAN PLANT (*TERMINALA CHEBULA*)

Though the rind of the myrobalan tree is known to contain tannin no one appears to have made a comparative study of the tannin content of the different parts of the plant.

To make a comparative test the following parts were collected from a big myrobalan tree belonging to the author's own garden and 5-g. of each were extracted with 50 c.c. distilled water by heating on the steam bath for 2 hours:

- (1) tender leaves, (2) mature leaves, (3) rind of the twigs, (4) rind of the trunk, (5) mature green fruits.

The filtrates from each sample were treated in the hot with equal quantities of animal charcoal and filtered. 2 c.c. of each solution (almost colourless) were taken in tubes of equal dimensions, diluted to 100 c.c. and 2 drops of ferric chloride solution were added to each. The blue black colour generated was carefully observed, the depth of which was found to be in the decreasing order as follows:—

- (1) mature green fruits, (2) tender leaves, (3) leaves, (4) rind of the twigs, (5) rind of the trunk.

From the results of the experiment we find that as in the case of the mango plant the tender leaves where photosynthesis is more active are richer in tannin than the old leaves.

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DISTRIBUTION OF PRESSURE IN THE AIR-CUSHION OF AN AIR-DRIVEN CENTRIFUGE

The air-cushion, on which the rotor floats and spins, plays an important and interesting part in the speed and stability of an air-driven ultracentrifuge. It is known that the Bernoulli effect creates a partial vacuum about the middle of the rotor-stator system. As a matter of fact the system can be held up side down and the rotor spun below the stator without dropping it off. This suction effect was demonstrated by Henriot and Huguenard in one of their earlier experiments.¹ On the other hand, when the centrifuge is spun in the usual erect manner, the rotor floats on the air-cushion so that there is no mechanical contact between the two units.

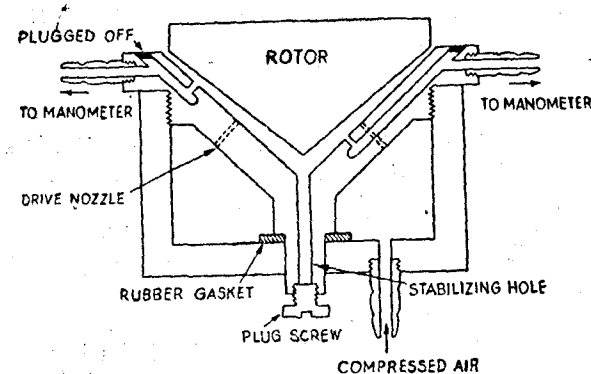


FIG. 1. Method of taking the manometer readings from different zones.

It is therefore evident that the air-cushion has different pressures at different radial zones, developing *partial vacuum* about the middle and *pressure-zones* towards the periphery. In the present experiments the distribution of pressure in the air-cushion at different radial zones have been measured using small rotors and low feed-pressures. The manometer readings were taken by the method shown in the diagram (fig. 1), and water was used in the manometers to read the zonal pressures. All the five manometers were operated simultaneously.

The specifications of the Stator and Rotors used are as follows:

Stator No. 3.—Size $1\frac{1}{4}$ inch; angle 90° ; number of air jets 8, drill No. 57 or 0.048 inch dia.; horizontal angle $P = 67\frac{1}{2}^\circ$, Vertical angle $Q = 60^\circ$ (convention as used by Beams^{2,3}); stabilizing hole⁴ $1/16$ inch which can be closed or opened by a screw; radial zones of manometer readings at 0, 0.2 , 0.31 , 0.41 , 0.55 inch measured from the axis of cone (and not along the wall of the stator).

Rotor No. 8.—Material—steel; size $1\frac{1}{4}$ inch; angle 100° ; flutings 55 milled corrugations⁴; length of flutings $\frac{1}{4}$ inch; weight 48 gm.

Rotor No. 10.—Material—cast alloy-aluminium; size $1\frac{1}{4}$ inch; angle 100° ; flutings 62 milled corrugations; length of flutings $\frac{1}{4}$ inch; weight 30.5 gm. (unloaded), 51 gm. and 71.5 gm. with loads.

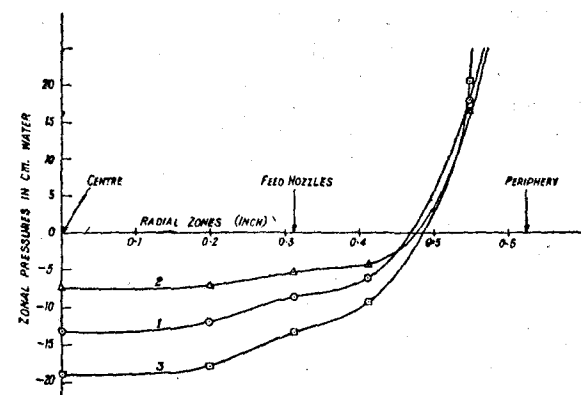


FIG. 2. Zonal Pressures with (1) 5 lb./sq. in. feed pressure, with stabilizing hole closed; (2) Same, with stabilizing hole open; (3) 7.5 lb./sq. in. feed pressure, with stabilizing hole closed. Rotor No. 8.

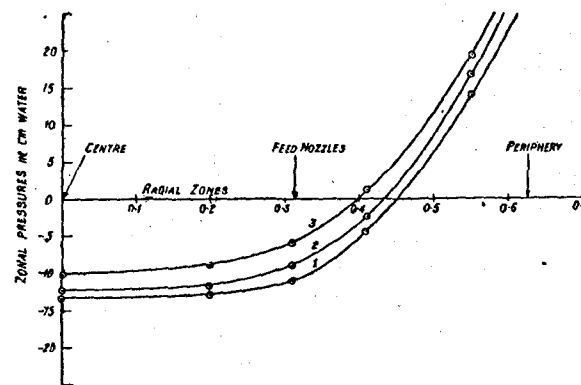


FIG. 3. Zonal pressures for different weights of the rotor 30.5, 51.0 and 71.5 gm. (Feed pressure 5 lb./sq. in., and stabilizing hole open, in all cases). Rotor No. 10.

Figs. 2 and 3 show the nature of variation of the pressures. The curves in fig. 3 are extremely smooth while those in fig. 2 take small but systematic inflexions near about the position of the feed nozzles. The inflexion is not, however, a regular feature of the air-cushion if the flow of gas is stream-line. The inflexion may be ascribed to some turbulent disturbances due to the constructional irregularities. In the present case, the flutings of rotor No. 8 is a little rougher and more irregular than those in rotor No. 10.

It is interesting that for very low feed-pressures all the manometers indicate 'pressures' in the cushion, and as the feed is increased some of the manometers (towards the middle zones) gradually reverse in the 'vacuum' side. For heavier rotors, as indicated in

fig. 3, the vacuum zone becomes smaller while the peripheral pressure-zone encroaches towards the middle. If v denotes the total force of suction in the vacuum zone, p the total pressure in the pressure-zone, and w the weight of the rotor, then $v + w = p$.

In a larger centrifuge, taking a $\frac{5}{8}$ lb. rotor no 'vacuum' was shown even at the centre up to about 30 lb./sq. inch feed pressure. There is, however, shown a tendency for the reversal which will occur at still higher pressure.

It may be noted that small changes of levelling of the centrifuge does not affect the zonal pressures materially.

The effect of stabilizing hole⁴ has not been shown to any marked degree at higher feed-pressures, although at low pressures (2-3 lb./sq. in. feed) the hole definitely stabilizes the air-cushion as indicated on the manometers.

Further investigations are in progress.

My thanks are due to Prof. M. N. Saha, D.Sc., F.R.S., for his kind encouragement during the progress of the work.

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¹ E. Henriot and E. Huguenard, *J. Phys. Radium*, 8, 433, 1927.

² J. W. Beams, *Review of Scientific Instruments*, 1, 667, 1930.

³ *Rev. Mod. Phys.*, 10, 245, 1938.

⁴ K. Ray, *SCIENCE AND CULTURE*, 8, 345, 1943.

VEGETATIVE PROPAGATION OF CINCHONA LEDGERIANA FROM GOOTES (MARCOTTE) AND CUTTINGS BY TREATMENT WITH AUXINS

In Indian plantations propagation of cinchona trees is made from seeds. Besides the time involved in growing plants by such a method there is another drawback associated with it. Due to the unavoidable natural cross-fertilization it is not possible to ensure the propagation of desirable varieties of plants with large quinine content, by such a method. To obviate this difficulty inarching has been adopted as a suitable method of propagation in Java and at present probably the entire cultivation of Java is made from grafted plants. In India too the value of the vegetative propagation of cinchona was appreciated but unfortunately it could not be introduced because no successful grafting has been possible since now.¹

Having obtained a considerable measure of success in our previous attempt at vegetative propaga-

tion of mango plants from gootes and cuttings by treatment with auxins² we thought it worth while making similar investigations on the possibility of vegetative propagation of cinchona plants. These investigations were carried out in the Government Cinchona Plantation at Mungpoo during the years 1941-42, and we are grateful to Mr S. C. Sen, Superintendent, Cinchona Cultivation, Bengal, for affording us every facility to carry on the work. Due to unavoidable causes it was not possible to continue the investigation beyond the preliminary stage. In view of some interesting results already obtained we have thought it desirable to publish a short account.

We tried different concentrations of synthetic auxins to produce roots in gootes and cuttings. Of all the different auxins tried, certain concentrations of indole butyric acid were found to be most effective in the formation of roots. In the gootes a treatment with 2% indole butyric acid in lanoline paste for twenty-four hours before dressing with bolls of earth, produced the best result; there was vigorous rooting in 88% of them within four months (fig. 1). In the hard wood cuttings a treatment

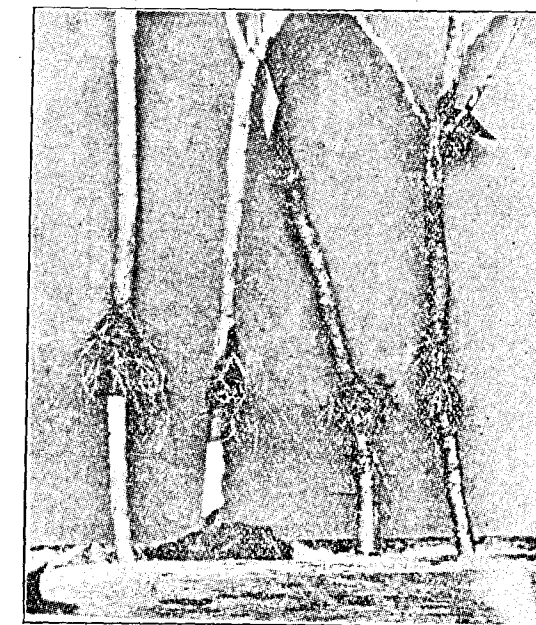


FIG. 1. Root formation in gootes of Cinchona ledgeriana by treatment with 2% indole butyric acid in lanoline paste.

with 0.02% indole butyric acid in water solution for twenty-four hours before planting in the soil produced roots in 20% within four months (fig. 2). The vigorous formation of roots on treated gootes and cuttings indicated that if these were planted intact to the soil and were properly taken care of, they would establish themselves and grow into vigorous plants, similar to the treated mango gootes

which were planted in the soil after the completion of our previous investigation. In the present case, however, we had to break open the boll of earth on

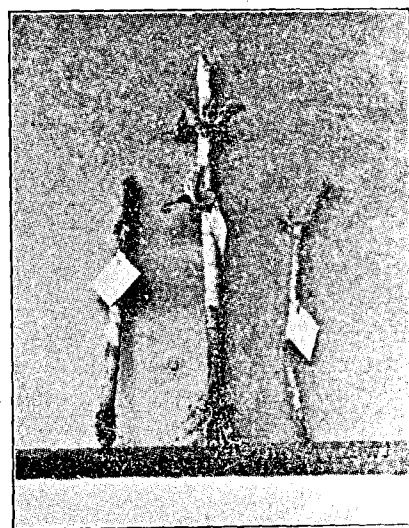


FIG. 2 Root formation in hard-wood cuttings of *Cinchona ledgeriana* by treatment with 0.02% indole butyric acid in water solution.

each of the treated gootes and also had to take the cuttings out of the earth to obtain a statistics of the success resulting from different modes of auxin treatment. The root system after being subjected to such rough handling did not survive when planted. Since then it has not been possible to continue the investigation.

It will be admitted that propagation by gootes and cuttings is by far an easier method than that by inarching. Moreover if propagated by gootes the time of cultivation can also be considerably shortened. As the goote is made with a two to three years old whole branch, a seedling will require at least two to three years to attain the initial size of a goote plant. The saving in time is also a point of great consideration, specially at a time when attempt is being made to rapidly increase the production of quinine by the Russian method of cultivation. The full text of the paper will be published in the *Transactions of the Bose Research Institute*.

A. GUHA THAKURTA.
B. K. DUTT.

Bose Research Institute,
Calcutta, 18-I-1944.

¹ Wilson, A., *Report on the prospects of Cinchona cultivation in India*, New Delhi, 1940.

² Guha Thakurta, A. and B. K. Dutt, Vegetative propagation of mango plant from gootes (marcotte) and cuttings by treatment with high concentration auxin. *Trans. Bose Res. Inst.*, 14, 1939-41.

ON THE LIMITING FORMS OF STATISTICAL DISTRIBUTIONS

Many important distributions of "Statistics" have been found to tend towards normality as we increase the value of some parameters mostly those depending on sample size or on 'degrees of freedom' involved in the distribution. As illustrations we can cite (1) χ^2 distribution, (2) classical "D²" distribution. With reference to χ^2 distribution Prof. R. A. Fisher states "Beyond $n=30$ it will be found sufficient to assume that $\sqrt{2} x$ is distributed normally with unit standard deviation about a mean $\sqrt{2n-1}$. As regards the "D²" distribution, Prof. Mahalanobis (1928) showed that

$$\beta_1(D^2) = \frac{2}{P} \frac{(3\delta+2)^2}{(\delta+1)^3} \dots \dots \dots (1)$$

$$\beta_2(D^2) = 3 + \frac{12}{P} \frac{(2\delta+1)}{(\delta+1)^2} \dots \dots \dots (2)$$

where P = no. of characters
 $\delta = \bar{n} \Delta^2$

Relations (1) and (2) show that β_1 and β_2 of "D²" statistic tend towards 0 and 3 as we increase $\bar{n}$ and P .

From the above discussion it is clear that we require to know the point, i.e., the sample size or the degrees of freedom at and beyond which the distribution of the statistic in question can be taken approximately equivalent to that of normal distribution at a particular level of significance.

In this paper we have tried to formulate a method by which we can specify the (β_1, β_2) combination corresponding to the transition from skew normal distribution to the normal form.

Let us take $F(x)$ to be the distribution which has its β coefficients differing slightly from 0 and 3. In such case the distribution is said to be skew normal and it may be represented by Gram-Charlier Series Type A. Taking terms up to fourth differential we may write

$$F(x) = \phi(x) - \frac{\sqrt{\beta_1}}{6} \phi^{III}(x) + \frac{\beta_2-3}{24} \phi^{IV}(x)$$

where $\phi(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

we are finding that value of x for which the maximum absolute difference of the incomplete probability integral of $F(x)$ and $\phi(x)$ may be less than or equal to α (say) i.e.,

$$\left| \int_{-\infty}^x F(x) dx - \int_{-\infty}^x \phi(x) dx \right| < \alpha$$

Now

$$\int_{-\infty}^x F(x) dx - \int_{-\infty}^x \phi(x) dx = \frac{\beta_2-3}{24} \int_{-\infty}^x \phi^{IV}(x) dx$$

$$- \frac{\sqrt{\beta_1}}{6} \int_{-\infty}^x \phi^{III}(x) dx = \frac{\beta_2-3}{24} \phi^{III}(x) - \frac{\sqrt{\beta_1}}{6} \phi^{II}(x)$$

The difference will be maximum or minimum at a point when

$$\frac{\beta_2-3}{24} \phi^{IV}(x) - \frac{\sqrt{\beta_1}}{6} \phi^{III}(x) = 0 \text{ and } \frac{\beta_2-3}{24} \phi^{IV}(x) - \frac{\sqrt{\beta_1}}{6} \phi^{III}(x)$$

is negative or positive.
i.e., when

$$\frac{\beta_2-3}{24} (x^4 - 6x^2 + 3) - \frac{\sqrt{\beta_1}}{6} (3x - x^3) = 0$$

$$\text{or } C(x^4 - 6x^2 + 3) + \frac{1}{3}x^3 = x \dots \dots (3)$$

$$\text{Where } C = \frac{\beta_2-3}{12\sqrt{\beta_1}}$$

Now for any value of (β_1, β_2) we can solve the equation (3) to find the values of x .

Substituting these values of x in

$$\phi(x) \left[\frac{\beta_2-3}{24} (3x - x^3) - \frac{\sqrt{\beta_1}}{6} (x^2 - 1) \right],$$

if we find that the absolute differences are less than α , we may consider $F(x)$ to be almost identical with normal. By trial we can find out the (β_1, β_2) combinations for the above level of significance.

We expect to publish the full paper shortly in *Sankhya*.

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Calcutta, 21-I-1944.

NITRITES OF THE RARE EARTHS

Practically nothing is known of the simple nitrites of the rare earths. Only one nitrite $\text{Ce}(\text{NO}_2)_3$ has been described by Morgan¹ which he obtained by double decomposition between the calculated quantity of cerium sulphate and barium nitrite. On evaporating the solution over sulfuric acid in vacuo, he obtained deliquescent crystals. The analytical results given by him, however, are not in accord with the above formula indicating that his compound was impure, mixed with hydroxide of cerium. The nitrites, however, have been used for the separation of yttrium earths among themselves by Holden and James² and Hopkins and Balke³ by the process of fractional hydrolysis, when the precipitate of basic nitrites is removed in fractions as usual.

Several insoluble triple nitrites with bivalent metals like Co and Ni, and alkali metals have been described by Cuttica and Gallo⁴. These are, truly speaking, not rare earth nitrites but merely cobalto- or nickelo-nitrites with alkali metals outside the complex partially replaced by rare earth metals.

Sarkar and Goswami⁵ prepared a number of triple nitrites of the general formula $\text{Cs}_2\text{Na R}(\text{NO}_2)_6$ (where $\text{R}=\text{Ce, La, Pr, Nd, Sm and Gd}$) and developed a method for the micro-detection of caesium. These are analogous to the corresponding salts of bismuth $\text{Cs}_2\text{Na Bi}(\text{NO}_2)_6$ prepared by Ball and Abram.⁶ These latter workers also prepared a number of complex bismuthinitrites of the types $\text{X}_3\text{Bi}(\text{NO}_2)_6$ and $\text{X}_2\text{Y Bi}(\text{NO}_2)_6$ where X stands for $\text{NH}_4, \text{K, Cs, Rb, Tl}$ and Y for Li, Na, Ag .

Several such series of salts have been prepared with the rare earth metals and described in this note. These have been prepared by evaporating in vacuo over sulfuric acid a concentrated solution of the rare earth nitrite obtained by decomposition between the sulfate and barium nitrite and the calculated quantity of respective alkali nitrites. The following salts have been obtained.

Double	Triple
$\text{Na}_3\text{La}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$	$\text{K}_3\text{NaLa}(\text{NO}_2)_6$
$\text{Na}_3\text{Ce}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$	$\text{K}_3\text{NaCe}(\text{NO}_2)_6$
$\text{Na}_3\text{Pr}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$	$\text{K}_3\text{NaPr}(\text{NO}_2)_6$
$\text{K}_3\text{La}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$	$\text{K}_3\text{LiLa}(\text{NO}_2)_6$
$\text{K}_3\text{Ce}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$	$\text{K}_3\text{LiCe}(\text{NO}_2)_6$
$\text{K}_3\text{Pr}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$	$\text{K}_3\text{LiPr}(\text{NO}_2)_6$
$\text{K}_3\text{Nd}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$	$\text{Ti}_3\text{NaLa}(\text{NO}_2)_6$
$\text{Ti}_3\text{La}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$	$\text{Ti}_3\text{NaCe}(\text{NO}_2)_6$
$\text{Ti}_3\text{Ce}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$	$\text{Ti}_3\text{NaPr}(\text{NO}_2)_6$
$\text{Ti}_3\text{Pr}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$	$\text{Ti}_3\text{LiLa}(\text{NO}_2)_6$
$\text{Ti}_3\text{Nd}(\text{NO}_2)_6 \cdot \text{H}_2\text{O}$	$\text{Ti}_3\text{LiCe}(\text{NO}_2)_6$
	$\text{Ti}_3\text{LiPr}(\text{NO}_2)_6$
	$\text{Ti}_3\text{LiNd}(\text{NO}_2)_6$
	$\text{Ti}_3\text{NaNd}(\text{NO}_2)_6$

These salts are completely dissociated in solution into its constituent ions, since physico-chemical methods failed to detect the presence of any complex ion in solution.

Thermometric and conductometric titrations of solutions of the rare earth nitrates with alkali nitrites gave no change in temperature and conductivity of the solution. The triple nitrites are generally stabler than the double nitrites. The salts are moderately soluble in water, the aqueous solutions gradually decomposing giving off nitrous fumes.

The double nitrites crystallise in plates while the triple nitrites in octahedral forms.

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Calcutta, 7-2-1944.

¹ Morgan, J. C. S., 91, 475, 1907.

² Holden and James, J. A. C. S., 36, 1418, 1914.

³ Hopkins and Balke, J. A. C. S., 38, 2332-47, 1916.

⁴ Cuttica and Gallo, *Gaz. chim. Ital.*, 53, 374-79, 1923.

⁵ Sarkar and Goswami, J. I. C. S., 308, 1935.

⁶ Ball and Abram, J. C. S., 103, 2120, 1913.

Mathematics and Statistics

Fundamental Equations of Quantum Mechanics

B. M. SEN

IN the course of about twenty years, the Quantum Theory has attained wonderful strength and maturity. Its success in explaining the major facts of atomic structure has been overwhelming. Based on some new physical principles which are fundamentally different from those of classical electrodynamics, it has tackled most of major physical problems and has even prophesied phenomena which have been verified experimentally. It is essential therefore that the subject should be treated in a logical and rigorous way. But unfortunately the mathematical theory lags far behind the experiments.

In the address, the branch of Quantum Mechanics dealing with the fundamental equations has been developed from the stand-point of a mathematician.

Starting from Bohr's hypothesis, the development of the theory is traced and its application to some of the outstanding problems shown. Special emphasis has been laid on the gaps in the theory. Attention has been drawn to the so-called spin of the electron, which if taken literally, contradicts the theory of relativity. The independent existence of so many fundamental particles such as photons, electrons, positrons, neutrons, protons, mesons, neutrinos etc. is open to scepticism. It raises the question of separability of charge from matter. In fact the distribution of charge in the electron itself has not been satisfactorily established. In conclusion, the latest attempts at generalisation of the Lagrangian Equations to include relativity as well as spin effects, have been referred to.

Geology and Geography

The Bombay Island

A. S. KALAPESI

BEFORE the advent of man upon the earth, Bombay formed a part of the mainland of India. Successive earth movements, subsequent to the Deccan volcanic activity, must have caused faulting along the present west coast of India and the portion to the west of this fault line went down into the sea; and the scarp-side near the Bombay coast is the result of this faulting. About this period (Pliocene) the existing ridge of the Western Ghats must have broken up into several islands lying off and fringing the western coast of the Peninsula. The present Island of Bombay is one of the multitude on the western shore of India. The present Bombay Island is constituted of seven islands: (1) Colaba; (2) Old Woman's Island; (3) Bombay (Central island);

(4) Mazagaon; (5) Parel-Sewri-Sion; (6) Mahim; and (7) Worli. These were separated by narrow creeks and channels. Ptolemy in A.D. 150 designated these seven islands as Heptanesia.

The aborigines (Kolis) who occupied these islands brought with them *Mumbā Devi* their patron goddess. The name Bombay is supposed to have been derived from *Mumbā Devi* or *Mumbā Āi*. People even to-day speak of the city as *Mumbai*. The temple of the goddess is now situated near the Mumbādevi Tank in the heart of the city.

The channel between Old Woman's Island (Lower Colaba) and Bombay (Central island) was filled up and a causeway was built about 1858. The

breach between Sion and Mahim was filled up about 1712 and the breach between Mahim and Worli was also dammed up about this time. The breach between Worli and Cumballa Hills, now known as Breach Candy, was dammed up about 1783 and is now known as the Hornby Vellard. Before this Vellard was built the tide used to come racing over Byculla Flats sweeping across Bellasis Road, thence to Grant Road invading Khetwadi and onward through Bhendi Bazaar reaching up to Pydhoni. The word Pydhoni is derived from 'Pāi-dhoni (Foot-wash). It was a shallow creek near Umbarkhādi (creek of the Fig-Trees) where a ferry-boat was employed and persons arriving from Mahalakshmi, Mahim and Salsette by boats used to land after crossing Umbarkhādi creek and get their feet washed in the shallow creek (Pydhoni) in approaching Bombay (central island) on foot.

The Bombay Island after artificially connected throws out a long projection southwards from one (western) extremity forming the Walkeshwar Point. The name Walkeshwar is supposed to have been derived from '*Valuka Ishwar*' meaning 'Sand-Lord'; the Linga (Sand-Lord) in the temple of Walkeshwar is supposed to have been erected by *Rāma*, when he was on his journey to *Lankā* (Ceylon). The other projection (eastern) stretches out southwards (Colaba Lighthouse). These two promontories include a great bight—Back Bay—between them. The present Island is united at its northern extremity with Salsette by means of two causeways, one at Mahim and the other at Sion, and two railway embankments and bridges.

Geologically the Island appears to consist of a conformable series of the Deccan Trap lava flows, intercalated with the fresh-water sedimentary beds. The general dip of the rocks is 10° to 15° towards the west.

The rocks of this Island were formed during four different periods. The basement rock is the lava flow of the Deccan Trap, over which the fresh-water lacustrine strata were deposited which are known as the Bombay inter-trappean beds. In these beds skeletons of tortoises and frogs were preserved

and even to-day we find beautiful specimens of fossil frogs in the shales at the foot of the Worli Hill cutting on the eastern side.

After this there was an outburst of the Deccan lava flows, the highest and the last in the series. This highest flow (andesite) covers the present summits of the hills of the Malabar-Cumballa ridge. But the rock that constitutes Colaba, the Fort and the Esplanade area is an ordinary plateau basalt.

After the consolidation of this sub-basic lava flow, local *secondary*-effusions took place. They did not penetrate the highest Deccan lava flow but formed a sill, intercalating and breaking up the fresh-water beds in some places. This sill has resulted in the formation of amygdaloidal trap and greenstone, exposed in the Parel-Sewri-area. In this greenstone big cavities were discovered; these cavities were found studded with calcite, quartz and several varieties of zeolite.

It seems after this another *secondary*-effusion took place which formed the volcanic ash and breccia. The Sion Hill is constituted of this breccia. These *secondary*-effusions were probably responsible for raising up the longitudinal ridges, bordering the eastern and western sides of the Island. But Antop Hill is made up of a peculiar black rock which appears to be an altered sedimentary rock, "Lydite-like rock".

After the *secondary*-effusions of volcanic breccia and dyke-like breccia, the volcanic activity permanently stopped in this Island. And during the period that followed Blue Clay, Littoral Concrete and alluvial deposits were formed. Also during the excavations for Alexandra (1910) and Prince's (1877) docks a submerged forest was discovered at about 40 feet below the high-water mark. All this suggests that the Island has undergone a series of subsidences and upheavals after the cessation of the volcanic activity.

Our "Lead-ratio" results show that the highest lavas of Bombay are of Oligocene age while the acid intrusions give a Pliocene age. This is in agreement with the results of the "Helium-ratio" as well as with the palaeontological researches.

Physiology

Harmony and Rhythm in Nature

S. N. MATHUR

CARBONIC acid gas, the reputed poison of the animal life, is not only present in and about every living cell of the animals, as a necessary sequence of the combustion of the food, but is actually required in the interior of the animals to keep them alive; and its importance for the breathing was already known. It is now shown that the harmonious working of the other systems, chiefly the heart and the digestive organs, of the body, is also directly or indirectly dependent on its presence. Although under ordinary conditions a certain minimum tension of carbonic acid gas is necessary for these vital bodily activities, and without which these would fail and death might occur, still this tension can either decrease or increase under emergencies, such as, the increase and decrease of normal body temperature, or the presence of the increased or the decreased amount of oxygen in the atmosphere; or in other words the peace time requirements of the body which were considered as the absolute necessities, have been sacrificed by the Nature to tide over an emergency which would otherwise have killed the animal. By this sacrifice of the normal carbonic acid gas in these emergencies the body tries to assure for itself the maintenance of the normal temperature, and tension of oxygen, both more necessary comparatively than the carbonic acid gas. But, of these three, i.e. the carbonic acid gas, the regulation of the tempe-

rature, and the oxygen, the last, being the most important link in the chain of life, so alters the bodily activities that even the regulation of the temperature, if it should interfere with its supply, is sacrificed, as, e.g., at very high altitudes. Oxygen is required for liberating the energy, from the food stuffs, required for movements—the most fundamental property of the life. Continued performance of activity demands alternate periods of rest and work. The machinery which controls this rhythm of work and rest is provided by the two divisions of the involuntary nervous system. Reasons are given for considering the rhythm of heart consisting of alternate contraction and relaxation, the daily rhythm of sleep and wakefulness, and the yearly rhythm of alternate periods of comparative rest and activity, beginning in autumn and spring respectively, in animals, as all to be under the control of the two divisions of the involuntary nervous system. Human beings at least as far as the pigment of their blood, the carrier of oxygen, is concerned, seem to pulsate with the entire nature.

Special points to be noted in the text are that there are regular changes in the reaction of saliva which depict the opposite changes occurring in the stomach and can be taken advantage of in diagnosis of the diseases of the stomach, and that the sun stroke cases can be better treated with oxygen and carbon-dioxide mixtures.

Agricultural Sciences

Some Aspects of the Present and Post-war Food Production in India

D. V. BAL

GYAN CHAND, Viswanath and others have shown that India's own food supply has fallen short of her requirements, and it is therefore clear that on this problem unanimity of opinion exists among the different sections of the thinking public.

On the basis of 1939-40 figures regarding the area under cereal crops in British India, the quantity of cereal foods grains available for human consumption comes to 53.2 million tons. Average requirements in respect of cereal food grains per head per day come to about 1½ lb. on the assumption that out of the minimum requirement of 2,600 calories, about 275 calories are derived from oils, pulses and vegetables and 1¾ lb. if the total calorific requirements as shown by different diet surveys are to be derived chiefly from cereals only. According to the recent census figures, the total quantity of cereal food grains required, will come to 57.8 to 67.5 million tons which is higher by 4.6 or 14.3 million tons respectively than what the land can normally be expected to produce under existing systems of crop production; in other words, the present production will have to be raised by 8.6 to 26.8% in order to meet the minimum food requirements of the existing population.

It is thus evident that leaving aside questions like birth control and other measures for checking the growth of population, our immediate need is to increase food production to the maximum extent possible apart from the economic factors governing crop production. Maximum capacity of soils of different regions or tracts in regard to crop production depends on various factors out of which climate, soil type, soil fertility, quality of the seed and incidence of disease may be considered to be of outstanding importance.

One of the methods suggested at present to increase the production of food crops in India is to break up fallow land. In this connection, the position of the cattle vis-a-vis human population

must be very closely examined. There is at present a very great scarcity of agricultural cattle in the country and the consumption of milk per capita per day which is already far below the minimum quantity prescribed for a balanced ration, has during recent years further dropped by about 12 per cent. Systems of cropping which are likely to increase the competition between the cultivators and their cattle must therefore be adopted with very great caution and after a full consideration of the pros and cons of this important question.

Taking the modest figure of loss for all crops during storage at 2½ per cent, nearly 1.3 million tons of the stored grain is annually being damaged in India as a result of insect attack. The question of provision of adequate storage facilities to protect the produce against the attack of insects, rats and spoilage due to a weather conditions must not therefore be ignored.

In view of the fact that it is obligatory on the part of the State to ensure minimum requirements in respect of food and clothing for every individual citizen, the State must come forward to help the cultivators whenever required.

Referring to the question of long-range problems, Mr Bal dealt briefly with the following factors:

(1) Necessity to conduct properly planned experiments to determine maximum crop production capacity of soils, (2) Need for training a large number of young persons, (3) Colonisation of new areas and utilisation of demobilised soldiers and various motor vehicles and tanks at present employed for war work, (4) Necessity to stabilise incomes of agricultural labourers and cultivators, (5) Prevention of fragmentation of holdings.

In conclusion, Mr Bal urged that all the forces at our disposal must be harnessed together in order to increase the production of food in India, not only to meet her present requirements but to banish the problem of food deficiency for all times to come.

Engineering and Metallurgy

Industrial Research

J. J. GHANDY

A PART from the inadequately staffed, official scientific services and a mere handful of research institutes and committees and engineering colleges, India has had few facilities for research in the past. The Department of Scientific and Industrial Research is only a creation of this War and suffers from many handicaps. The hour has come when we must plan national research on national lines or abandon all hopes for the future.

In every advanced industrial country of the West, industrial research is fostered by State bodies, such as the Reichsanstalt and the State Council for Research in Germany, the Department of Scientific and Industrial Research in England, the National Bureau of Standards, the Bureau of Mines and other Federal departments in America, and by the Council of People's Commissars and the re-habilitated Academy of Sciences in Russia; by universities and technological institutes; by private companies; and by industrial or trade association, like the Kaiser-Wilhelm Gesellschaft with its different institutes in Germany, the Iron and Steel Industrial Research Council in England and the Mellon Institute in America.

There is always the closest liaison between Government, the university and the factory in the furtherance of scientific and industrial research.

For India, it is suggested that the existing Department of Scientific and Industrial Research, consisting of a Research Council and a Board and a Research Utilisation Committee should be de-politicised, and its membership enlarged so as to include representatives of all branches of science.

The Council should only lay down policy and co-ordinate the work of the technically subservient

bodies, corresponding in its functions to the Committee of the Privy Council for Scientific and Industrial Research in England.

The Board and the Committee, both aided by chains of Committees, should plan national research in close collaboration, under the general direction of the parent Council. The Board should concern itself with the scientific aspect, and the Committee with the industrial aspect, of the planning of a national programme, and its direction and execution.

For children, 'Pioneer Palaces' on the Russian model, equipped with science laboratories, should be set up and for adults, facilities for scientific research at the universities and for technological training should be extended.

The vocational, practical training of science students in the workshops of private companies and the railways should be arranged, to make the science students 'shop-minded'.

Industries should set up their own research laboratories, if they can afford them, or combine together and foster co-operative research like the Iron and Steel Industrial Research Council in England; arrange part-time technical instruction for the average factory worker, who is the eventual agent for the application of research to industry; and stimulate the growth of an industrial fellowship plan on the American model.

The daily, non-technical press, in addition to the technical press, exhibitions, the film and the radio should be fully exploited for the general dissemination of scientific intelligence.

The problem of research in India can brook no further delay. For today, research is progress, research is life.

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PLANNING AND PROSPECT

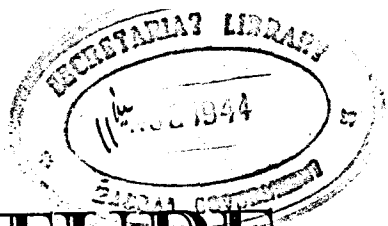
PLANNING for the country on a comprehensive basis has been the all-absorbing programme of Soviet Russia ever since 1928. The idea of industrial and economic planning on a national scale was first introduced in this country by Sir M. Visvesvaraya in 1933. Very few people in this country appear to have appreciated his ideas, but from its very inception in 1935, this journal has been trying to mobilise public opinion in this country for a programme of national development by harnessing science and technology in a planned manner. It was largely due to our advocacy that the then President of the Indian National Congress took the first steps in this country to start the actual work of detailed planning and constituted for this purpose the well-known National Planning Committee with Pandit Jawaharlal Nehru as the Chairman. That work, though unfortunately interrupted by the incarceration of the Chairman, brought the idea of planning to the fore and resulted in a large collection of materials and formulation of tentative schemes, which may perhaps be published in happier times. The work was inspired by realistic idealism and under the inspiring guidance of Pandit Jawaharlal Nehru some of our best intellects in the domains of science, economics and industry and in our national life gave ungrudgingly their time and labour. The vastness of the scope of the work may be indicated by the fact that for the preparation of the detailed reports, the Committee constituted no less than 28 sub-committees for dealing with various subjects. The amount of work put in by the Committee and its various sub-committees is an index to show how much can be achieved in a relatively brief space of time when a genuine love of the country under inspiring leadership provides the driving force. Summaries of recommendations of several sub-com-

mittees were published in the press, and others were almost complete when the work was interrupted.

WHY PLANNING?

Although planning is now in the air, it may be useful to restate the reasons for planning. The amount of interest shown by all sections of the public showed clearly the appreciation of constructive thinking on a programme of such vast general importance. But even now in interested quarters the question is asked why planning should be necessary for the economic development of India, when countries such as Britain, Germany and U. S. A. have reached their present pre-eminence without any planning from the top. Why not *laissez faire*? *India shall forget the answer at her own peril.* The aforesaid countries started their industrial revolution more than a century ago by the use of scientific and technological discoveries made in the West. In a largely undeveloped and uncompetitive world their scientific and technical superiority helped them to acquire not only the economic hegemony of the world, but also military and political hegemony. The results of those conquests are now obvious to all. If today India wishes to proceed to develop her industrial and agricultural economy without any plan, centrally conceived and centrally directed, she will only find herself economically out-fought by the incomparably more advanced countries. India requires therefore a planned and a forced march under the driving force of her own Government if she is ever to fight her way out of the present axis-combination of poverty, disease and illiteracy.

But it is not at all correct to say that even in the U. K., U. S. A., and Germany a policy of *laissez*



faire has been followed. The need of some sort of planning and central direction is being felt even in these industrially advanced countries. If not for anything else, at least for securing greater equity in the distribution of wealth, for avoiding cut-throat competition among the different industrial concerns, for limiting those "anarchic" conditions which develop with the growth of uncontrolled capitalism under the motive of profit, for ensuring a more balanced structure of production necessary for the all-round strength and prosperity of a nation which ought to be the concern of the State and *above all* for conserving exhaustible national resources like coal and petrol and developing power and mineral resources planning is being increasingly considered even in the highly capitalistic countries. England has got, for instance, her political and economic planning (PEP) groups and during the war the State has intervened more and more in regulating production and is already planning for the post-war period. The generation of electrical power has been completely State-controlled since 1927, and the production and utilisation of fuel has largely come under planned control in recent years. In America capitalistic genius had in the past received free play and had reached perhaps the highest water mark of efficiency. But President Roosevelt, since his accession to Presidency in 1932, has introduced 'National Planning' under the name 'New Deal', and within the last twelve years, vast development projects like the Tennessee Valley Reclamation, The Boulder Dam, The Grand Coulee Dam, etc. have been completed. These schemes, which could never have been completed without State intervention, and premeditated planning, have enormously enhanced U. S. A.'s productive power; the T. V. A., established in 1933, alone produces about twice the electrical energy produced in India, and the total increase in electrical energy-production due to the 'New Deal' will be about 50,000 million units, almost equal to Germany's production of electrical energy in 1939. But 'planning' has not been confined to such vast reclamation works alone. After the fall of Malaya, a plan has been framed by the Compton-Conant-Bharuch Committee for the production of synthetic rubber, whereby a balanced production is secured from petroleum on the one hand and alcohol, derived from the fermentation of grains, on the other. Both industrial and agricultural interests have thereby been secured, which is the ultimate objective of national economy as a whole. This plan is now being loyally implemented by the Government and the interests concerned. This and other vast production works like production of aluminium, fertilisers, chemicals could not have been so speedily undertaken if Roosevelt had not the foresight to develop hydro-electrical power, as a part of reclamation scheme.

RUSSIA

The finest and untrammelled fruition of planning has, of course, been achieved in the Soviet Union where a clean slate was provided by the abolition of the inherent contradictions of capitalist society altogether. What the Five Year Plans, starting only in 1928, have achieved for the Soviet Union, is now clear to all. Her industrial and agricultural strength built up in the space of barely 15 years by a forced and planned march has stood up to the test of the most fiery ordeal that any country has known in history. In this march, which was proving too strenuous and exhausting for many people, Stalin provided great inspiration and guidance as will be seen from his address in 1931:

"It is sometimes asked whether it is not possible to slow down a bit in tempo, to retard the movement. No, comrades, this is impossible. It is impossible to reduce the tempo. On the contrary, it is necessary as far as possible to accelerate it. To slacken the tempo means to fall behind. And the backward are always beaten. But we do not want to be beaten. No, we do not want this! The history of old Russia is the history of defeats due to backwardness. All beat her for backwardness. . . . They beat her saying 'You are abundant, so we can enrich ourselves at your expense'. They beat her saying, 'You are poor and helpless, so you can be beaten and plundered with immunity'. You are backward, you are weak, so you are wrong, hence you can be beaten and enslaved. You are mighty, so you are right, hence we must be wary of you. That is why we must no longer be backward. . . . We are fifty to hundred years behind the advanced countries. We must cover this distance in ten years. Either we do this or they will crush us".

Today the war has revealed Russia's strength secured at colossal sacrifice. Today she makes all the highly mechanised equipments that a modern military power needs.

On the other hand, as the war has intensified, India's industrial and agricultural backwardness, has been increasingly brought home to us almost in every aspect. India made no tanks, aeroplanes, trucks or cars. We made hardly any basic chemicals, dyes or synthetic drugs. Engineering, metallurgical and chemical industries which are absolutely pivotal to a country's development were practically non-existent. Probably there can be no better index to India's backwardness than the incontrovertible facts that her production of electrical energy is still 7 units per capita, and energy from coal is about 12 units per capita. One has only to compare these figures with that of 2,000 for the U. S. A., from all sources, to realise India's backwardness. Agriculture produces less rice and less wheat per acre than any country in the world. The level of literacy is likewise the lowest and therefore educated and trained personnel and labour are largely lacking. Famine and epidemics have supervened and people have died in hundreds of thousands

from starvation and from easily curable and preventable diseases for lack of drugs and preventive agents. In five months in Bengal alone about 7 lakhs of people perished owing to the famine and its aftermath, according to a Government communique, while barely 1.6 lakhs of people have been killed in four years in this war in the whole of the British Empire, as stated by Mr Churchill in Parliament on April 4, 1944. Such a shambles could scarcely be imagined if it were not so real.

THE BOMBAY PLAN*

The question of rapidly getting out of this valley of death, poverty, disease and illiteracy is therefore the vital problem for India. Recently some well-known industrialists of India have produced a tentative plan, popularly known as the "Bombay Plan", for this accelerated development. This plan has attracted wide-spread attention. Explaining why there should be a plan—a point which we have discussed above—one of the authors, Mr J. R. D. Tata said in an address at the Bombay Rotary Club on the 15th February, 1944:

"While it is true that the great prosperity has been built up in other countries, and particularly in America, without any centralised planning and control, the conditions facing us in India to-day are entirely different. Climatic disabilities, the gradual erosion and de-mineralization of our land, the progressive loss of vitality, the political subjection and economic degradation of the people, the massive increase in our population, has brought the nation to a state where, like a patient exhausted by a long illness, it lacks the vitality and capacity to fight back to health unaided. The progress towards recovery that could be achieved in the natural course of things would be too slow. We cannot wait a hundred years or even half that time. There is no margin of safety left, as the recent tragedy in Bengal has shown us."

This is but too true.

The plan envisages doubling of the standard of living of the Indian people over a period of 15 years covering the essentials of life, viz., food, clothing, shelter, health and education. The per capita annual income of Rs. 65/- is sought to be increased to about Rs. 135/-. This is a far more modest idea than that of the N. P. C. Taking into account the probable rise in population to about 490 millions during the 15-year period, this would mean a three-fold increase of the annual national income from Rs. 2,200 crores to Rs. 6,600 crores. This increase in the national income means, of course, more production. Apart from the over-all increase in production, the plan seeks to organize a more balanced structure of production. Thus agriculture and industry are expected

to contribute respectively 40 per cent and 35 per cent of the national income as compared to about 55 per cent and 17 per cent today. The rest of the income would be contributed by the services.

The plan then considers the outlay necessary for securing this increased national income and indicates the following figures for investment under different heads spread over 15 years:

	Crores of Rupees
Industry	4,480
Agriculture	1,240
Communications	940
Education	490
Health	450
Housing	2,200
Miscellaneous	200
	10,000

For purposes of execution it has been proposed that the scheme should be divided into three 5-year plans and that the investment should increase in geometric progression from one period to the next. It should be stated, however, that the plan would naturally help to pay its way as production increases.

Regarding priorities in production, more emphasis is rightly laid on the development of basic industries than of industries for consumption goods, although to avoid hardships as far as possible the latter are also proposed to be developed along with the basic industries but on a relatively smaller scale particularly during the earlier stages of industrialisation. It is only too apparent that in this country whatever industrial development has taken place is largely a spurious lop-sided development (except in the iron and steel and some other industries). Thus sugar and textiles are produced in fairly large quantities but sugar and textile machineries have largely to be imported.

In our opinion, the plan is neither so broad nor exhaustive as that of the N. P. C., but it is to be welcomed that our industrial magnates have been able to come out of their narrow grooves, and think in terms of the Nation. No doubt the idea has been accelerated by the large accumulation of surplus money which has flown into their coffers. Vast constructive works on a national basis, which India badly needs, will provide a channel for this 'capital', and make it *creative*. If such works are not undertaken, this 'capital' will produce, as it has already produced, 'inflation'; and poverty, disease and degradation will continue.

Some criticisms have been made against the plan. It is said, for instance, that it is a scheme to benefit the Indian industrial magnates. Perhaps, but would

* 'A Plan of Economic Development for India' by Sir P. Thakurda, J. R. D. Tata, G. D. Birla, Sir Ardesir Dalal, Sir Shri Ram, Kasturbhai Lalbhai, A. D. Shroff and John Matthai.

we prefer the present backward condition which is exploited and perpetuated by *foreign* industrial magnates? Would the British people prefer American capitalists to their own? It is true, of course, as we have indicated above, that it is *socialist* planning as that adopted in Russia which allows the full fruits of planning to be reaped by the entire community on an equitable basis. As a matter of fact the Bombay Plan itself recognises the necessity of a National Planning Committee functioning under a free National Government to frame the detailed schemes, the execution of the schemes being in charge of a "supreme economic council working alongside the national planning committee under the authority of the Central Government". The problem of distribution is referred to as "vital" but this and the "allied question of the control to be exercised by the State over economic activities" are expected to form the subjects of a later report.

The question of finance is complicated and has been proposed to be raised both internally and externally. The question of possible inflation is also touched on. The Soviet Union had to rely chiefly on internal finance and by exporting food-grains at great sacrifice secured part of the necessary capital goods. In this country, similarly, we can hardly bypass toil and sweat and tears if we wish to compress a century's development into a quarter of a century.

The plan fully recognizes that without a National Government such a plan of development cannot be adopted. We would add that that National Government will also have to keep in view the good of the entire community and the even distribution of wealth in framing and executing the future National Plan. The fruits of planning should, on no account, be allowed to be frustrated by sectional, group or individual or provincial interests, which run counter to the good of the community.

THE PROSPECT

The planning may be there but what is the prospect? The Government of India and also the Provincial Governments have appointed a number of post-war reconstruction committees. The terms of reference of these committees are so circumscribed that they have hardly inspired any confidence, but more commendable are the proposals of the National Institute of Sciences of India for a National Research Council for dealing with scientific research in a comprehensive manner embracing scientific, industrial, agricultural, medical, public health and engineering research. In order to see that the results of research may be implemented in actual practice the National Institute have also recommended that the proposed National Research Council should have corresponding

Development Sections in the relevant Departments of the Government. There is also the proposal for a Government Member in charge of Research and Development. These are all progressive steps, but all of these including the Bombay Plan cannot replace a National Planning Committee or a State Planning Commission for centrally directing and integrating a plan of national development with its myriad criss-crossing strands. Above all, the will and driving force of the State organ is necessary not only in framing the highly complex National Plan but particularly in executing it in a stated period of time.

Government spokesmen have on several occasions professed a desire for the industrial development of India. But it is curious to note that, not to speak of Government's framing a full-fledged scheme of industrialisation, whatever planning has been made by others has received very little commendation from the Government. Sir Jeremy Raisman said that the Bombay Plan was going to impose too great hardships on the people. The die-hard Tory papers, the *London Times* and the *London Economist* thought that it was largely unpractical. Far more ambitious projects are apparently practical in the Soviet Union and are highly commended by the British allies of the Russian Soviets, but even modest schemes for doubling the standard of living in 15 years are according to the same critics apparently not practicable in India!

There are already disturbing signs of a double-pronged attack on Indian industries including those which have been started owing to the Government's own war needs. On the one hand, facilities for these industries are being restricted and in wartime it is Government alone who can accord those facilities and, on the other, Government are helping the import of consumers' goods with the object, as they say, of counteracting inflation. This pincer movement is bound to kill a number of Indian industries. Of late even alum, dichromate, sodium sulphide, 'hypo' and many other chemicals, which were already being made in India, are being provided shipping space for importation into India, inspite of the supposed pressure on shipping, which prevented the Government to get food to India for a considerable period during the famine. The arguments advanced by the Government for this policy are interesting and worthy of critical examination.

(a) It is said that there is shortage of coal, transport and other essentials necessary for Indian industries. It will be noted, however, that the British Government is maintaining the British industries for which an essential requirement is coal, inspite of the fact that there is a serious shortage of miners' labour in Britain and there have been serious coal strikes entailing a loss of several million tons. If coal had

been withheld from British industries, how could they increase the export of finished goods besides maintaining the war and the civil industries of Britain? Apparently the British Government on plea of coal shortage is not starving their industries. Why do the India Government starve ours?

(b) It is said that many of the Indian industries are "uneconomic" and therefore they ought to be discouraged. Such arguments are apparently not advanced in Britain, U. S. A., Canada or Australia with regard to their own industries. Industries may be said to be "uneconomic" if in peace time under conditions of free trade they cannot produce and sell goods at a price at which they can be imported. Judged by this standard, the production of dye-stuffs in Britain was uneconomic compared with that in Germany. Then why was not the British industry discouraged by the British Government? In every country the economics of production improve with time and if industries are nipped in the bud, how will they ever get a chance to reduce the cost of production? A fine example is afforded in India itself, where the sugar industry, on account of the protection it has enjoyed, has not only effected an all-round improvement, (e.g., the recovery has increased from 6-7% in 1931 to 11% in 1943), but has been giving of late a far larger amount to the Central Exchequer in the form of excise, and income tax than the Government ever used to realise from customs duty on sugar imported from Java previous to 1934. Were not practically all Soviet industries uneconomic in the beginning? If so, why did not the Soviet Government suppress them? The fact is that an all-round industrial development is regarded as essential in every progressive country, firstly because it is needed for prosperity, and secondly because it is essential for defence. Apparently that principle does not apply to India.

(c) It is said that importation of consumers' goods is necessary in order to fight inflation. But inflation can also be fought by producing those goods in one's own country. In fact, Lord Wavell stated in the Central Legislature on 17th February, 1944 that inflation should be fought by both these methods. Accordingly, the Government recently announced that they were vigorously moving for increased imports of finished goods into India. But the Government did not say what vigorous steps they were taking to increase the production of those goods in this country. Can any other country be mentioned where finished goods are being deliberately imported to fight inflation? Is it not rather a fact that every country of any importance is increasing its home production of consumers' goods not only to fight inflation but to maintain foreign markets even during the war? In fact, as we have mentioned earlier, the present

surplus wealth in the hands of the Indian industrialists and the public can flow into creative channels, and can materially help to solve India's poverty problem if the Bombay scheme is adopted. But if that is not adopted, this wealth will become inflative and enhance the poverty.

(d) Facilities for importation of plants, machineries and basic materials, etc., are often refused to Indian industries on the ground that shipping space is saved by importing the finished goods rather than those heavy materials. One may ask how Britain gets the enormous shipping space necessary for importing heavy raw materials from distant countries from which British industries manufacture finished goods to sell often in countries, wherefrom these raw materials are imported. Sir Gilbert Morgan, an authority on British chemical industry, stated "Apart from coal and iron ores, the mineral resources of the United Kingdom are relatively limited and many of our metallurgical trades depend on sea-borne minerals". If Britain now sends finished goods for fighting inflation in India, it is obvious that the British Government provided very large shipping space for importing enormous quantities of heavy raw materials. Then why should shipping space be unavailable for importing machineries and basic starting materials for Indian industries?

(e) As is well-known, industrial activity has been restricted in India by the restriction on the starting of new concerns and even on increasing the share capital of existing concerns, in the name of protecting the prospective investors, who might otherwise be cheated. We doubt whether there are similar restrictions in Britain or U. S. A. In any case, one should have thought that, since fighting inflation is one of Government's objects, they should have encouraged fresh investments of capital for the manufacture of consumers' goods in India.

The above would show the wide gulf between Government's professions and actions and this hypocritical policy is already in operation. These policies would be more intelligible in the light of the following press report from London:

"Expert economists here see danger for post-war Indian trade and industrialisation in India in Lord Woolton's (Minister for Post-War Re-construction in Britain) speech today. Lord Woolton envisaged:

- (1) statutory provisions for securing adequate British exports to India and the Empire,
- (2) gradual export of investment capital to the Empire under State auspices and
- (3) increase of invisible exports under cover of an expansionist policy. . . .

British post-war prosperity is to be built up gradually on the above 3-point plan. British manufacturers and financiers are at present planning means to strengthen the economic control on India by exporting investment capital and by

increased exports of manufactured goods. The future Indo-British trade is bound to be based on bartering of raw materials for consumer goods. Experts declare that this policy will hinder Indian industrial development until such time as India can politically be free to devise and execute her own economic policies" (*Hindusthan Standard*, 20-3-1944).

Satisfactory answers could not be elicited from the Government when questions were asked by Mr T. T. Krishnamachari in the Central Legislative Assembly on March 20, 1944, regarding the activities of the United Kingdom Commercial Corporation and the Imperial Chemical Industries. He said that the I. C. I. had a stranglehold on Indian industries and also referred to the statement said to have been made

by the Chairman of the I. C. I. that if a concern was as large as the I. C. I., its interests became identical with those of the nation (British) as a whole. The prospect before many Indian industries is therefore bleak indeed.

Planning is possible and desirable. But planning without power only make us conscious of our lack of power. It is like a river channel without the vivifying water.

Indian industrial concerns should have no illusion about the Government's actions in the years to come. They should put their heads together and devise methods for fighting the menace.

STANDARDISATION OF ELECTRICAL QUANTITIES—THE MODERN TREND OF ACCURACY

J. N. BHAR,

SECRETARY, RADIO RESEARCH COMMITTEE, B. S. I. R.

THE purpose of standardisation is to specify characteristics such as size, value, performance, quantity, etc. of commodities with a view to obtaining reasonably uniform performance from them. As an illustration, the case of incandescent lamps may be cited. These are nowadays standardised: this means that certain specifications are drawn up regarding such essential characteristics as the power consumption, luminous output, the cap size and so on of each type of lamp; and, a standard lamp should conform within certain specified tolerances to these specifications. Whether or not these specifications are satisfied by a particular sample is determined by actual measurements. Thus, standardisation has two distinct aspects. Firstly, the drawing up of standard specifications which should be comprehensive enough to determine the performance of a commodity unequivocally and secondly, the development of methods of measurement for checking with precision whether these specifications are complied with or not.

THE ADVANTAGES OF STANDARDISATION

Standardisation has numerous advantages, and some of the more important ones may be mentioned here for illustration.

1. Standardisation assures easy replaceability. This is perhaps the greatest and most obvious advantage from the point of view of the public. It

would certainly be extremely awkward if the newly purchased electric bulb would not go into the existing socket or the new tyre would refuse to fit on the wheel of the car.

2. It facilitates business transaction by enabling the buyer and the seller "to speak in the same language". This eliminates any risk of misunderstanding and is of mutual benefit to the consumer, the distributor, the manufacturer and the trade as a whole.

3. Standardisation warrants mass production and thus reduces costs to a considerable extent.

4. It is relatively safer for manufacturers to produce standardised goods (as opposed to goods not conforming to any standard specifications) even in slack periods, i.e., even in the absence of any immediate demand. Thus standardisation indirectly stabilises production and employment.

5. Standardisation brings out the necessity of discovering new facts in order to determine what is best and also to provide the basis for the settlement of disputable questions. In this way it acts as a powerful stimulus to research and development.

NATIONAL STANDARDISATION LABORATORIES

It is therefore easy to understand why every civilised Government enacts laws and statutes for the

purpose of standardisation. The Governments also establish standardisation laboratories, the primary function of which is the establishment of standards and testing.

As such, these laboratories are responsible for the maintenance of and improving upon standards for all types of commodities which include scientific apparatus or instruments of the highest precision used in laboratories, as well as the development of the technique of measurement for accurately testing these commodities with reference to the existing standards.

In recent years the activities of these laboratories have expanded considerably in the direction of scientific and technical research. The laboratories carry out in close co-operation with the industries such fundamental investigations as may have long range application and serve as a vital link between scientific research on the one hand and industrial development on the other, their contributions to the advancement of purely scientific knowledge being no less important. Pre-eminent among these institutions are the National Physical Laboratory, England, National Bureau of Standards, Washington, U.S.A., Physikalisches Technische Reichsanstalt, Germany and the Bureau de Poids et Mesures, France.

ACCURACY OF STANDARDISATION

In the standardisation of ordinary consumers' goods the tolerances allowed may be relatively large. But in the case of industrial machinery or of scientific instruments used in laboratory work, the permissible tolerance is much smaller. In the standardisation of instruments of precision and research the tolerance allowed is a minimum. The precision demanded for this type of work implies that standards of the highest possible accuracy should be employed for such measurements. As already mentioned, it is one of the functions of the national standardisation laboratories to prepare such standards, to maintain them with scrupulous care and to constantly improve upon them.

It is therefore but natural that with the progress of industrialisation and the development of new branches of industry—which are more often than not interrelated with one another—the standard of accuracy should be continually rising. The increase of precision has been particularly marked in the measurement of electrical quantities. For instance, while in 1923, an accuracy of ± 1 in 10^4 was considered to be exceptional in the measurement of the frequency of electric oscillations, one is not content today with measuring the same even with an accuracy as high as ± 1 in 10^7 . In fact, it is now possible to measure almost every electrical quantity with an accuracy of 1 part in a million or even more.

In the case of frequencies, as noted above, the increase in precision has been particularly spectacular and at present frequencies can be standardised with an accuracy of one or two parts in 10^7 .

The following remark of Dr H. L. Curtis, principal physicist at the Bureau of Standards of Washington, will bear quotation in this connection.

"The discussion of the methods is based on the assumption that an accuracy of one part in a million is desirable in every type of measurement. This accuracy was selected as the most precise that was demanded in any electrical measurement. However, since the preparation of this manuscript was begun, there has been a pronounced increase in the precision of measurements in several fields. Comparisons of resistance standards are now made in one part in ten million, and the same can be said concerning standard cells. Standard frequencies are now disseminated which have this accuracy. The need for this extreme accuracy is exceptional but its use indicates the trend in electrical measurements and shows that an accuracy of one part in a million should be the goal in most fields. Moreover the use of the same standard of accuracy in all fields of electrical measurements greatly facilitates comparison between them" (italics ours)."

It is to be noted that this high precision is possible only in the measurement of an electrical quantity of a particular kind in terms of an accepted standard of the same kind. For instance, a resistance may be measured, in terms of a standard resistance, to an accuracy of a few parts in a million. The absolute value of the standard, however, may not be known with the same degree of accuracy. In fact, it is generally much less, being of the order of 1 in 10^5 . The reason for this difference is not far to seek. Whereas, for example, for the comparison of a resistance with a standard resistance the simple bridge method with due precautions suffices, the technique of measuring the absolute value of the standard in terms of the fundamental mechanical units of mass, length and time involves complicated and elaborate methods which necessarily introduce relatively large uncertainty. In early measurements of the absolute value of the ohm, for instance, an accuracy greater than 1% could hardly be attained. In recent years, however, the accuracy has increased considerably and it has now been possible to establish the absolute value of the ohm with an accuracy of 1 in 10^5 .

ACCURACY OF MODERN ELECTRICAL MEASUREMENTS

It should be clearly understood that by standardisation of an electrical quantity is meant the determination of its value relative to the established standard maintained in one or other of the national laboratories. We give below a brief account of the accuracies with which the important electrical

¹ Curtis, H. L., 'Electrical Measurements', McGraw-Hill Book Co., p. vii, 1937.

quantities—resistance, capacitance, inductance and frequency—can be measured at present.

Resistance.—It is relatively easy to measure resistances of intermediate values, e.g., one ohm to one megohm, with an accuracy of one part in a million. This high accuracy can also be attained for very low resistances (down to 1/1000 ohms) if special precautions are taken². We may quote here the following remarks of Dr L. Hartshorn of the National Physical Laboratory:

"It is possible to make relative measurements of resistances—to compare the resistances of Manganin coils—with an accuracy better than 1 part per million and it will be found that recent reports of the International Committee of Weights and Measures give values of resistances to 0.1 part per million."

The National Physical Laboratory of England can standardise resistances ranging in value from 1 ohm to 10 megohms with an accuracy of a few parts in a million. It may be pointed out that resistances of the order of 10^5 ohms and more are not sufficiently stable. In practice, therefore, such resistances are seldom required to be measured with the high accuracy mentioned above.

Standard resistances for use in laboratories for precision measurements can now be purchased from reputable firms with a guaranteed accuracy of the order of a few parts in a million.

Capacitance.—Capacitances can be measured in terms of standards with an accuracy of 1 part in 10,000 $\pm$ 0.01 micromicrofarad for values ranging from a fraction of a micromicrofarad to several microfarads. Astbury of the National Physical Laboratory in describing an equipment which provides a basis for capacitance standardisation in England writes:

"The normal range of the bridge which is intended for frequencies below a few thousand cycles per second is from 1000 μ fd. to 20 μ fd. and over that range it is possible to obtain an accuracy of 2 or 3 parts in 10^5 ."

In discussing the accuracy attained in a typical measurement, Curtis says:

"Under favourable conditions the uncertainty in a single measurement of a 0.25 μ fd. air capacitor will not exceed 1 or 2 parts in a million."

Such extreme accuracy is perhaps not possible for capacitances of all values but it may be said that even the smallest practicable capacity can be measured correct to within 0.0001 μ fd, if not more. Astbury and Jones have developed a capacitance attenuator which can be applied to the measurement of very small capacitances. They say that this instru-

ment can be applied to measure capacitances as small as 0.001 μ fd correct to within 0.0001 μ fd.

Capacitances can be standardised in the National Physical Laboratory with an accuracy of 1 in 10,000 $\pm$ 0.05 μ fd. for values between 5 μ fd. and 10 μ fd. at 1000 cycles per sec. It is understood that values up to 1000 μ fd. can be measured with this accuracy but such high precision is not required in practice for these high values. Very low capacitances (e.g., the inter-electrode capacities of thermionic valves) are measured even with greater accuracy, namely correct to 0.000001 μ fd.

Some well known instrument manufacturers also market accurate bridges which are capable of measuring capacitances ranging from 0.1 μ fd. to 1000 μ fd. with an accuracy of 1 part in 1000. For measuring still smaller capacitances instruments are available in the market which claim to give values correct to 0.01 μ fd.

Inductance.—Inductances can also be measured with the same order of accuracy as capacitances at 1000 cycles per second.

In the National Physical Laboratory, inductances of values from 0.1 μ h to 1 h are standardised with an accuracy of 1 in 10,000 $\pm$ 0.05 μ h at 1000 cycles per second. It is understood that values up to 1000 henrys can be measured with this order of accuracy but that is seldom required in practice.

In describing a method of measuring self-inductances, Curtis estimates that inductances as large as 0.1 h can be measured correct to 1 part in a million at a frequency of 150 cycles per second³.

It is often necessary to measure inductances of smaller values at radio frequencies. Such measurements can be carried out in the National Physical Laboratory with an accuracy of 5 parts in 10,000 $\pm$ 0.05 μ h though higher accuracies can be attained under favourable circumstances. The smallest inductances (a fraction of a microhenry to 1 micro-henry) can be measured with still higher accuracy viz., to the nearest 0.001 μ h at radio frequencies.

Precision Inductance Bridges available in the market can give an accuracy of 1 in 1000 $\pm$ 0.1 μ h in the range 1 μ h to 100 h. The range can be extended to 1000 h but the accuracy for such high values is relatively smaller.

Frequency.—We have already mentioned that the accuracy of measuring the frequency of electric oscillations has increased tremendously in recent years. This has been largely due to the rapid development of broadcasting which demands the maintenance of the transmitter frequency constant to within the prescribed narrow limits.

At the National Physical Laboratory frequencies up to 30 mc/s can be standardised with an accuracy of 1 part in 10 million.

It is interesting to quote in this connection a remark made by Dr A. J. Gill in course of his address as Chairman of the Radio Section of the I.E.E. in 1939. In the words of Dr Gill

"Whereas the precision of measurement of $\pm$ 100 parts in 10^6 was exceptional in 1923, corresponding orders for 1928 and 1933 were $\pm$ 10 parts and $\pm$ 1 part in 10^6 respectively. To-day it is possible to measure to $\pm$ 1 part in 10^7 and in the near future it will be possible to work to $\pm$ 1 part in 10^{10} ."

In describing an equipment capable of measuring frequencies in the range 0 to 2000 mc/s. developed at the National Physical Laboratory, Mr L. Essen writes:

"Frequencies less than 30 mc/s. are compared directly with a signal obtained from oscillators controlled by the standard, and the accuracy of the measurement is limited only by that of the standard, which is $\pm$ 2 parts in 10^6 , if the primary quartz clock at the National Physical Laboratory is used."

The high accuracies in the modern measurements as described above, have been attained by taking the greatest precautions in the minutest details. For instance, in the measurement of a resistance an important source of error is the variation of temperature. All possible precautions are therefore taken to maintain every part of the standard resistance coil at the same temperature (by immersing it in an oil bath, for example, and keeping it constantly stirred) and noting the same accurately. The resistance of even a high quality standard coil changes by 20 parts in a million due to a change of 1°C . If the resistance is therefore to be measured correct to one part in a million the temperature is

² Gill, A. J., *Journ. I. E. E.*, 84, 248, 1939.

³ Essen, L., *Proc. Phys. Soc.*, 52, 616, 1940.

to be measured correct to within 1/20th of a degree centigrade. Again the sensitivity of the galvanometer must be such that it gives detectable indication for a change of resistance of the adjustable arm of one part in a million. Special attention is also paid to reduce contact resistances to a minimum. In the measurement of capacitances and inductances sufficient care is taken to minimise the stray capacitance of the leads and maintaining them constant throughout the experiment. Residual impedances of the bridge arms as well as the various connections forming the bridge circuit are taken account of in the calculations for accurate results. The alternating electromotive force impressed on the bridge is made as free from harmonics as possible. The detecting instrument is sensitive enough to indicate the smallest changes in the impedance of the adjustable arm. Further, special attention is paid to thorough shielding of the components wherever necessary in order to make the bridge balance sensibly independent of its surroundings, the position of the operator and also the type of generator and detector employed.

The author of this article, as Secretary of the Radio Research Committee of the Board of Scientific and Industrial Research, had been required to draw up a questionnaire regarding the availability or otherwise, in this country, of equipments and facilities for the standardisation of radio components and apparatus. In this connection he had to collect data regarding the present trend of accuracy of electrical measurements in modern Standardisation Laboratories. The present article is based on the information so collected and has been prepared at the request of the Chairman of the Radio Research Committee.*

* The author takes this opportunity of thanking the Chairman of the Radio Research Committee for helpful discussions and also the Director, Scientific and Industrial Research for granting permission to publish the article.

² Curtis, H. L., *Ibid.*, p. 93.

³ Hartshorn, L., *Reports on Progress in Physics*, 5, 306, 1938.

⁴ Astbury, *Report on Progress in Physics*, 6, 403, 1939.

⁵ Curtis, H. L., *Ibid.*, p. 128.

⁶ Curtis, H. L., *Ibid.*, p. 116.

CORRELATIONS BETWEEN LINGUISTIC (CULTURAL) REGIONS AND THE PHYSIOGRAPHIC DIVISIONS OF INDIA, BURMA AND CEYLON

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INTRODUCTION

THE great riddle of the world,—the Unity of Mankind,—will be solved by scientists, especially geographers, whose task it is to read the world as a whole with the lights of all other sciences focussed together; it is to discover the interaction of man and nature in its many aspects and to re-interpret it for the growth and development of human life and civilisation.

Similarly the riddle of India, the burning question of the day, *viz.*, the Unity of Communities, can be solved not by politicians but by geographers who will be called upon to re-interpret nature in the light of Indian history and to discover how the various communities, living in India, are formed and how the physical environment of rocks, soils, minerals, climate, water-supply, etc., has played its part in helping to produce different conditions and cultures in different physiographic regions.

CULTURAL REGIONS OF INDIA

Nature has made India a vast subcontinent, a conglomeration of many natural regions, many climates and many other physical stimuli for man to form convenient groups in different geographical surroundings. No wonder, then, that within its enormous area of nearly two million square miles, there live to-day almost four hundred million peoples of various castes and creeds, struggling to carve out their destiny under peculiar circumstances. And yet it is true that it is an exceedingly good and suitable geographical unit with enough geographical aloofness from the rest of Asia due to the great mountain barriers. It is capable of producing a single nation with one national goal of its own. It is true to say that from the points of view of external defence and internal management India is a natural unit. Well protected also by the seas in its coastal areas,—the country is singularly lucky to get opportunities to develop its own economic resources. Its good and perennial northern river systems have afforded very good settlements in the Indo-Gangetic plain formed by them, with their unifying influences and good neighbourliness created among those who managed to enter the region through the few but convenient mountain passes. Again, the numerous blocks of

table-lands, in the Peninsular area, of volcanic rocks and igneous massifs, forested or unforested, have given the old classes of people, such as the aborigines and the Dravidians, good protection and shelter whereby they have been able to preserve their special cultures in wholesome climates within uncongenial latitudes. Thus, in India we have so many oases of culture, so to say, in a vast desert land, but their waters require to be mingled by a process of spiritual irrigation and assimilation in order to form an All-India Civilisation. If there is any country in the world most suited to the plan of unifying mankind, it is India.¹ Such a plan from the point of view of cultural regions has been projected in the present paper, keeping culture apart from religion, provincialism and politics.

COMPOUNDING OF INDIAN CULTURES

If cultures, instead of being made mere mechanical mixtures within unnatural and uncongenial political boundaries, are fused together as a real compound, they will be turned into one All-India civilisation, lasting for long epochs of time and benefiting all the communities, apart from their religious beliefs. Thus it is possible for all of us to live in India peacefully and progressively without interfering with our religious beliefs and without the unnatural methods of unification, such as inter-marriages, conversions etc. If religion is kept apart from social life and politics, a certain amount of contact of cultures is bound to be healthy and fruitful. "The establishment of contact between peoples with different training and equipment produces new ideas and liberates initiative".² The Parsees of Gujarat, for example, have rendered good services to India in this respect, without losing their identity for the last thirteen centuries (see my "Contribution of Gothic Culture to Indian Civilisation", Rathstar New Year Number 1941). The different modes of life, food and drink, industry, architecture, etc., all depend upon the environment found in the natural regions which are homogeneous in character and which afford a definite setting for man's life.

¹ T. N. Jagdisan—"Leaves from Indian Culture", 1943 (Blackie), Bombay, pp. 208 ff.

² J. H. Hutton—Census of India, 1931, Vol. I, India, Pt. 1, p. 453.

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Again, a true region has a speciality in production, trade, art, etc., based on its environs and resources. It is, therefore, absolutely necessary that there should be a proper scientific planning of daily life and its activities in all the cultural regions, so that each unit may give its share in the evolution of the whole country. Not only this, but there are other deeper and subtler uses of culture apart from religion. "That intermediate activity of humanity which lies between its religious function and its daily life,—the activity of culture, in which the glimpse and urge of a deeper life are expressed through the symbolism of the life that we know; in literature which uses words and images drawn from daily life for the expression of a life beyond the day; in the arts which have the sounds and colours of nature as means to the disclosure of a light that never was on sea or land."³

Such cultural activities of human beings in the different physiographic regions of our country are truly Indian in character, regardless of our religion or political and dynastic authorities. They provide stylistic evidences and nothing else.

CULTURE AND LANGUAGE

But the best and most useful product of a particular region is the language of the people living in it, again irrespective of their castes or creeds. "Culture is fine but certainly not great enough till it has found means to translate itself to the language of the masses of the people and reach down to their understanding and at the same time keep itself vigilantly engaged in upholding its true nature. For, even in order that a few should be enlightened, the many must be persuaded to prefer light to darkness."⁴ It is true that words are excellent carriers of culture in whichever region it thrives and language is a rich storehouse of ideas and ideals of man. It is the proper expression of the physical conditions, the raw materials, their uses and by-products. Men really think in terms of these and clothe their thoughts in suitable words. It is equally true to say that a certain region gives rise to a certain vocabulary and a certain kind of people produces a certain kind of literature. It is, therefore, said that the mother tongue is the best for expressing our thoughts and therefore the most precious asset of a class of people. Our language has definitely close connections with our history, habits and aspirations. It is decidedly the most powerful instrument for the unification of different groups living in the same

region, as it is a symbol of unity, the tongue of the hearth and not of the market place.

The better the race, the more powerful is the medium of expression and the more dominant the language and literature produced by it. Nearly 75% of the people living in India speak the Indo-Aryan languages, which shows that the Aryans have left their most indelible mark upon them. "The most important and the lasting gift of the Aryans in India was probably their language,—a vehicle of communication and expression belonging to a family of languages which has produced its superiority in all parts of the world by superseding any other languages with which any of its members have come into effective competition."⁵

It is no wonder, then, that this Indo-European group of languages has pushed out the ancient Dravidian languages into the remotest and least fruitful parts of the Peninsula and even of Ceylon. Not only this but there has also been such a severe mingling of these cultures in some convenient parts of the country such as the fertile river valleys that it is difficult at times to define exactly the areas occupied by the peoples and to point out the stages at which a transformation is taking place in the physical characteristics and the linguistic peculiarities of the peoples.

REGIONAL LANGUAGES OF INDIA

In such an enormous land mass, in which there are so many and such varied physical environments, where there has been an influx of so many classes of people from time to time and where so many kingdoms and empires have come and gone, it is but natural that there are over 175 different languages with more than 500 dialects spoken by the people in different parts, so much so that in Marathi there is a regular proverb: "Speech changes within a distance of one-hundred miles". About 50 of these languages are spoken by less than 1,000 persons and so are unimportant. The dominant languages, which are taken by me as regional, are 23. Unfortunately for us, these linguistic regions do not coincide with the political divisions of the country. But on the other hand, there are some marked correlations between them and the natural divisions. India is most unnaturally divided to-day into some 11 provinces including the Native States, which are again subdivided, without any sound principle, into divisional circles and districts, so that in a particular presidency such as Bombay or Bengal, there are half a dozen principal languages spoken by the people, who therefore cry for the separation of more and more provinces. This is the root cause of all the troubles

³ James Cousins—"The Cultural Unity of Asia", Adyar, 1922, p. 4.

⁴ A. C. Bose—"Culture and Mass Religion", *Mod. Rev.*, Sept. 1941, p. 239.

⁵ J. H. Hutton—*op. cit.*, p. 369.

in our country. There is not one language which is the real carrier of culture to unify these unnatural political divisions, of which the boundaries are so haphazardly made. Their peculiar sizes and shapes are due to strange historical circumstances and chance treaties. Because a Bombay army had to conquer Sind on their way to the Punjab and Afghanistan, Sind remained annexed as an appendage of no great importance to the Bombay Presidency for well-nigh 100 years. Its separation in 1936 was therefore most welcome, as it is a natural division falling within the limits of the Lower Indus Basin (see my "Geography as an aid to the unification of Indian Culture", *Ind. Geog. Journal*, December 1941).

POLITICAL BOUNDARIES—THE HINDRANCE

These political provinces have made the peoples, living within their limits, think in terms of party politics and not of real culture. They have created much provincialism, unworthy of a great country. Under provincial autonomy, recently granted by the British rulers, the situation has grown worse and the essential unity of India is fast breaking up. The cleavage between several Indian provinces, e.g., Bihar and Bengal, Sind and the Punjab, Ceylon and South India, is really due to these artificial political barriers and rugged provincial boundaries. There is no inter-provincial exchange of cultures, crops, etc., on the same account.

REDRAWING OF THE MAP OF INDIA

What then, is the remedy? Since India is such a large sub-continent with different physiographic features, a re-division of it on a really cultural basis should be made with a provision for a re-union of them with convenient lines of communication and for a re-grafting of them with common natural ideals under a benign and representative Central Government. In other words, if India is to be divided for its efficient administration and maximum benefit of the people, its best divisions should be *physiographic with natural boundaries and congenial environmental influences for their growth and evolution*.

PHYSIOGRAPHIC DIVISIONS—THE BASIS

For the solution of this most vital problem of India's cultural unity, the first thing to do is to break the political barriers and to set up natural physiographic boundaries. This will stimulate the cultural process considerably, as its administration will also be more effective. For this purpose, the author has already presented his scheme of Physiographic Divisions of the country, commenting upon which he expressed the hope that they would probably coincide with its Cultural Regions:

"These regions will greatly facilitate the programme of national planning in India and will conduce to the harmony and prosperity of the various peoples without losing their individuality on account of their congenial environment and to the evolution of an all-India civilisation, which is our need today."⁶ This hope is fortunately realised to a great extent.

In the map drawn for the present paper, an attempt has been made to show the correlations between these physiographic divisions and the linguistic regions, taking the latter to be *representative of the cultural regions*, as shown above (see the Map showing the regions). A region has been considered by me to be belonging to a particular culture, if the majority of the people, say 60% living in it, speak the *dominant language* which is representative of that culture. To a certain extent, this linguistic map coincides with the ethnological one.

As India is physically divided into three main divisions, the Extra-Peninsular Mountains, the Indo-Gangetic Plain and the Peninsular area, its main cultural groups also coincide with them nearly. The Pahari group rests largely on the Himalayan mountains, with the Pushto-Lahnda (Indo-Iranian) bordering on its western flanks and the Tibeto-Chinese on its eastern flanks. This high-mountain culture is still exclusive and segregated from the valleys lower down, though it is affected by the neighbouring Tibetan and Iranian plateaus. It harbours a warlike race of itself with runaways from plains below and from the Iran plateau through the convenient passes on one side and immigrants from the Chinese river valleys on the other five main languages are spoken in these parts.

The Indo-Aryan family, in which are included no less than 11 prominent languages, has taken full possession of the Indo-Gangetic Plains and has also penetrated a large part of the Peninsula owing to its superior culture, thus occupying more than half of the country. Here and there on the plateau there are a few "islands" of aboriginals speaking prominent languages, e.g., Munda and Bhili, segregated in forested areas; but in the fertile valley with good water supply and food plains there has been a definite absorption of ancient cults and a proper intermingling of the Indo-Aryans with the inner (Madhya Desa) belt of important languages and the outer belts or others (outer belt). The sea has begun to affect the coasts decidedly in recent years. The third Dravidian group, which has been driven as far away as possible by the invading Aryans, nearly coincides with the old Archaean block including Ceylon. Poor

⁶ Ref. my "Physiographic Divisions of India, Burma and Ceylon", *SCIENCE AND CULTURE*, 7, 537 ff, 1941-42.

rocky soils, rain-shadow areas and tropical heat have imposed many vicissitudes of life on these people, yet they harbour a very high degree of old culture comparable with the Aryan civilisation which has

lisation.⁷ It must be noted that in every natural region in which a particular group of people lives, the physical environment *does not remain the same*. Scientists have proved that everything on the earth



FIG. 1. Map showing Linguistic and Physiographic Divisions.

displaced it from Hindustan proper. There are five of these Dravidian languages evolved by this race in South India and Ceylon.

PHYSICAL ENVIRONMENT CHANGES

It is a mistake to suppose that physical environment is only static and cannot create a lasting civi-

is changing,—land masses, seas, lakes, river courses, desert areas,—all are inconstant; even the axis of the earth and with it the climates are changing, as has been proved by the presence of tropical coal seams in the polar region. Nature is not static but is dynamic and man therefore gets varying oppor-

⁷ R. K. Das—"Civilisation", *Mod. Rev.*, July 1941, p. 36.

tunities to evolve himself on the globe. Man can control nature but there is a certain limit to this. Hence the only chance of unifying all the regions permanently rests with man.

PROCESS OF CULTURAL EVOLUTION

A study of the regions shown in the Map, reveals some of the following definite phases of cultural evolution:

1. *Mingling of Cultures*: This process is prominent in the Indus Valley (Sindhi and the Punjabi), the whole Ganges Valley (Hindi, Bihari, Bengali), Central India Tableland (Hindi and Rajasthani), Golconda Coastlands (Oriya, Munda and Telugu) and Malabar Coast (Malayalam and Tamil).

2. *Stabilisation of Cultures*: The process of acculturation is more or less stable though not without an overflow in the following regions:—

Rajputana Uplands (Rajasthani), Western Peninsulars (Cutch, Kathiawar and Gujarat), Western Ghats, Bombay Deccan and Konkan (Marathi), Nilgiri Hills and Bellary Section (Kanarese), Caddapah Section (Telugu), Tamil Sections (Tamil) and S. W. Westlands of Ceylon (Sinhalese).

3. *Isolation of Cultures*: Cultures, whether aboriginal or native, are completely isolated in the forested areas of the Mahanadi Basin and Chota Nagpur area (Munda), Central India Tableland (Bhili and Gond), Nilgiri Hills (Todas), Shillong Plateau, Khasi Hills (Naga) and Central Massif of Ceylon (Veddah). There is, however, a slow but steady absorption of these by the more powerful cultures which surround these isolated groups of ancient cults in the whole country, e.g., Bhili into Gujarati and Rajasthani, Munda into Hindi and Oriya, etc.

4. *Migration of Cultures*: As stated above, the Indo-Aryan languages have penetrated far into the Peninsular area as far south as possible, displacing the original languages through the efforts of successive hordes of invaders. Migration is definite in so far as the cultures are dynamic and the lines of communication possible, though not easy. Even the sea is not the limit, as India's Culture has greatly influenced Greater India, including Java and Sumatra⁸ and also China, Korea and Japan.⁹

The Dravidian languages have duly crossed the Gulf of Manar for Ceylon and the ocean further south for Australia, proving thereby that this pre-Aryan culture is not quite static, though not as powerful as its original rival.

While natural channels, such as a perennial river system, are the best means for carrying and spreading the various cultures and deserts or mountain systems the worst obstacle for them, any artificial stimulants also work wonders.

EXAMINATION OF NATURAL AND ARTIFICIAL STIMULI

The best example is that of the carriage of Marathi culture from its elevated position on the Deccan Plateau to the low coastland of Konkan by a railway route through the Western Mountain barrier, allowing an exchange of men and materials through the Bhor Ghat. A telling evidence of this is found in the inscription of the railway bridge constructed by Captain Hughes in 1830: "During the administration of Major General the Hon'ble Sir John Malcolm, G.C.B. anno domini 1830 the road on this ghat was constructed, which by rendering the transit of merchandise on wheeled carriages available and thereby facilitating an intercourse between the Deccan and the Konkan, secures to the country permanent and solid advantages." The greatest advantage of this, no doubt, was the transference and interchange of cultures, as the linguistic map of the region shows.

At the same time, any artificial barrier, such as the political boundaries of a British territory or a Native State, does not prevent cultures from mingling. A very good instance of this, is the Deccan Hyderabad State, the population of which is drawn from three or four cultural regions, viz., Marathi, Kanarese, Telugu and Hindi, the first being the most dominant. An attempt to enforce the State language, viz., Urdu, upon the populace is futile, as the avowed medium of instruction in the Osmania University is "the language of the court but not of the hearth". Nearly 90% of the people belonging to the Hyderabad State speak Marathi, while only 10% speak Urdu, which is really speaking a foreign language for the masses. "The Maharashtra of Godavari Valley (Paitha) was the pristine Maharashtra and is entitled to be in touch with the Modern Maharashtra of the Krishna (Wai). The real mother tongue is the only language through which we imbibe our culture and natural nationality."¹⁰ Indeed Marathi cannot be suppressed by Urdu in this region in this manner.

Again a reshuffling of the population of the political divisions, as was attempted by the dictators of Europe, will fail to solve the problem of the Unity of India. It is not within the bounds of practical politics in any country. Nature must be allowed to do its work as best as she can; but at the same time

man can help by offering some artificial stimuli, such as roads, railways, schools and colleges and Universities, planned on an all-India basis. The old system of pilgrimages to certain special shrines and temples, situated in different regions of India and playing a certain part in awakening the geographical consciousness of India, as a whole, should be revived. "What contributes towards making a nation is not only a common language, religion, government or culture, but the evolution of a common country, a common fatherland."¹¹

Besides, any new settlements that may be established in India should not be unnaturally based on religious denominations and according to the present provincial interests but on the common natural advantages, such as the utilisation of fertile lands, canal waters, rocks or minerals as well as on the common disadvantages such as floods, famines, diseases, etc. This co-operative spirit is still dominant in our villages, but not in the urban centres due to foreign education. It is clear that the level of culture among the vast bulk of our rural population is fairly uniform and that divergence in the religious beliefs does not affect the neighbouring feeling existing among the people. "The villages still retain some semblance of a well-balanced self-sufficing economic unity."¹²

THE QUESTION OF A *Lingua Franca*

One more question in connection with the problem of the unification of cultures remains to be solved, viz., a *lingua franca* for India. Often in recent years a claim for Hindustani has been put forward that it is and can be widely understood by people in all parts of India. A common language is, by all means, the most unifying factor in national planning. U. S. A. has done it for long. Now we have already noticed that if there is any language that is most widely diffused, it is Hindi, both eastern and western. It covers naturally a big territory belonging to Section-(2) IV A, B, C, D, (3) I C and (3) III A. It is still spreading wider, and yet there are many difficulties of making it a *lingua franca* of India at present:

1. There is the question of the script, neither Persian nor Sanskrit can be accepted; it must be Romanised, as is done in Turkey.

2. The bulk of the rural population in India speaks its own original language and Hindi is not even known to them, e.g., people living in the Dravidian regions are quite ignorant of this medium. A

¹¹ Radhakumud Mookerjee—"Nationalism in Hindu Culture", London, 1921, p. 49.

¹² Sir Jogendra Singh—"The Cultural Problem", Oxford Pamphlet No. 1, 1942, p. 54.

simplified form of Hindi or Hindustani will have to be introduced in all our primary schools in the first place.

3. Hindustani cannot boast of any great literature and as such it cannot be accepted by the educated classes as a medium of expression. It would take long for it to evolve to a high literary stage. Other Indian languages such as Bengali and even Telugu have excellent literatures of their own and would not readily yield to such a language of the market. The late Professor P. Seshadri has wisely opined "To put the matter plainly, the question of *lingua franca* should wait for an exhibition of literary superiority by Hindustani which will sweep people off their feet and recognise high realm of beauty and genius."

However, as the Map shows clearly, Hindustani has a very great future in India for a common Indian language. Its vocabulary, as enriched from both Hindu and Islamic sources, will grow and will be acceptable to both the major communities. There is no compulsion in the choice of words used by any party. It is successfully handled by the elite of both the classes of people and well accommodated in writing to Urdu or Nagri scripts for the national evolution of a common Indian vernacular.

ALL-INDIA CIVILISATION

How, then, will it be possible for us to evolve an *Indian civilisation in the near future*? Our only hope is to harmonise the different cultures under the guidance of a wise Central Government and to produce one All-India Culture by mutual understanding and good will. Not by dividing and re-dividing the country *unnaturally*, not by enforcing any *foreign* language or culture on the masses of India and not by any *unnatural* social methods, shall we be able to unite all the communities and form one united nation with common ideals and aspirations. One culture should not be allowed to suppress another. A free hand and equal opportunities should be given to all the different cultures to satisfy the *needs of all* who live in the country. In a land saturated with pantheistic ideas, these cultures are like the immortal souls dwelling in the body forming its total civilisation. To make this body last long, there should be harmony and health of the organs of which it consists. Thus if we want India again to be proud of a great civilisation in the modern world, it must be re-integrated and re-souled by the cultures of all the classes of people, on the basis of national planning. These are:

1. Revival of all forgotten or forsaken contacts by a process of cultural irrigation;

⁸ Kalidas Nag—"India and the Pacific World", Calcutta, 1941.

⁹ James Cousins—"The Cultural Unity of Asia", Adyar, 1922, p. 31 ff.

¹⁰ N. C. Kelkar—"Hyderabad Education Policy"—*The Progress of Education*, Vol. XX, Oct. 1943, pp. 72-73.

- 2. Utilisation of nature and her resources as best as we can without regard to political boundaries or communal interests ;
- 3. Collection of moral and spiritual forces inherent in the different races, without disturbing their religious susceptibilities ;
- 4. Development of a common language like Hindustani, by mutual co-operation, with a common script and by a national system of education from the primary stage and organisation of Literary Leagues on a linguistic basis throughout the country ; and
- 5. Appeal to the Inter-University Board to co-ordinate the scientific work done in all Indian Universities, particularly geographical researches. The most urgent work to be done is that of preparing the *Geography of India based upon the regional geographies of the 23 physiographic-cum-cultural regions* shown in the Map.

CONCLUSION

If the linguistic map of the country is superposed on the physiographic map, we notice that there are some marked coincidences between the cultural regions represented by the vernaculars and the physiographic divisions previously drawn and that, except in a few regions, cultures have constantly moved inside and outside their boundaries, *though they were born of the geographical environment found within the limits of the divisions.* In some cases they have even migrated to distant parts along certain natural channels, such as river valleys or seas. There are, no doubt, certain outer bands or fringes of the regions which cannot be defined from the point of view of a dominant language or culture.

TABLE SHOWING CORRELATIONS BETWEEN LINGUISTIC (CULTURAL) REGIONS AND PHYSIOGRAPHIC DIVISIONS OF INDIA, BURMA AND CEYLON
(Ref. :—"SCIENCE AND CULTURE", 7, 538-543, 1940-'41)

Linguistic (Cultural) Region	Physiographic Divisions covered.	Brief Notes on Characteristics, Environmental influences, Cultural traits, etc.
1. EXTRA PENINSULAR MOUNTAINS.		
1. Sindhi ..	(1) I A Kirthar Mountains .. (1) I B Kohistan Section .. (2) I A Indus Western Valley (2) I B Indus Eastern Valley (1) I C Indus Deltaic Area (2) III A Pat Section (2) III B Thar Section	One of the best regions for a mingling of cultures. Entry into the Valley by some 16 different peoples by land and sea. Partial desert land made habitable by man with the help of a perennial river. The human factor active in annihilating Nature's calamities e.g., Ancient irrigation system. Cradle of the Mohenjo Daro or Indus Valley Civilisation (Dravidian?). Destruction of the civilisation by natural catastrophies, such as floods, river changes, and by Aryan and other invasions from Iran plateau etc. Language mixture of Arabic and Sanskrit. Home of Sufism. (For further details, see my "Geography and Culture," Karachi 1942).

They can be called neutral bands or no-man's lands. The most prominent region, however, viz. that of Hindi, is most widely spread in India, having absorbed many foreign elements. This is the heart of Indian national culture, already an inseparable compound of Hindu and Muslim cultures ; it has been beating forcefully and, if nature is not unduly disturbed here but helped by man, the life blood from the region will flow fast and far and mingle at no very distant date, into an Indian National Civilisation, provided we put into action a first-class nation building programme at all the Indian Universities.

Not only this, but such a unified Indian Civilisation is likely to influence the outer world as well. "The genius of the Indian nation is a vast presence which transcends the actual physical or geographical embodiment and in its ideal possibilities can indeed embrace the whole world of man. Thus the evolution of India as the mother-country of the Indians has but followed the lines of the cosmic process revealing the Universe in the Particular and the Particular in the Universe. Here is no insular culture lacking in universality, nor a dismembered one which is homeless and therefore infructuous and sterile."

But even if we do not aspire so high, we can but hope for complete fruition at home. And so the Indian nation can be likened to the age-old Banyan tree, whose massive trunk has taken deep roots into the rich soil of the mother earth and whose larger branches and smaller twigs are the different communities and creeds, still clinging in a congenial atmosphere, to their kith and kin, and from whose sides again descend the hanging roots all anxious to meet the mother, who gave them birth, once more. May it flourish for ever long !

¹³ Radhakumud Mookerjee—"Nationalism in Hindu Culture", *Op. cit.*, pp. 98-99.

LINGUISTIC (CULTURAL) REGIONS AND PHYSIOGRAPHIC DIVISIONS—Contd.

Linguistic (Cultural) Region	Physiographic Divisions covered	Brief Notes on Characteristics, Environmental influences, Cultural traits, etc.
2. Pashto ..	(1) III A N. W. Dry Lands (2) II B Punjab Plain (1) IV A Potwar Section	Influenced by Afghan borderlands and fringing the western parts of the Punjabi belt. Superseding also the language of Swat and higher reaches of the Indus as a <i>lingua franca</i> here. Gandhara sculptural relics and also Greek relics found.
3. Pahari ..	(1) II A North Himalayas (1) II B South Himalayas (1) III C Lesser Himalayas (1) IV B Sub-Himalayas	Mountainous region from Chamba to Nepal, harbouring a special culture, as an excellent example of isolation in the highlands but covering vast areas. Culture derived from Iranian on the one hand and Indian such as Rajput from Rajasthani in the low lands, a sort of transplantation. Specialised in the Sub-Sections e.g., Naipali, that is New Pali. Warlike peoples with martial traits.
4. Kashmiri ..	(1) III B Dun Section	Specialised Pahari tongue in one Dun and isolated in the Upper Jhelum Valley. Special Dun culture, developed on independent lines by a colony of the Punjabis. Bulk of the population Moslem but ancient Hindu (Gandharva) relics are found here. Excellent climate and beautiful nature scenery, inspiring the people to produce various arts and crafts from olden times.
5. Mon-Khmer	(1) V A Shillong Plateau	An instance of Indo-Chinese influences on the eastern frontier of India, like Pushto on the western borderland. An island among Tibeto-Burman languages but correlated to Burmese. Recognised as an Indian vernacular by the Calcutta University.
6. Burmese ..	(1) V A Shillong Plateau (1) V B The Burmese Yomas (1) V C Irrawadi Valley (1) V D Shan Plateau (1) V E Irrawadi Valley (1) V F Kaladan Valley (1) V G Salween Basin, Burma	A singular instance of assimilation of Tibeto-Burmese Culture on such a vast scale. Has spread to the North-South valleys of Burma's great rivers. People of Mongholian origin, resourceful and hard-working. Has migrated to Andaman (Andamanese) and Nicobar (Nicobarese) islands in the south.
2. INDO-GANGETIC PLAIN.		
7. Lhanda ..	(1) III B Dun Section (1) IV A Potwar Section (2) II B Punjab Proper	A casteless region. Infiltration of Persian elements into western Punjab. 74°E Longitude is considered to be the dividing line. Hilly influences give rise to Sub-Sections, e.g. Lhanda Shina and Lhanda Kashmiri in convenient plains. Buddhist, Persian and Hellenistic influences.
8. Punjabi ..	(1) III B Dun Section (2) II A Doab Section (2) IV A Indo-Gangetic Watershed	Intermediate between Lhanda and Hindi. Several tribes are absorbed here. Has produced a virile and warlike race. No caste restrictions due to Mahomedan predominance. Special caste of Sikhs evolved, a mixture of Islamic and Hindu cultures. Good soil and crops in all the Doabs. Good nourishment. Mughal art and architecture prominent with Indo-Saracenic influence.
9. Hindi ..	(2) IV B Jumna-Ganges Doab (2) IV C Piedmont Zone (2) IV D Trans-Jumna Tract (3) I C S.E. Rajputana Section (3) II A Central India Tableland (3) III A Mahanadi Basin (3) III B Godavari Basin	Most important of all Indian cultural regions. An intermixture of Indo-Aryans and Dravidians. Most widely spoken language in India, with the Upper Ganges valley as its home. Mingling of cultures exceptional. Cradle also of Buddhism and Gupta arts. Even the Peninsular area and Central India Tableland penetrated through the river channels of the Chambal, the Betwa etc. Tribal cults absorbed. Influenced by Arab or Persian Mahomedans in the west (western Hindi or Urdu developed) and by Aryan Hindus in the south east (eastern Hindi developed). Even architecture is influenced by Moslem and Hindu art. Indo-Saracenic culture. Meeting Marathi further south and giving rise to a number of dialects. People have a traditional knowledge of agriculture and have a high sense of duty and hospitality as the culture is cosmopolitan and dynamic. Hindustani offshoot a promising <i>lingua franca</i> of India.
10. Bihari ..	(2) V A Bhangar Section (2) V B Khadar Section (2) III A Mahanadi Basin	Belongs to the middle Ganges Basin chiefly. Intermediate between Hindi and Bengali. Covers also Oudh, Baghelkhand, Chatisgarh etc. Offshoot Ardhamagadhi, the language of Indian epic poetry. Centre of great religious movements. Sacred Ganga (Ganges) cult and land of many saints. Stronger and more hard-working race than those of the Lower Ganges Basin. Valuable coal and iron mines find suitable labourers.

LINGUISTIC (CULTURAL) REGIONS AND PHYSIOGRAPHIC DIVISIONS—Contd.

Linguistic (Cultural) Region	Physiographic Divisions covered	Brief Notes on Characteristics, Environmental influences, Cultural traits, etc.
11. Bengali ..	(2) VI B Old Ganges Delta (2) VI C New Ganges Delta (1) V B The Yomas (1) V F Kuladam Valley	Another excellent delta culture. A blending of Dravidian, Mongoloid and Aryan elements. Resembles Sindhi on the other side of the country. Excellent tongue and literature developed. Situated in the most thickly populated part of India and therefore there are the greatest numbers of speakers. Early English influence at the time of the East India Company. Missionary work done. Even the Bengali language is affected by them, though the literary form is Sanskritised. Special types developed in Sub-Sections of Burmese Yomas and the Arakan Coastland. Delta people with little energy in an enervating climate.
12. Assamese ..	(2) VI A Lower Brahmaputra Valley	Belt between Assam on one side and the Himalayan slopes on the other. Good seclusion in the narrow Lower Brahmaputra valley parts and therefore command a special language and literature. Naturally free from Sanskrit traits, though related to Bengali, due to its aloofness.
13. Rajasthani	(3) I A N.W. Rajputana (3) I B Marwar Peneplain (3) II A C. I. Tableland	Powerful influence in the dry uplands. Flow of the midland races passing through Rajputana belt to the sea in Gujarat. Even Buddhist contact, e.g., Sanchi. Many tribes and their dialects meet here. Jaina Brahmanical art developed. Safe from the dread of the attacks from rulers in the plains in the north. Castes (tribal) superiority preserved in some States. Some migration to the northern mountains.
14. Gujarati ..	(3) IX D Western Peneplain	Showing the cultural unity of Gujarat proper, Kathiawar and Cutch. Cutchi dialect is affected by Sindhi while Marwari just enters Gujarat in the north. Can be styled the most westerly branch of the Indo-Aryan tongues, reaching the sea board for further contacts by sea. Jain influences. Contains many other relics of old. A soft people belonging to soft soil. Have often suffered due to famines. Good traders due to sea ports, through which also Zoroastrian culture has entered.
15. Marathi ..	(3) II A Central India Tableland (3) II B Western Ghats (3) II C Bombay Deccan (3) II E Konkan Coastland (3) III B Godavari Basin	Very dominant plateau culture for at least 1000 years on Deccan Trap region. Remarkable coincidence of Trap rock and Marathi. Rich regur (black cotton) soil and cultivable valleys, though parts suffer from rainshadow and famines. Underground passage and hill fortresses possible due to the peculiar structure and denudation of the rock. Has affected the Konkan coast due to artificial line of communication and penetrated Berar through river valleys and the Nizam State and merges into Oriya. Has contacted Gujarati (another denuded Trap soil culture) and developed Khandeshii. Also absorbed tribal languages e.g., Gondi and pushed back Kanarese in the south. Unaffected by Islamic culture. Excellent literature of a spiritual character. Warlike as well as saintly character of the people, fond of music and other arts. Wonderful caves cut in the dykes etc. Scytho-Dravidian traits in Maratha Brahmans.
16. Oriya ..	(3) III C Eastern Ghats (3) III D Golconda Coastland	Isolated Munda-type, unchanged for centuries. Good literature. People live a life of struggle against natural handicaps.
17. Munda ..	(3) III A Mahanadi Basin	Forests of Chota Nagpur, its principal home. Relations with further Indian cults, such as Nicobar. Small "islands" persisting still in other parts of India. Probably aboriginal.
18. Bhili ..	(3) II A C. I. Tableland	An "island" of aboriginal culture, secluded in forest areas of the Sathuras.
3. THE PENINSULAR AREA.		
19. Telegu ..	(3) III B Golconda Coastland (3) III C Eastern Ghats (3) IV A Cuddapah Section (3) IV G Coromandal Coastland	Offshoot of Dravidian Culture still persisting in the north of Madras Presidency and the Andhras. Special character evolved locally. Poor people living on scanty rice food, meat and fish. Little cultivation due to poor rainfall and Archaean rock soil.

LINGUISTIC (CULTURAL) REGIONS AND PHYSIOGRAPHIC DIVISIONS—Contd.

Linguistic (Cultural) Region	Physiographic Divisions covered	Brief Notes on Characteristics, Environmental influences, Cultural traits, etc.
20. Tamil ..	(3) IV D Tamil Section (3) IV E Eastern Slopes (3) IV G Coromandal Coastland (3) V C N-N.E. Drylands (Ceylon)	Has preserved what is best in the Dravidians, since it is driven to the furthest south. A most highly developed language with extensive literature. Frugal habits of the people. Influence of double monsoon. Northern parts of Ceylon inhabited by Tamil folk living a hard life in drier areas, proving that from the point of view of culture as of rocks, Ceylon is an integral part of India. Conflict with the Sinhalese, still further south in the island.
21. Kanarese ..	(3) II C Bombay Deccan (3) IV B Bellary Section (3) IV C Nilgiri Hills	Chiefly confined to the Mysore plateau and the rainshadow parts of the Western Ghats. Land rich in minerals of the Dharwar rocks, excellent waterfalls for producing electric energy. An advanced Native State. Relics of ancient Hindu art. Very old literature preserved.
22. Malayalam	(3) IV C Nilgiri Hills (3) IV D Tamil Section (3) IV F Malabar Coastlands	A modern dialect of Tamil but confined to the East (Malabar) coast. Difference due to foreign influences by sea and through the Palghat Gap. Hence half a dozen dialects within a couple of hundred miles. Cochin murals a prominent art.
23. Sinhalese ..	(3) V A Central Massif (Ceylon) (3) V B S.W. Wet Lowlands (Ceylon)	The only other language found in Ceylon and yet belonging to the Indo-Aryan group. Furthestmost offshoot of the culture of the culture of the ancient peoples with Veddahs living as a separate colony of aboriginals within the Binthana forest belt. Influence of Buddhism so far. Mingling has taken place between the Tamils and Sinhalese in the island. An Aryan migration from the Ganges Basin to Ceylon, with Sanskrit and Pali culture, pressed down by the old Tamil folk from the northern drier parts and now occupying nearly three-fourths (S.W.) of the island, with gems and graphite mines, rubber and tea plantations and paddy fields. A thin rural population of Buddhists, rich due to the riches of the island and high-class but more luxurious and backward than the hard pressed Tamils in the north. Rejuvenation of the rivers of Ceylon must keep the people and their culture ever alive.

SUMMARY OF THE TABLE.

Major Physiographic Division	Provinces and Sections covered	Number of Cultural Regions affected
(1) The Extra Peninsular Mountains	21	6
(2) The Indo-Gangetic Plain	22	12
(3) The Peninsular Area	27	5
Total (3)	Total 70	Total 23

ASTRONOMICAL WORKS OF MAHARAJA SAWAI JAI SINGHJI

B. N. TEMANI

ACCORDING to Garrett, of the five observatories constructed by Maharaja Sawai Jai Singh—the one at Delhi was built first of all in 1724 A.D., the largest and the most perfect was built at Jaipur in 1734, while those at Benaras, Ujjain and Muttra were built afterwards.

On the refusal of Farrukhsiyar to accept his help, Jai Singhji appears to have returned to his capital and to have enjoyed three years of uninterrupted quiet. He took no part in the subsequent struggles for the throne of Delhi which terminated in 1721 with the destruction of Syeds and the accession of Muhammad Shah. During this period and afterwards Jai Singhji devoted himself to his favourite pursuits, astronomy and history, and built his observatories at Delhi, Jaipur, Ujjain, Benaras and Muttra, but very early in Mohammad Shah's reign he was appointed Governor of the provinces of Agra and Malwa. So highly was his learning and science esteemed, that Muhammad Shah especially appointed him to reform the Calendar and to make observations to correct the astronomical tables in use. After seven years' work, Jai Singhji brought out, and in 1723 published, his tables, the "Zeech Muhammad Shahi" named after the Emperor Muhammad Shah. One manuscript copy of it is in Pothikhana, Jaipur, and a complete Persian manuscript copy is at the British Museum.

Jai Singhji appointed Samrat Jagannath—a Maratha Brahmin, who was one of his most eminent astronomers—as his Guru. The book 'Samrat Siddhanta' was written by him. He also had a good knowledge of Arabic and could translate from, and into Arabic. He translated Claudius Ptolemy's 'syntaxis' (astronomical treatise) from its Arabic version known as 'Almajista' into Sanskrit. This book is called 'Siddhanta Sara Kaustubh', and is available in Pothikhana. He also translated the whole of Euclid's 'Elements of Geometry' from Arabic into Sanskrit. It was named 'Rekha Ganit'. It is also available in Pothikhana.

Samrat Jagannath was the son of Ganesh and grandson of Vithal. He got village Manga-Bhata for Rs. 2,000/- per annum as Dakshina on account of his teaching Gayatri Mantra to Maharaja Sawai Jai Singhji on the occasion of the latter's Yagyopavit (holy thread) ceremony held on Chait Bud 3rd Samvat, 1771. He also began to teach the Vedas to Maharaja Sawai Jai Singhji from Jeth Bud 13th Samvat, 1772, Sal-Samvat, 1771, on the completion of which he was granted village Sri Kishanpura for

Rs. 600/- per annum. The custom of teaching Gayatri Mantra by the descendants of Samarat Jagannath to the Rulers of Jaipur is observed up to the present day.

The present descendants of Samrat Jagannath hold seven villages yielding an income of 8 to 10 thousand rupees per annum.

Pandit Keval Ram was also one of the prominent astrologers in the service of Maharaja Sawai Jai Singhji. He was an Uddambri Gujrati Brahmin and belonged to Modhasa (in Gujarat) whence he came to Jaipur. Maharaja Sawai Jai Singhji was pleased to confer on him the title of 'Jyotish Rai' which up to the present day is enjoyed by his descendants in Jaipur. He wrote the following seven books:—

1. *Jai Vinod*
2. *Vibhag Sarni*—Sanskrit translation of Logarithmic tables of Napier.
3. *Mithya Jiwachhaya Sarni*—on the basis of a bench work.
4. *Drig Paksh Sarni* } on the basis of de la Hire's tables.
5. *Drig Paksh* }
6. *Tara Sarni*—on the basis of Ulugh Beg's book with necessary modifications.
7. *Brahmpaksh Niras*.

All these books are in Sanskrit manuscript and are very helpful in the preparation of Panchanga and in the calculation of the position of Grahas (planets), Tithis (lunar days), Nakshtras (position of stars).

The present descendant Pandit Nandlal Jyotish Rai is designated as Darogha, Jyotish Yantralaya. He holds a land grant of Rs. 1,500/- per annum. 10 Jyotishies (astronomers and astrologers) work under him; all of them have land grants.

Not content with observations in India and the information contained in books, Sawai Jai Singhji sent out several skilful observers to other countries. Thus Muhammad Sharif, a Mohammadan, was sent to some places in the Southern latitude, and Muhammad Mehdi to the further islands. In 1728 Father Figueredo, a Portuguese Jesuit, was sent to Portugal. At Maharaja Jai Singhji's request two priests set out from Chandranagar in 1734; one of them was Father Boudier and the other Father Andre Strobel. The maps and globes of the Feringhes (Europeans) were obtained from Surat.

The names of the early astronomers and mathematicians referred to in works attributed to Maharaja Sawai Jai Singhji are:—

Euclid	...	...	Circa	B.C.	290
Hipparchus (Abarkhas)	...	...	"	"	130
Ptolemy (Vilamayus)	...	...	"	A.D.	150
'Abd-ul-Rahman b. 'Omar abul-Husain al-sufi	...	...	Died	"	986
Nasir al-Din al Tusi	...	...	Born	"	1201
'Ali b. Muhammad al-Sayyid al-Sharif	—	—	"	"	1339-1414

Jamshid b. Mes 'ud Jijat al-Din al-Kashi	...	...	Circa	"	1440
Ulugh Beg	...	...	Died	"	1449
Maulana Chand	...	...	Circa	"	1550

Of those who came actually into personal contact with Sawai Jai Singhji names of the following deserve mention:—

Muhammad Sharif, Muhammad Mahdi, Padre Manuel Figueredo, Father Andre Strobel, and his companion, Father Claude Boudier, and Don Pedro de Sylva.

Don Pedro de Sylva, who, according to Hunter, was a physician and an astronomer, resided at Jaipur with Jai Singhji. De Sylva died about A.D. 1792. His descendants still hold one village in Tankha and one in Inam.

Sawai Jai Singhji possessed at least some of the works of Ptolemy, Ulugh Beg, P. de la Hire, J. Flamsteed, and also certain European astronomical tables and mathematical text-books. He had, as mentioned already, Ptolemy's 'Almagest' translated into Sanskrit, and a text on the astrolabe compiled, and he brought up to date Ulugh Beg's celebrated catalogue of stars. The instruments themselves are evolved from the types used by the Muslims, and Jai Singhji's inspiration was avowedly of Muslim origin.

Jai Singhji copied the instruments of the observatory at Samarkand. His masonry instruments were designed after the notions taught by the Muslim astronomers and had absolutely nothing in common with those described in Hindu works.

Jai Singhji himself refers to La Hire's table and to other European tables and in the palace library at Jaipur a copy of Flamsteed's great work is still

to be found. La Hire was a French scholar of repute who lived from 1640 to 1718 A.D. John Flamsteed, the first Astronomer Royal, lived from 1646 to 1720 A.D.

The old fort at Muttra known as Kans-ka-Kila was rebuilt by Raja Man Singhji of Jaipur. On the top of this fort Jai Singhji built the last of his observatories. The whole of it has now disappeared.

The work on Hindu ritual, viz., 'Jaisingh Kalpa-drum', giving detailed descriptions of fasts, penances and devotions, to be observed on certain days, with the appropriate hymns to be recited was written by Pundarik Ratnakar, one of Jai Singhji's Gurus. It was finished in 1714.

Pundarik Ratnakar belonged to a Maharashtra family of Shandilya Gotra and was the son of Deo Bhatta, a resident of Benaras. The family of Bhatta Ratnakar came to Amber in Samvat 1764 (1707 A.D.). In Samvat 1765, Bhatta Ratnakar was granted Rs. 4,000/- for Vershasan. The sum was enhanced to Rs. 8,000/- and the title of 'Brahma Murti Vajpaiji' was conferred on him in Samvat 1767. In Samvat 1768, he was granted another title of 'Brahma Murti Pundrikji' and the Vershasan grant was further enhanced to Rs. 12,000/-. This grant was still further enhanced to Rs. 25,000/- and Rs. 35,000/- in Samvats 1770 and 1771 respectively.

In Amber there is a tank named Ratna Sarowar after his name. In the centre of this tank, there is a tomb where his 'foot print' (Charan Chinah) still exists.

The present descendants of Pundarik Ratnakar in Jaipur are Padmakar and Umakar. They enjoy a land grant of Rs. 3,500/- and Rs. 2,500/- respectively.

SIR JADUNATH SARKAR ON JAI SINGHJI'S WORKS ON ASTRONOMY*

WHY JAI SINGH BUILT HIS OBSERVATORIES

COL. JAMES TODD, not a very friendly critic of Sawai Jai Singh, has admitted that "he erected monuments which irradiate this dark period of the history of India." And, indeed, no history of Jai Singh would be complete without an account of his astronomical studies and observatories, which are the greatest contribution of the House of Jaipur to the enrichment of India's cultural life. "Jaipur became the refuge and sanctuary of Hindu learning, and it was from thence that Colonel Polier procured in 1779, the first complete copy of the Vedas, which he afterwards presented to the British Museum."

* Extracts from the 'Jaipur History' by Sir Jadunath Sarkar, kindly sent to us by Mr G. N. Bansal.

(An English Officer, writing in the *Calcutta Govt. Gazette*, 1820).

Five of the astronomical observatories built at Delhi, Jaipur, Ujjain, Muttra and Benares by him still survive. Their genesis is thus given in his own words in the preface to his Table of Stars named *Zij-i-Muhammad Shahi*, in which he speaks of himself in the third person:—

"This admiring spectator of the theatre of infinite wisdom . . . was, from the first dawning of reason in his mind and during his progress towards maturity, entirely devoted to the study of mathematical science, . . . and by the aid of the Supreme Artificer he obtained a thorough knowledge of its principles and rules. He found that the calculation of the places of the stars, as obtained from the tables in common use (Sanskrit, Arabic and European) in very many cases give them widely different positions from those determined by observation especially in the appearance of the new moons. Seeing that very important affairs,

both regarding religion and the administration of the Empire, depend upon these, . . . he represented the matter to the Emperor Muhammad Shah, who was pleased to reply :—

"Since you, who are learned in the mysteries of science, have a perfect knowledge of this matter, having assembled the astronomers and geometricians of the faith of Islam, and the Brahmans and Pandits and the astronomers of Europe, and having prepared all the apparatus of an observatory—do you so labour for the ascertaining of the point in question, that the disagreement between the calculated times of those phenomena and the times which they are observed to happen, may be rectified."

"So he (Jai Singh) constructed at Delhi several instruments for astronomical observation. But finding that brass instruments did not come up to the ideas which he had formed of accuracy, because of the smallness of their size, the want of division into minutes, the shaking and wearing of their axes, the shifting of the planes of the instruments etc. . . . he constructed in Delhi instruments of his own invention, of stone and lime of perfect stability . . . such as Jai Prakash, Ram Yantra and Samrat Yantra. . . . And, in order to verify the truth of these observations, he constructed instruments of the same kind in Sawai Jaipur, Muttra, Benares and Ujjain, . . . so that every person who is devoted to these studies, whenever he wished to ascertain the place of a star—might observe the phenomena."

"But seeing that in many cases it is necessary to determine past or future phenomena, and also that—the opportunity of access to an Observatory may be wanting—he deemed it necessary that a table be constructed by means of which the daily places of the stars being calculated every year and disposed in a calendar, may always be in readiness."

"After having constructed these instruments, the places of the stars were daily observed. After seven years had been spent in this employment, information was received that observatories had been constructed in Europe and that the learned of that country were employed in the prosecution of this important work. . . . For this reason, having sent to that country several skilful persons along with Padre Manuel (de Figueiredo) he procured the new tables (of stars) which had been published there thirty years before under the name of Pere de la Hire (*Tabulae Astronomicae*, completed in 1702) as well as the European tables anterior to these (especially Flamsteed's *Historia Coelestis Britannica*, 1712-1725.) . . . On comparing these tables with actual observations, it appeared that there was an error of half a degree in the former in assigning the moon's place, and there were also errors in the other planets, although not so great,—especially in the times of the eclipses. . . . Hence he concluded that, since in Europe astronomical instruments have not been constructed of such a size and so large diameters, the motions which have been observed with them may have deviated a little from the truth."

Hence, on the basis of his own long researches, he constructed and published his own astronomical tables, named after his suzerain as *Zij-i-Muhammad Shahi*, in 1733.

JAI SINGH GATHERS SCIENTIFIC KNOWLEDGE FROM EUROPEANS AND ALL THE WORLD

With no less catholicity of mind than wisdom, Sawai Jai Singh called to his aid the best scholars of the Hindu, Muslim and European worlds. He took his first lessons in Hindu astronomy from Jagannath Pandit, who later translated at his

command the ancient Greek scientist Ptolemy's '*Syntaxis*' from its Arabic version '*Almagest*', into Sanskrit under the name of '*Sidhanta Samrat*' (also known as '*Siddhanta Sar Kaustubha*').

"Jai Singh collected and studied all the available astronomical works." (G. R. Kaye). For the purpose of acquiring manuscripts of the great mediaeval Muslim astronomers and apparatus, and also for making observations, he deputed Muhammad Sharif and Muhammad Mahdi abroad. "Several European works were translated into Sanskrit under his orders, particularly Euclid's '*Elements*', with a treatise on plane and spherical trigonometry, and on the construction and use of logarithms, . . . and also a treatise on conic sections. . . . Maps and globes of the Feringhis were obtained from Surat." (Kaye).

But he would not be content unless he could quench his thirst for knowledge at the very fountain-head of European science. For this purpose he sent a request to the King of Portugal, through the Viceroy of Goa, for a learned European scientist and also a physician to be sent to Jaipur, whose expenses he would pay. The scholar chosen was Padre Manuel de Figueiredo, the Superior of the "Mogor Mission" at Agra. He left Goa about 6th November, 1730 for Jaipur, whence he was afterwards sent to Europe with money for buying books and instruments. The doctor who accompanied him to Jaipur was Pedro da Silva Leitao, who settled at the Kachhwa capital and whose son or grandson, Xavier da Silva, known as "Hakim Shewair", was an influential courtier in 1799. But in the twentieth century his descendants have sunk very low owing to ignorance and economic decay.

Next came, by the Rajah's invitation, two French Jesuits, Claude Boudier and another, who left Chandernagore on 6th January 1734 and reached Jaipur after taking astronomical observations on the way, at Benares, Muttra and Delhi. Andre Strobel, a Bavarian Jesuit, arrived by ship at Goa on 30th September 1737, reached Jaipur on 4th March 1740, and after passing some years at Jaipur, went away to mission work at Narwar in 1749. (He died at Agra in 1758). Another Bavarian Jesuit, Antoine Gabelsperger, accompanied him to Jaipur but died next year. Jai Singh's observatories thus had the benefit of the latest state of scientific knowledge in Europe.

JAI SINGH'S CHIEF ASTRONOMICAL INSTRUMENTS

Technical details and a precise appraisalment of the scientific value of each instrument* in these

* For an account of Jai Singh's astronomical instruments, the readers are referred to "Maharaja Sawai Jai Singh II (1686-1743)"—by Prof. M. F. Soonawalla, published in SCIENCE AND CULTURE, April, 1944.—Ed. Sc. & Cul.

observatories would be out of place in a history like this. For them the reader is referred to A. H. Garrett and C. Guleri's *The Jaipur Observatory and its Builder* (1902), G. R. Kaye's *memoir* in Vol. 40 of the new Imperial series of the Archaeological Survey of India, and the last-named writer's short but useful *Guide to the Old Observatories at Delhi, Jaipur etc.* (1920). These works supersede earlier descriptions like those of Tieffenthaler (c. 1745) and Dr W. Hunter (1793).

The final appreciation of his scientific achievement can be best given in the words of a specialist like G. R. Kaye.

"The Hindus had no instrument of precision before Jai Singh's time; neither were they interested in making prac-

tical observations of the heavenly bodies; their rules and the elements given in their approved works sufficed them. . . . But the work of Jai Singh was exactly of that nature which differentiates between the two schools,—Hindu and Muslim astronomy. What the Muslim astronomers had, and what the Hindus lacked, attracted Jai Singh.

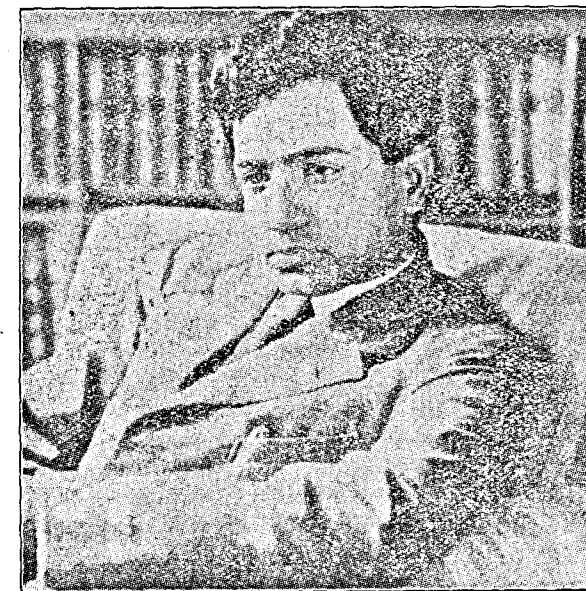
"That Jai Singh made no new astronomical discoveries is hardly a fair criterion of the value of his work; for, indeed, a great deal of the most valuable astronomical work is not concerned with new discoveries. His avowed object was the rectification of the calendar, the prediction of eclipses, and so on. Considering the state of the country in which Jai Singh lived, the political anarchy of his time, the ignorance of his contemporaries, and the difficulties in the way of transmission of knowledge, his scheme of astronomical work was a notable one, and his observatories still form noble monuments of a remarkable personality."

PROFESSOR S. CHANDRASEKHAR, F.R.S.

DR. S. CHANDRASEKHAR who has earned international reputation as one of the foremost astrophysicists of the present time had his early training in the Madras Presidency College. Even as a student at the early age of nineteen he completed a piece of original work on "Compton Scattering and the New Statistics", which was published in the *Proceedings of the Royal Society*, London, in 1929. This work is an extension of a paper by Dirac and deals with Compton Scattering by electrons in the atoms. It is clear that electrons having different momenta will produce different Compton shifts and the intensity of any particular shift will depend on the number of electrons in that state. It is well known that electrons in the atom obey Fermi-statistics. Chandrasekhar, by taking the Fermi-distribution law for electrons showed that the distribution of the intensity about the primary frequency for the scattered radiation was parabolic, whereas an exponential distribution of the intensity was obtained by Dirac by assuming Maxwell-Boltzmann Statistics for the electrons. Compton Scattering is usually calculated for stationary electrons. Chandrasekhar's work may be said to be an extension of the theory of Compton Scattering for the electrons in motion. The parabolic distribution law as found by Chandrasekhar appears to be confirmed by observations. This work clearly showed the zeal and enthusiasm of young Chandrasekhar and his keen interest in the most recent developments in physics, for it was only in 1929 that Fermi-statistics came into existence and its great practical importance was realised by Pauli and Sommerfeld in 1928. Unlike other brilliant students Chandrasekhar never sat for any of the competitive service examinations, but a Government Scholarship enabled him to proceed to Cambridge after his graduation from the Madras University.

The stay at Cambridge gave him great

opportunities to study the application of the new statistics to problems of Astrophysics. He was initiated in this fascinating domain of science



Prof. S. Chandrasekhar

by the work of Prof. Milne who was then trying to establish a new stellar model in which a star was conceived to possess a dense core containing Fermi electrons, and a gaseous envelope surrounding it. Following Milne, Chandrasekhar worked out a very exhaustive theory of white dwarfs, a type of stars which remained a puzzle to the astrophysicists for a long time. These stars have normal masses of the order of the sun but relatively very small radii; they are underluminous, i.e., relatively very much less bright, and are characterised by

abnormally high densities—one cubic inch of the stellar matter weighing about a ton. The electrons in such stars according to the new theory should obey the Fermi-distribution law, and are called *degenerate* in technical language. Eddington showed some years earlier that there is a definite relation between masses of stars and their luminosities, *i.e.*, the total amount of radiation they emit in one second, which is known to astro-physicists as the Mass-Luminosity relation. Chandrasekhar found that there is a corresponding relation between the masses and the radii in case of white dwarf stars. The determination of stellar masses is rather difficult, and a direct determination is dependent on some fortuitous circumstances. But Eddington's Mass-Luminosity relation for gaseous stars enables us to determine in a rough way their masses when their luminosities can be measured. Chandrasekhar's Mass-Radius relation serves the same purpose as regards determination of masses of white dwarfs from their radii.

His investigations led him to the further striking result that the career of a star depends on its mass, and there is a critical mass value which sharply divides the paths of evolution of stars. If the mass of a star be less than 5.75 times the mass of the sun divided by the square of the mean molecular weight of the stellar material, the degeneracy of the electron gas in the interior of the star will always begin at a certain stage of its evolution; whereas for stars of larger masses the electrons will always remain in the state of perfect gas. A star of smaller mass than this critical one will therefore, in course of evolution when the source of its energy is exhausted, end its career as a white dwarf. For stars of larger masses the situation is quite different. Such a star will behave as a perfect gas sphere and cannot allow the growth of degeneracy within itself. So in course of evolution the star will first radiate all energy that can possibly be produced within it, and then shorn of every internal energy-supply it will continue to contract. But degeneracy is not allowed even under great pressure produced by contraction as long as its mass is above the critical value. It gets an opportunity to escape from this situation when the pressure of the flow of an immense amount of radiation though it becomes enormous. The star is blown up and some matter is ejected from its outer parts till its mass falls below the critical mass mentioned above. The paths then open for it to follow the career of a white dwarf. There is a class of stars frequently observed which suddenly burst forth as it were, and rapidly increase in brilliancy even to a value more than a million times the brilliancy of the sun, and then slowly decrease in brightness and often become so dim ultimately that they can be observed only through a very high power tele-

scope. These are known as Nova and a particular class which appears to radiate a large part of its mass is known as Supernova. During the flare-up of a Nova or Supernova, spectroscopic analysis reveals that its hot gaseous mass is expanding outwards with terrific velocity. Chandrasekhar connects such a Nova or Supernova phenomena with the bursting of a contracting star. The theory has not yet reached its final stage as much observational material must be collected before a full confirmation is possible. It has, however, found a certain amount of support in the discovery of the "Crab Nebula" which is an extensive luminous cloud formed perhaps by the gas masses expelled during a Supernova explosion in the year 1054 A.D., which was observed by Chinese and Japanese astronomers. The central star of the Crab Nebula has been found to be a white dwarf of mass comparable to that of the sun. Chandrasekhar has done extensive researches on the problem of internal constitution of stars. His famous book *The Introduction to the Study of Stellar Structure* contains indeed only a selected portion of his valuable contributions to the subject. Besides he has also given a theory of the chromosphere, *i.e.*, the gaseous outer envelope of the sun and stars.

Chandrasekhar now appears to be greatly absorbed in the problems of stellar dynamics, on which he has already published two comprehensive articles in the *Astro-physical Journal*. His monograph on the subject "Principles of Stellar Dynamics" is unfortunately not yet available in India. In this treatise, he is said to have very elegantly developed the dynamical methods of interpreting the motions of stars in the galaxy, spiral nebulae and star clusters. This book, according to its reviewer in *Science*, should exert a profound influence on the future developments in the field of galactic dynamics. Chandrasekhar has been developing in the recent issues of the *Astro-physical Journal* a statistical method applicable to the large scale gravitational field of stellar worlds. An introduction to his ideas may be obtained from his masterly article on the "Stochastic Problems in Physics and Astronomy" published in the *Review of Modern Physics*, Vol. 15, 1943.

Apart from the intrinsic merit of Chandrasekhar's work his extensive contributions to astro-physical literature show his immense capacity for taking pains especially in the line of numerical work, and his mathematical analysis is marked by a scrupulous care for rigour. He was invited for a lecture tour to Soviet Russia in 1934, and was for some time Associate Professor of Astro-physics in the Harvard University. He held for a time a Fellowship in the Trinity College, Cambridge. Lately he has been appointed Professor of Astronomy at the famous Yerkes Observatory under the University of Chicago

and has gathered round him an enthusiastic band of younger American workers.

Chandrasekhar is a son of Mr C. Subrahmanyam Iyer, elder brother of the famous physicist, Sir C. V. Raman, who retired some years ago as Accountant General from the service of the Government of India and is an amateur musical critic. It is a pity that, even a man of Chandrasekhar's stamp could not be offered a post befitting his abilities in the country of his birth. We are, however, glad to learn that attempts are being made to get him back to India. The amount of scientific talents in this country is not

so large that we can spare a man of Chandrasekhar's type. He should be in this country, training our young hopefuls in the methods of science, and if he is allowed to remain longer in the U. S. A.*, the gain will be all on the side of that country, and the loss will be India's.

R. C. M.

* But in spite of the appreciation of the American men of science for Chandrasekhar, is it not somewhat shocking to find that, according to U. S. A. law, he cannot be a citizen of that country—Ed.—*Sc. & Cul.*

Notes and News

ROYAL SOCIETY PRESENTS 'PRINCIPIA' TO THE ACADEMY OF SCIENCES

THE recent presentation of a copy of Newton's celebrated work *'Principia'* to the Academy of Sciences of the U. S. S. R., at the request of the Royal Society, represents another significant attempt at promoting a feeling of good will and mutual co-operation among men of science of these two great countries. According to a report in *Nature*, the occasion was celebrated by an interesting ceremony which took place in Moscow on January 6, 1944. H. M. Chargé d' Affaires presented a copy of the first edition of Newton's *'Principia'* to a deputation representing the Soviet Academy of Sciences. The present was further accompanied with the original draft of a letter by Newton to Prince Alexander Menshikov, informing the latter of his election to the fellowship of the Royal Society in 1714. It may be noted that Prince Menshikov, a distinguished figure at the time of Peter the Great, was the first Russian to be chosen for this British honour. The book was handsomely bound in polished Levant Morocco and contained a sheet of vellum on which the signatures of the President and Council of the Royal Society, authorizing the gift, were recorded. The President of the Academy failed to be present at the time of presentation owing to indisposition and his part was played by Academician Baykov, the first Deputy President. It is further stated in the report that the Academy now appears to be the only scientific body in the U. S. S. R. to possess a copy of the first edition of Newton's monumental work.

INDICTMENT OF IMPERIAL CHEMICAL INDUSTRIES AND DU PONT DE NEMOURS

THE recent announcement of the U. S. Government's indictment of the Imperial Chemical Industries (I. C. I.) and Du Pont de Nemours of U. S. A. for having violated the Sherman Anti-Trust Act has excited much comment in the Press all the world over as an event of far-reaching consequence. These two gigantic chemical firms on the two sides of the Atlantic formed an international combination or cartel which is now alleged to be contrary to the Anti-Trust Laws. Accordingly charges have been brought against Lord McGowan and Lord Melchett, of I. C. I., Mr Lamont Du Pont, Chairman of the Du Pont De Nemours and Mr W. S. Carpenter, President of the Remington Arms Company, and several others. The inclusion of such distinguished personalities as two British peers in the list of the accused has naturally made the news all the more exciting.

Combination of Big Business or the cartel system in the field of international trade has been for a long time a recognized practice under capitalistic economy. The indictment appears to have dealt a major blow to the cartel system and have raised the important question whether the capitalist countries have at long last really decided to do away with a system that found so much favour until recently. While it is well-known that the cartel system undoubtedly introduced great orderliness, the same system gave rise to secret agreements involving the control of prices and of competition in a manner often injurious to the

interest of the consumers. Furthermore, the system was held responsible for shortage of essential materials and of skilled industrial labour during war and unemployment and closing of plants during peace and led to concentration of power which was not infrequently abused in the hands of such combinations.

In this connection the recent incidence of a cordite charge explosion at the I. C. I.'s Glasgow office may be mentioned. Three Scottish youths, apparently belonging to the junior branch of the Scottish Nationalist Party, placed a tin containing 5 lb. of cordite at the door of the I. C. I. offices in Glasgow and caused an explosion. It was revealed in course of investigation that their action represented a political demonstration against the company which, they were of opinion, planned to strangle Scottish economic life. This incidence was shortly followed by another explosion at the same premises, believed to be caused by five hand grenades that shattered the basement and ground-floor windows.

The Scottish explosions at any rate demonstrate the common people's suspicion for the intentions of Big Business in their own country at a time when Great Britain is involved in a life and death struggle. And again while Great Britain and U. S. A. have joined hands in destroying their common enemy and introducing a new world, news comes of the U. S. Government's indictment which is so damaging to the prestige of the two great and representative chemical companies co-operating with each other, it is alleged, for the establishment of world monopoly. Lord McGowan has, however, defended his stand by stating that such scheme of international co-operation in industry would be necessary in any orderly planning for post-war industry. These are events which forebode a general offensive against India's nascent chemical industries in the years to come. Indian chemical concerns will do well to watch and organize a defensive in time.

SOLAR ECLIPSE EXPEDITION

AN expedition of leading Mexican astronomers to observe the total solar eclipse on January 25, from Peru was jointly sponsored, according to a report in *Science*, by the Mexican Federal Government, the State of Puebla and the University of Mexico. The expedition headed by Dr Joaquin Gallo, Director of the Mexican National Observatory at Tacubaya included Dr Luis Enrique Erro and Dr Carlos Graeff Fernandez, Director and Assistant Director of the Astrophysical Observatory at Tonanzintla, among other distinguished astronomers in the party. Dr Gallo is one of the most able and experienced astronomers to lead such expedition. He took part in the 1905 eclipse in Spain as a member of the Mexican

expedition and in 1922 led the Mexican expedition to observe the total eclipse visible in northern Mexico.

The two observatories at Tacubaya and Tonanzintla provided the necessary instruments and equipment, including modern eclipse cameras and spectrographs. The instruments were set up at Cajamarca in Peru, where the total solar eclipse was expected to be visible with the best advantage. The zone of the totality extended across South America through Brazil and Peru. Owing to war conditions, elaborate arrangement for observing the eclipse could not be made. Furthermore, this appears to be the only expedition from North America, as no eclipse expedition was reported to be arranged from the United States of America this year.

TRAINING IN SCIENCE AND TECHNOLOGY IN GREAT BRITAIN

THE scientists in Great Britain, it appears, are determined to give their Government no rest whatsoever over the question of more and yet more expansion of scientific activities in all possible fields and directions. According to a report of the Parliamentary correspondent of the *Times*, about one hundred members of Parliament of all parties have recently urged the Government to take bold action to encourage scientific and technological training and to stimulate and co-ordinate research work of all kinds as an aid to post-war reconstruction policies. The motion has been signed by members mostly belonging to the Parliamentary and Scientific Committee. There are also among them several members of the Tory Reform Committee. The sponsors of the motion include Mr E. W. Salt, Lord Hinchingsbrooke, Dr A. V. Hill, M. P. Price, Sir George Schuster and H. Graham White. The following is the text of the motion:

"That this House, recognizing that if the United Kingdom is to maintain its position in the post-war world and carry out effective plans for physical reconstruction and social betterment, research and the application of scientific knowledge in all fields must be promoted on a far bolder scale than in the period 1919-39, urges his Majesty's Government forthwith:

(1) To assure the universities that in planning future developments for research, teaching, and higher learning as a whole they will receive support from the State on a much larger scale than hitherto.

(2) To arrange that education and training in schools, technical colleges, and universities shall be directed at the earliest date towards providing a far greater number of persons highly trained in science and technology.

(3) To set in motion schemes to ensure a substantial and co-ordinated expansion of research

activity by private firms, co-operative industrial research associations, and State and other research establishments; and to this end, to provide assistance by adjustment of taxation, by more generous financial grants and through adequate priorities both in demobilization and for materials required for building and equipment."

HEAVY INDUSTRIES IN BRITISH INDIA

THE All-India Manufacturers' Organization, Bombay, has recently issued a monograph to indicate the present position of British India with regard to heavy industries and the possibilities of setting up new ones in future. The case of eleven provinces has been reviewed separately, and specific problems and the lines of future industrial development for each province have been briefly outlined. To give a rough idea of the industrial position of the various provinces, the monograph has quoted figures for income tax which these provinces pay in a normal year to the Government of India. The tax collected during 1941-42 in Bombay was Rs. 6'97 crores, in Bengal Rs. 6'67 crores, in Madras Rs. 2'17 crores, in the United Provinces Rs. 1'47 crores, and in the Punjab Rs. 1'32 crores. In Bihar, Sind, Central Provinces and Berar and Assam, the income tax revenue ranged between Rs. 65 and Rs. 25 lakhs. The remaining two provinces paid less than Rs. 25 lakhs. These figures are themselves significant and reflect the poor taxable capacity of the Indian people and hence the industrial backwardness of the country they inhabit. About 77 per cent of the population in British India depend on agriculture, while only 10 per cent are engaged in industry. It is needless to point out that there is a great scope for establishing manufacturing industries in the various provinces.

The monograph has given a list of some important heavy industries, e.g., automobile, aeroplane, ship-building, internal combustion engines, railway locomotives and power machinery generally, industrial machinery and machine tools, iron and steel, heavy electrical industries, special defense machinery, heavy chemicals, such as sulphuric, hydrochloric and nitric acids, chlorine, caustic soda, soda ash, dye-stuffs, and rayon. It is suggested that to start with each province should choose two of the above heavy industries for which the province offers best opportunities for development and immediately set to exploring ways and means to establish them. A Committee or a Board may be constituted with leading industrial magnets and business men of each province, who should select the industries and bring together men of resource and enterprise to organize joint-stock companies, frame schemes and estimates and keep themselves ready to start the two heavy

industries after the war. By such provincial drives, the monograph states, all the key industries necessary for industrialization of this country may be set up. What is wanted is that leading industrialists and citizens in every province should take immediate steps to help the industrialization movement to the best of their opportunity while the war is still in progress.

NEW THEORY OF ZODIACAL LIGHT

THE origin of the zodiacal light formed the subject of an interesting paper by V. G. Fessenkoff in *Astro. J. Soviet Union*, 19, No. 4; 1942, of which a summary has been published in a recent issue of the *Astrophysical Journal* (98, 129; 1943). There is common agreement about the fact that the light principally results from the scattering of sunlight by small dust particles. But the astrophysicists could not properly account for the existence of an oblate cloud of cosmic dust in the neighbourhood of the sun. Fessenkoff now advances his theory that this cosmic dust has its origin in the collisions between sporadic meteors and asteroids. Such meteoritic collisions with planets and satellites without an atmosphere are, however, established facts. The asteroids, it is proposed, suffer the same collisions producing dust particles which cannot be retained owing to the insufficient gravitational attraction of the asteroids. This process of dust formation is particularly active throughout the asteroid zone. From his calculations, Fessenkoff concludes that a dust cloud produced in this way will form an oblate spheroid, with the sun at its centre, surrounded by a dense ring of dust in the asteroid zone. The conical zodiacal light then arises from this oblate spheroid of cosmic dust, while the dense ring of dust in the zone of asteroids is accountable for the uniform zodiacal band visible along the entire ecliptic throughout the night.

PREHISTORIC SKELETONS IN INDIA

THE Principal Information Officer, Government of India, has recently issued a note stating that a rich pre-historic microlithic and bone industry, besides remains of several partly fossilized bones and three incomplete human skeletons, has been discovered in Gujarat by the Director-General of Archaeology in India. The discovery of so many human and animal remains and a bone industry comprising tools and articles of decoration, such as beads in association with microliths, is the first of its kind in India. The archaeologists are of opinion that this discovery, properly interpreted, may lead to results of the greatest importance for the study of early man in India. The expedition worked in co-operation with the Director, Deccan College Post-

Graduate and Research Institute, Poona, and the staff of the History Department. It has been conducting extensive excavations at Langhraj, Mehsana Prant, Paroda State (Gujarat).

THE STRUGGLE FOR MARKETS

APROPOS the Editorial in this issue, the following Reuter's telegram from New York appearing in *Hindusthan Standard* of 26-4-1944 will be of interest.

"The *New York Times* writes that American exporters charged on Friday that in violation of Lend-Lease the British are processing lend-lease carbon black into news ink and exporting it to India, while the Controller of Imports in India refused to issue import licenses for American news ink. They said their Indian importers were advised by the Controller last December that 'mere willingness by exporters to supply goods is not sufficient justification for issuance of licence to import goods from a difficult currency country'. The exporters pointed out that the United States are virtually the only source of carbon black used for the manufacture of news ink and they are surprised to learn that Britain is being permitted to rob American exporters of their normal markets'. They added, 'It seems strange that Britain has man power to spare to process United States raw materials in a business in which the United States has the lead.'"

This is verily the struggle for markets.

INDUSTRIAL RESEARCH PLANNING

THE first meeting of the Industrial Research Planning Committee was held at Bombay on March 20, 21 and 22 last.

The following were present—Sir R. K. Shanmukham Chetty, K.C.I.E., Seth Kasturbhai Lalbhai, Colonel Sokhey, Dr M. D. Qureshi, Dr Hamied, Dr S. K. Mitra, Sir S. S. Bhatnagar, Dr A. L. Sundara Rao.

The Committee was of opinion that a comprehensive national register of all the persons qualified to conduct scientific and industrial research was essential and that the task of initial preparation and maintenance of this register might be delegated to an unofficial agency like the National Institute of Sciences of India. For the purpose of preparation of this register the minimum qualification must be the B.Sc., B.E., or an equivalent degree in science or technology.

The Committee further decided that a national register of persons actually engaged in scientific research should be prepared and kept up-to-date from time to time. This register should contain the names of those persons who after taking the University degree in science or its equivalent are engaged in research work in universities, research institutions, private laboratories, and industry.

The Committee has undertaken the initial preparation of this register (see advertisement pages of the journal).

With a view to getting the names of research workers employed in industry a questionnaire is being addressed to the Federation of Indian Chambers of Commerce and Industry, the Associated Chambers and other Chambers of Commerce, all Directors of Industries, Universities, Defence Services, Government Departments.

With a view to collecting the completest information about the existing facilities for research available by way of research personnel, equipment and library, the Committee decided to issue questionnaire of universities, research institutions and industries.

Sir R. K. Shanmukham Chetty is the Chairman of the Committee and Sir S. S. Bhatnagar is the Secretary. The Committee is constituted under the auspices of the Council of Scientific and Industrial Research. Dr A. L. Sundara Rao has been appointed assistant Secretary to the Committee.

ADAIR, DUTT RESEARCH FUND

At the meetings of the Adair, Dutt Research Fund Committee held under the auspices of the Indian Science News Association on March 1 and April 11, 1944, the following scholarships were awarded.

Scholars	Subject	Under whom research to be carried
1. Govinda Ram Debnath	Androgenic Hormones (Chemistry).	Prof. J. K. Chowdhury, Dacca University.
2. Arobinda Nath Bose	Processing of food-stuffs on vitamin values (Higher Technology).	Prof. B. C. Guha, Calcutta University.
3. (Mrs) Amina Rahman	Methods of estimation of the vitamin of the "B" Groups and their assay in Indian foodstuffs (Nutrition).	Prof. B. C. Guha, Calcutta University.
4. Amal Chand Ghosh	Cyclotron work (Higher Technology).	Prof. M. N. Saha, Calcutta University.
Renewal for the Second Year		
1. Satyendra Nath Ghosh	Measures of the intensity of the night sky (Physics).	Prof. S. K. Mitra, Calcutta University.
2. Sailendra Nath Ghosh	Feeding in Carps (Zoology).	Prof. H. K. Mookerjee, Calcutta University.

ANNOUNCEMENT

We are glad to inform that Mr P. K. Dutt of the well known firm of Messrs Adair, Dutt & Co., Ltd. has placed a further sum of Rs. 3,000/- at the disposal of the Adair, Dutt Research Fund Committee. The total sum upto date amounts to Rs. 12,000/- only.

SCIENCE IN INDUSTRY

SOAP AS LUBRICANTS

THE use of soap as a lubricant is not a new thing. The fact that it is clear, easy to handle, concentrated and more readily adoptable has recommended its use almost universally for lubrication purposes. A note in the *Scientific American* indicates the many uses to which soap has been put in industry in recent years with promises of yet many more.

Drilling, drawing and turning on a lathe are some of the commonest operations involving the use of lubricants, through which metals must pass before being shaped into usable objects. In drawing wire, for instance, the very large friction of nearly 18,000 to 30,000 pounds per square inch is produced in the die, which can only be reduced through use of lubricants. Powdered soap made from tallow or a combination of tallow and palm oil, when the latter is available, serves as a good lubricant in dry drawing. In wet drawing, however, a soap solution in water is used, and the wire and the die are either submerged under the solution or the solution is dripped over them as the drawing is in progress.

Soap forms an important component in the manufacture of a large number of new greases which have recently been produced. The use of soap in grease makes the latter adhere more closely to the rotating surfaces and prevents its leaking away from points of friction. Moreover, gasoline which quickly dissolves ordinary grease has little action on these new varieties processed with soap, and as such these lubricants can be advantageously used in pumps and carburetor valves frequently coming in contact with gasoline. Grease lubricants containing a certain proportion of soap are more resistant to extreme cold and sudden temperature changes and are now largely used in aircraft industry.

Some other uses of soap enumerated in the note include the use of soap coating in the manufacture of 37 mm. cartridge cases. This eliminates the need for copper plating. Soap is extensively used in the preparation of lubricants for drawing copper and brass tubes and wire, also of cups in the production of shell cases for ammunition. The property of soap to improve the stability of oil emulsion and increase its film strength is utilized in cutting oils which have been developed to meet the requirements of many kinds of high speed war production.

PLASTIC FROM SAW DUST

Science News Letter, January 1, 1944, reports the development of a new plastic from waste saw

dust by Dr Robert A. Hardin, Chairman of the industrial education department of the University of Oklahoma. The waste of saw dust and savings from saw mills and lumber manufacturing plants, Dr Hardin has revealed, amounts to as much as 76 per cent of the country's forest products, and this led him to undertake research in the possible utilization of this waste product.

The plastic he has developed is black and opaque and has high tensile strength and resistance to moisture absorption. Its tensile strength has been measured at 9,000 pounds per square inch. Besides its resistance to moisture, the new plastic yields little to the action of acids and is not inflammable.

The black colour of the new product, which is often a disadvantage, is due to the presence of lignin in the wood. During the process of treatment, lignin turns black and makes the colour of the plastic so. The colour disadvantage has, however, been sufficiently countered by the lower cost of production. The lower cost arises from the fact that the new plastic requires only 25 per cent of the costly resin, which is much less than the amount consumed in the manufacture of other plastics now in use. The cost of a plant capable of producing two tons of the new plastic daily has been worked out at 133,000 dollars, including plant location, building and total expenses for one year operation. In his model manufacturing plant at the University of Oklahoma, Dr Hardin has also moulded his new product into several finished articles.

HIGH-SPEED MOTION-PICTURE CAMERA

AN ultra-high speed camera, known as the Western Electric Fastax High-Speed Motion-Picture Camera, has been recently developed in the Bell Telephone Laboratories and manufactured by the Western Electric Company. At their top speed, the Fastax cameras are capable of taking pictures at the rate of 8,000 per second, which means an exposure period of 33 millionths of a second and a film speed of about 70 miles per hour. Such cameras have been designed to use both 8 mm. and 16 mm. films. The cameras using 8 mm. film take pictures at the rate of 300 to 8,000 per second, whereas the 16 mm. model has a rate of 150 to 4,000 pictures a second. The ordinary line voltages of 110 to 125 volts may be used to secure the top speed and lower speeds can be obtained by applying smaller voltages through the use of rheostats in series with the motor.

The Fastax cameras are of the continuous-motion type, as distinct from the stop-expose-

advance type of the slow motion cameras, and employ rotating prism or optical compensator to produce the succession of images. The 8 mm. model uses an eight-sided prism and the 16 mm. model a four sided prism between the lens and the sprocket, permitting eight and four pictures respectively per prism revolution. The images formed by the lens are refracted by the rotating prism to meet the film moving with great speed. This arrangement makes possible continued exposure throughout the period that the film travels past the aperture. Either 50 ft. or 100 ft. spools of film are used in both these types. The total time of exposure, at full voltage, for a film length of 100 ft. does not exceed 1'25 seconds.

The Fastax cameras, because of their ultra-high speed, have opened up possibilities hitherto unthought of in the field of research and investigation. The Fastax can photograph action far too fast for the ordinary slow motion camera and reveal innermost secrets of mechanical parts moving with high speed. In one set of investigations, the Fastax revealed the heretofore undetected cause of false signals in telephone equipment. In the Bell Telephone Laboratories, these cameras have recently been used to study the action of the vocal cords during speech and the explosive short-circuiting of wires carrying heavy currents of electricity. The Fastax cameras further lend themselves to colour photography of the self-luminous objects. Stress and impact conditions of new equipment designs have been conveniently studied by these cameras working in slower speeds, while medium speeds of about 1,500 to 4,000 pictures per second have been employed to investigate automatic operations, laboratory-controlled breakage of parts and the causes of noisy operation in machines. For a fuller detail as to the construction and design of these cameras and the various uses to which these have been put, the reader is referred to an article by H. J. Smith in the *Bell Lab. Rec.*, 22, No. 1, October, 1943.

INDIAN WOOD FOR TEXTILE AND JUTE MILL ACCESSORIES

INDIAN Forest Bulletin No. 121, issued recently by the Forest Research Institute, Dehra Dun, contains an account of the tests carried out at the Institute on the suitability of Indian timbers for the manufacture of textile and jute mill accessories.

Restricted import of the American persimmon (*Diospyros virginiana*) and cornel (*Cornus florida*), the best shuttle woods in the world, and increased demand of wooden articles for textile and jute mills led the Institute to direct its attention to the question of finding suitable indigenous woods for such purposes soon after the war started.

The requirements of wood to be used for shuttle making are very exacting. It should have fine, even and straight grain, good weaving qualities and a density of about 52 lbs. per cubic foot at 12 per cent moisture content. Moreover, the wood should season well without much splitting so as to ensure a reasonable yield, should not split when metal fittings are inserted and finally should be easy to work and smooth to a finish. A large number of timbers which appeared suitable from the data available from their physical and mechanical properties were obtained and tested. The timbers which failed in the preliminary examinations were rejected. Eleven species were finally selected for manufacturing trial and service tests in the mills; the finished shuttles were then tested in weaving mills under factory conditions. The leaflet contains detailed results of these tests in tabular form.

The results of these tests are on the whole satisfactory. *Diospyros melanoxylon* (ebony), the light coloured sapwood, appears to be the best timber so far tested for cotton mill shuttles. It gives a life of about 50 per cent of imported cornel wood. *Ougeinia dalbergioides* (sandam), *Acacia arabica* (babul), and *Schrebera swietenoides* come next to ebony as regards their suitability for shuttle making. Some manufacturers also approve of *Gardenia tatifolia* and *Succopetalum tomentosum*, but their supply is limited. Some weaving mills in North India are using ro quat wood with satisfactory results. Another timber *Buxus sempervirens* (box-wood), available in limited quantities in the high elevation forests of the Himalayas and Kashmir, has, however, been preferred to persimmon and cornel in making shuttles for silk worms and for fine quality cotton fabric. There is yet another timber *Parrotia jaequemontiana* (parrotia) which has been considered suitable for shuttle by certain manufacturers.

The leaflet has further laid down some important precautions regarding the conversion and seasoning of shuttle woods.

RISE AND DECAY OF THE INDIGO INDUSTRY IN INDIA

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NOMENCLATURE

INDIGO (Earlier *indico* from Lat. *indicum*; Greek *indikon*) belonging to the genus *Indigofera* L., is a large genus (350 sp.) of herbs of the family Leguminosae, found throughout the tropical regions of the globe (both in the Old and the New World) with Africa as their headquarters,—India having about 40 species. It is a genus of rather dry climates; and is subject to disease at the roots in moist climates, where the species are apt to wilt as a result, and where they suffer from inadequate function of root nodules.

Amongst these are the plants best known as sources of the well-proved dye, indigo or anil, which is still the "king of the dyestuffs". Commercial indigo is a paste or powder of the chemical substance, *indigotin* or indigo blue mixed with impurities which are difficult to separate in the process of manufacture. Nothing has been found to equal the permanency and strength of its deep-blue colour.

The Sanskrit name is *nili* from *nīla*, dark-blue and the Arab name al-nil (through Portuguese) *anil*, gives us *aniline*.

ORIGIN

The latin name *indicum* clearly shows that the Romans knew that the indigo was originally brought from India. As to the wild nature of the plant Roxburgh says "Native place unknown, for though it is now common in a wild state in most of the provinces of India, it is seldom found far from the districts where it is now cultivated or has been cultivated formerly." (De Candolle, 1895.) The existence of a Sanskrit name renders its Asiatic origin more probable. (Brühl, 1908.)

INDIGO-YIELDING SPECIES

The following species have been the source of well-known dark blue dye of commerce. All these plants are stiff-stemmed, weedy-looking annuals or shrubby perennials.

1. *Indigofera arrecta* Hochst. (Natal Java plant).—This is a tropical African species, brought into Dutch Indies about 1860. It is the richest variety and later became the chief source of Bengal Indigo. Seeds were obtained from Natal and plants acclimated in Java. Natal plants are more vigorous in growth than those commonly grown in India and have been proved to yield a much higher proportion

of dye from a given weight of plant. It is also used as a green manure and as a catch crop in Malaya peninsula.

2. *I. articulata* Gouan (= *I. argentea* Linn), *Surat indigo*.—It is a native of Tropical Africa, Nubia and Arabia. From Gujarat Arabs took it westwards to the Mediterranean.

3. *I. longeracemosa* Boiv.—This is a native of Madagascar. It was re-discovered and cultivated in Travancore. It is supposed to be one of the most valuable indigo-producing plants in the world.

4. *I. suffruticosa* Mill (= *I. anil*).—It is a native of tropical America. American indigo was brought to China and the Philippines by the Dutch. This is the Madras variety and has a poorer yield. It is also used as a green manure.

5. *I. Sumatrana* Gaertn. *Bengal indigo*.—According to Prain (1902) "*I. Sumatrana* is most probably a species developed under cultivation from the wild form of *I. tinctoria* which is indigenous in T. Africa (Nubia)". It is the chief cultivated form in Bengal, United Province and Madras and was introduced by the Dutch from Malayasian region about 1758.

6. *I. tinctoria* Linn.—This species is cultivated in the tropics and may be of Asiatic origin. The Dutch took it to Malayasia and also to the W. Indies.

I. arrecta, *I. Sumatrana* and *I. tinctoria* are the species now cultivated in India.

WOAD PLANT

In addition to the *Indigoferas*, several widely different plants yield the same substance chemically. The dye prepared from these has borne a synonymous name in most tongues.

Isatis tinctoria L (Woad plant) is one of these belonging to the Family *Cruciferae* and is a native of the Mediterranean and Europe. This is of historical interest, since upto the middle of the 17th century i.e., before the introduction of indigo it was the only blue dyestuff used by dyers in England and the adjoining countries. The dye was used by primitive Britons to paint their bodies.

The leaves of the woad plant are moistened to a paste slightly fermented, moulded into balls and dried. The plant is still cultivated to some extent.

EARLY HISTORY

Indigo has had a very long history, the beginnings of which are wholly unknown. It was used

in ancient Egypt—for mummy clothes dating perhaps from 2,300 B.C. have been found dyed with it. The manufacture which supplied the trade article must have been already well advanced at that period.

The historical record of this industry goes back almost to the beginning of the Christian Era and the process of manufacture is described by many early travellers to India.

When Rome was at its zenith, indigo was an import received through Alexandria, and being of Indian origin, was called '*Indicum*', as stated before. In the 6th century A.D. Persia was one of India's markets for it and through Persia it reached China overland. Later, in 1200 A.D., indigo reached China no longer by the overland route but by sea from Gujarat and about 1652, the Chinese spread the cultivation to eastern Malayasia.

BOMBAY INDIGO

There is abundant evidence that when European traders first began to purchase and export the dye from India, it was procured from the Western Presidency and shipped for the most part from Surat. Indigo was then cultivated in western and southern India.

ARRIVAL OF THE PORTUGUESE

The entry of the Portuguese into the Indian Ocean by rounding the Cape in 1498, seems to have led to increased indigo production in India. The dye was carried by the Portuguese to Lisbon and sold by them to the dyers of Holland from 1516 onward. The centre of production remained in Gujarat, Cambay and Surat.

About 1610 Gujrati merchants lived at Goa, in order to trade conveniently with the Portuguese and trade in indigo was more esteemed and valued than trade in cloves both in India and Portugal. Trade with China also continued.

DUTCH EAST INDIA COMPANY

It was the desire to secure a more certain supply of the dye stuff that led to the formation in 1631 of the Dutch East India Company, and shortly afterwards, this led to the overthrow of the Portuguese supremacy in the East. (Watt, 1908).

About 1612, there was an increase noticeable in the amount arriving in Europe. It was sold for use in the place of woad (*Isatis tinctoria*) in Britain and France. The success of the Dutch merchants aroused the jealousy of other European nations. "The woad growers and merchants of Germany, France and

England were threatened with ruin and to protect them nearly every country passed edicts rendering the importation or use of indigo a criminal offence punishable by death" (Watt, 1908). Efforts to fortify woad against indigo, by the scientific improvement of the woad plant in France failed and by 1737, the penalties for using indigo were removed and indigo was an established trade in Europe.

INDIGO IN ENGLAND

In 1608, England learned the art of indigo dyeing and in the reign of Queen Elizabeth its use was permitted along with woad. But opposition to its use was so strong that it was again prohibited on the pretext of being poisonous and in 1660, Charles II, had to procure dyers from Belgium to reteach the English the art of using the dye.

ENGLISH EAST INDIA COMPANY

When the English East India Company began persistently to export indigo from Surat direct to England and with the increasing demand of the dye from India—the trade flourished so much—that this had the effect of stimulating the Spanish, French, Portuguese and English colonists to make strenuous efforts to extend the cultivation in various directions and to produce the dye in many countries outside India. The European colonist in America took to growing and manufacturing the dye and the improvements they effected were so great that this Indian article was no longer desired and its cultivation was discontinued in Gujarat and was never resumed in that part of the country.

COLONIAL COMPETITION

The East India Company later voluntarily gave up the importation of indigo into England "in order to avoid a competition with the British colonists in West Indies and the Southern provinces of North America. About the year 1747, most of the planters in the W. Indies particularly in Jamaica, gave up the cultivation of indigo in consequence of the high duty imposed upon it." (Watt, 1908). At the same time the American colonists found that sugar and coffee had proved even more profitable in the W. Indies than indigo. The impetus was thus given for a revival and re-establishment of the Indian traffic in Indigo and the province of Bengal was selected for this revival.

RE-ESTABLISHMENT IN INDIA

About 1778, the East India Company revived the cultivation of Indigo in Bengal and gave it direct

encouragement for the next 20 years, and India recovered her foremost rank among the indigo-producing countries of the world from which she had been temporarily ousted by W. Indies. Bengal indigo as manufactured then was the best of its kind and soon superseded all other indigo and from 1815-16, Bengal supplied all the indigo required for the consumption of the world.

For a time, the production was a monopoly of the company but as its servants were free to trade, many took to its cultivation on their own account and were so successful that they obtained permission to resign from the Company's service and became a perfectly self-supporting industry—under European management—the pioneer planting industry of India.

As far back as 1801 the indigo planters of Bihar formed an association to facilitate correspondence with the Government in the interests of the community, to safeguard their interests and to deal with applications for the settlement of differences between one member and another or between members and local Zamindars and ryots. The rules were remodelled in 1837 at the instance of Government and altered in 1877 and 1905. The successful exploitation of synthetic indigo later, drove many of these planters to cultivate other crops e.g., sugarcane, etc.

TROUBLES IN BENGAL AND MIGRATION TO TIRHOOT (BIHAR)

It had no sooner been organised, however, than troubles arose in Bengal itself, through misunderstandings between the planters, cultivators, and the Government, which culminated in Lord Macaulay's famous memorandum of 1837. This led to another migration of the industry from the lower and Eastern Bengal to Bihar (Tirhoot) and United Provinces. Ultimately legislation to protect the cultivators became imperative in 1859 (Burkill 1935, Mollison 1908, Watt 1890, 1908, Hill 1937).

WOES OF BENGAL PEASANTRY UNDER EUROPEAN INDIGO PLANTERS

About 1855 "3 or 4 millions of cultivators in Bengal were subjected by European indigo planters to a system of inhuman oppression which only finds a parallel in the annals of negro-slavery in America" "Every form of oppression, were put into practice by the indigo planters." (Chaklader, 1905). From the time of the introduction of indigo cultivation into the province down to its final banishment, facts prove clearly and undeniably that the ryots were forced to take up the cultivation of indigo. The immense fortunes which the European planters realised by the manufacture of indigo, did not incline them to redress the grievances of the people, upon whose labour, the success of the industry was solely depen-

dent. This vicious state of things, continued for half a century (1810-1860), till they were unearthed by the Indigo Commission appointed in 1860, with Mr W. S. Seton Kerr, C.S. as President. The commission was instructed to take evidence and report on the whole practice of contract, cultivation and delivery of indigo. They reported "that the system on which indigo had been cultivated was a coercive system of an unrelaxing character and had broken down, because, it was, in the long run unremunerative to the cultivator". On the wake of this came the '*Nildarpan*' a Bengali drama dealing with the life of cultivators under the indigo planters published anonymously (by the middle of September, 1860) by the late Rai Bahadur Dinabandhu Mitra, when the indigo question had reached a crisis. It did immense service in awakening the mind of all classes of the Indian population and it had the same effect in helping the cause of the abolition of indigo-slavery in Bengal as Uncle Tom's Cabin had in abolishing negro-slavery in America.

An English translation* of '*Nildarpan*' with a preface by the author was circulated by the Government of Bengal. The planters denounced the drama as infamously obscene and grossly libellous. They prosecuted the printer and the publisher Rev. J. Long, an English clergyman. Mr Long was sentenced to pay a fine of Rs. 1,000/- and to serve an imprisonment for one month. The fine was paid then and there by Mr Kali Prasanna Singha, an enlightened citizen of Calcutta.

Mr Seton Kerr was punished departmentally for patronising the publication and helping the circulation of '*Nildarpan*'. Sir J. P. Grant, Lieutenant Governor of Bengal, was also similarly charged. (Mitra 1903; Chaklader 1905).

Thus ended one of the most troublous periods in the history of Bengal. Subsequently, Government enacted measures to help the indigo-planters, but the indigo interest had long been doomed and could never recover its former position in Bengal.

HORTUS MALABARICUS, 1686

There is no evidence of any detailed descriptive account of the manufacture of indigo in any writing prior to Rheede's great '*Hortus Malabaricus 1686*' where its export from Coromandal and Negapatam is mentioned as also its production in Ceylon. Rheede figures *I. tinctoria* L. as the indigo plant, a species better suited to a moister climate than *I. articulata* Gouan grown in a large scale in Gujarat.

* '*Nildarpan*' was translated into English by Michael Madhusudan Dutt. It is said that the poet was admonished in private for this and lost his job in the Supreme Court which had been his main source of livelihood. (Bando-padhyaya & Das, 1943).

The Dutch introduced *I. sumatrana* from Malayasian region to India, a species better than *I. tinctoria*. *I. tinctoria* was taken from the old world to the W. Indies and *I. suffruticosa* was brought from America to China and the Phillippines. The Arabs took the Gujarat *I. articulata* westwards to Egypt and the Mediterranean but found on the upper Nile another suitable species *I. arrecta* Hochst and its cultivation obtained a wide extension. The ever-experimenting and alert Dutch had first given up *I. sumatrana* for the American *I. suffruticosa*; then *I. suffruticosa* to *I. arrecta* (1860) and this was what they were growing when artificial indigo was first heard of (Burkill, 1935).

SYNTHESIS OF INDIGO BLUE: CHEMICAL DISCOVERY

India's position remained unassailed, though there was cultivation also on a considerable scale in Java until as a result of laborious research by Baeyer and his pupils the constitution of indigo was established (1880) and Germany found themselves at last in a position to produce indigo from coal-tar by chemical methods though manufacture, on a commercial scale was achieved in 1897. Perkin (1856) was the original discoverer of the coal-tar dyes and the first process for making synthetic indigo was patented in 1880; the method that has proved a commercial success and which enables synthetic indigo to be sold at a price much lower than that obtained from the natural product is based on a reaction discovered by Heumann in 1890, and it was put on the market in large scale in 1897. It is generally agreed that synthetic indigo obtained a footing in the market because the production of natural indigo was not brought under scientific control in time. When it came in, indigo planters were carrying on their business in old haphazard ways, neither understanding how to get good crops, nor how to extract the greatest quantity of indigo and they quickly lost the advantages which they had.

By 1905, although indigo crop was grown over considerable areas in Lower Bengal and Bihar and the output was very small, still it was the best in the world. Since then the indigo industry has been steadily on the decline owing to the increasing manufacture of synthetic indigo as mentioned above.

INDIGO TRADE BEFORE THE GREAT WAR

Till the production of synthetic indigo by chemical process, at a price which competed with the natural dye, the industry was thriving. Successful exploitation of synthetic indigo and decrease in the quantity of natural indigo available for export resulted in a fall in the price of Bihar indigo, which threatened ruin to these planters, who were forced to substitute other crops, e.g., cultivate sugarcane and manufacture sugar.

The results were apparent for the first time in the export of 1899-1900 (Fig. 1). The average export in each decade of the 20 years ending in 1901-1902 were for the first decade i.e., 1882-3 to 1891-2, 141, 811 cwt. and for the second decade i.e., 1892-3 to 1901-2, 135, 396 cwt. and the average for the quinquennium 1909-10 to 1914-15 being 15,000 cwts.

A gradual decline in the export of natural indigo is further revealed by the following figures:—

Year	Quantity
1899-1900	111,420 cwt
1900-1901	102,491 "
1901-1902	89,750 "
1902-1903	65,377 "
1904-1905	49,252 "
	(being less than half the average of the previous years' prosperity).
1912-1913	11,857 "

When in 1894-95, 237, 449 cwts. were produced from 1,688,642 acres, 166,830 cwts. were exported from Calcutta, whereas in the year previous to the last Great War, the all-India exports amounted to 10,939 cwts. of which 8,752 cwts. came from the factories of Bihar.

Until 1907-08, indigo represented more than half the total value of dyeing and tanning materials exported. This percentage had fallen to one-fifth in 1913-14, but had recovered its old position the following year (1915-16).

The province which continued to contribute chiefly to the foreign export trade before the war was Bihar, where the dye was more systematically extracted and marketed under European supervision.

The inferior indigo of Northern India and Madras, manufactured in factories on indigenous methods, continued to serve a purpose and is still being continued, much of it being used in India, but this industry is of small importance compared with that of Bihar.

At one time it was hoped that the introduction of Natal Java plant (*I. arrecta*), giving a higher yield of indigotin with improved and cheaper methods of cultivation and extraction might stem the tide, but retrogression proceeded steadily until the declaration of hostilities in 1914 closed the markets of the world to the synthetic substitute. By 1910, Java industry was dead (the Phillippine industry had been abandoned before 1900) and in 1913-14, the area under cultivation in India was scarcely more than a tenth of that in 1895-96 (Fig. 1).

Since the introduction on a large scale of synthetic indigo efforts have been made in India and in Java to place the cultivation of the plant and the manufacture of the natural indigo product on a more scientific basis. But although many important improvements have been achieved from the agricultural as well as from the manufacturing point of

view, resulting no doubt in the retention of a portion of the industry, the synthetic product has continued to gain the upper hand.

GREAT WAR AND INDIGO

Soon after the outbreak of the last Great War (1914-18) supply of synthetic indigo from Germany was cut off and the shortage of dye-stuffs among the Allies became acute, and in India, when the Calcutta indigo sales were resumed in December, 1914, the prices realised were nearly four times as great as those of previous March. This gave a temporary stimulus to indigo growing in India, Java, China and Japan.

The feature of the export trade in 1915-16 was the heavy shipment from Madras, greatly in excess of those from Bihar, which went chiefly to the United Kingdom, and also to Egypt, Persia and U. S. A. In recent years (1939-40) an increasing participation by Greece is noticeable with Egypt and Yugoslavia coming next in importance.

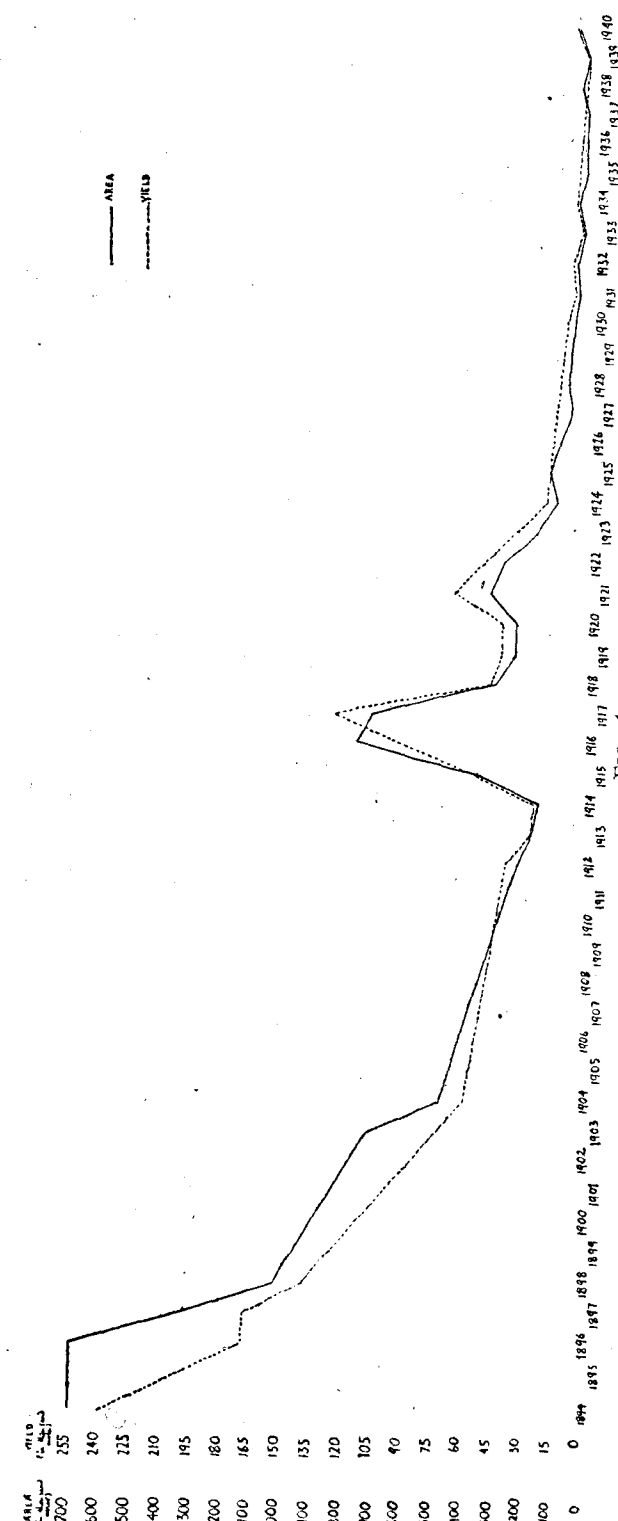
With the encouragement to exporters and with the Indian dyers finding supplies of aniline increasingly difficult to obtain and then only at extravagant rates, the area under indigo in India increased $3\frac{1}{2}$ times in 1916-17 (Fig. 1) as compared with the preceding five years. But even then the total acreage was less than half the high water mark reached twenty years before and the output was scarcely proportionately raised as the increase in cultivation was chiefly in Madras and the United Provinces where, the industry is mainly in the hands of small holders and the dye manufactured with simple and less costly machinery—the general quality being much lower (40 to 50 p.c. indigotin) than the Bihar quality (60 to 70 p.c. indigotin).

A reaction had set in even before the armistice. The dye shortage in the United Kingdom led to the re-opening of the Badische Branch Works at Ellesmere Port for the manufacture of aniline and alizarine dyes, as soon as the secrets of manufacture had been re-discovered by English chemists, and when Germany was once more in a position to export her dye stuffs freely, the competition of the synthetic substitute with natural indigo became even more acute than before (Cotton, 1919, 1924: Saksena, 1937).

INDIGO TRADE AFTER THE GREAT WAR

In 1917-18, there was a fall in the acreage under the plant and a marked fall in prices and in 1918-19 these elements of weakness became even more accentuated.

While the area in 1922-23 was 60 p.c. above and the yield nearly double the corresponding figures for 1913-14, the loss of the Japanese market in competition with synthetic indigo resulted in a considerable decrease in the total exports. Japan took only 400 cwts. as compared with 7,200 cwts. in the previous



year. Egypt, Mesopotamia and the United Kingdom in that order were the principal recipients.

RISE AND FALL OF INDIGO TRADE

The area cultivated with their yield in cwts. and export in cwts., with the value of export and value of import of aniline and alizarine dyes are given in Fig. 1 and in the table given below.

Year	Export of Indigo (in cwt.)		Value of export of Indigo in £	Value of import in £ of aniline & alizarine dyes
1876-77	100,000	Average 135,400 cwt. Being less than half the average of previous years of prosperity	2,000,000	
1886-87	138,000		2,500,000	
1894-95	166,830			
1896-97	169,523		3,000,000	
1897-98	133,849			
1898-99	135,187			
1899-00	111,420			
1900-01	102,491			
1901-02	89,750			
1902-03	65,377			
1903-04	60,000	Improvement in export Average 31,000 cwt.	700,000	
1904-05	49,252			
1912-13	11,857			
1913-14	10,939		141,398	699,915
1914-15	17,142		599,691	313,237
1915-16	41,932		1,385,795	113,808
1916-17	34,230		1,408,373	435,853
1917-18	31,062		1,018,766	652,050
1918-19	32,707		832,340	779,566
1919-20	32,687		885,068	922,870
1920-21	10,250	Average 15,000 cwt.	274,755	1,575,601
1921-22	12,362		342,457	1,947,099
1922-23	4,535		112,936	1,636,781
1929-30	867			
1932-33	342		5,386	1,626,560
1933-34	502		7,265	1,581,080
1934-35	544		8,012	2,053,963
1935-36			4,910	2,275,296
1938-39			2,733	
1939-40			1,333	81,851

PRESENT POSITION OF INDIGO TRADE

The largest area under the crop is now in Madras, contributing about 75% of the whole yield—where (as in the Punjab and U. P.) it is for the most part cultivated in small holdings and is chiefly grown by Indian cultivators and the inferior dye produced largely disappears in local consumption, though there has been a definite market for the better grades. There is also an appreciable but not definitely ascertainable area in Travancore, where *I.*

longeracemosa for which a high indigotin yield is claimed, has been re-discovered (Saksena, 1937).

TRADE IN SYNTHETIC INDIGO

The bulk of the indigo which now comes into the European market is prepared synthetically from coal-tar. Between 1906-13 synthetic indigo captured the Chinese market by sheer efficiency and due to poorness of the Indian product. China and Japan have always been by far the largest markets for synthetic indigo, their combined consumption in 1913 being 27,000 tons (20 per cent paste) out of an estimated exportable surplus from Germany of 47,000 tons. In the same year Great Britain, British Dominions and the United States of America together took little more than 6,000 tons, China and Japan together took three-fifths of the whole of the synthetic indigo produced. "Into these far eastern markets, India scarcely penetrated in her heyday, owing to the competition of primitive indigenous manufacture, and showed little sign of capturing them in the more favourable conditions created during the last Great War, although the prosperity of the Indian industry and its ability to compete with synthetic dyes depended largely upon its being able to supply the Eastern markets" (Cotton, 1919).

CULTIVATION IN INDIA

In deep alluvial loamy soils and lands annually renovated with silt indigo cultivation is very inexpensive and the above conditions suit the crop best. Simple cultivation after the water has gone down followed by broadcast sowing, is all that is required. No irrigation is done in such tracts. But the best indigo is produced in highlands under a careful system of cultivation.

Deep alluvial soils in Bihar which grow indigo are deficient in phosphoric acid and nitrogen but richer in all other useful constituents. Extensive experiments in Bihar have proved that in such soils superphosphate and nitrate of potash can be economically applied.

The *Sumatrana* plants are reared from seed sown about the end of April or beginning of March. The spring sown crop yields the best dye. Plants make slow progress until the monsoon sets in when the growth becomes very rapid. By the middle of June, the plant has attained a height from 3 to 5 ft. and the first crop is ready in July, a second crop being obtained in September.

Ten to fifteen seers of seeds are required per acre. Thirty to forty bundles (a bundle weighing about 300 lbs.) is the produce per acre and the yield of dye about 12 lbs. per acre in lower Bengal and

20 lbs. per acre in Bihar (Voelcker, 1893 ; Mukherjee, 1923).

EXTRACTION OF INDIGO—WET PROCESS

Indigo occurs in the leaves of the plants not as such but in the form of *Indican*—the colourless glucoside of Indoxyl and is a crystalline substance extractable from the leaves with hot water. When hydrolysed by means of certain ferments (contained in the leaves) or with dilute acids, Indican yields glucose and indoxyl, the latter being oxidised to indigotin (the colouring matter of indigo) in contact with atmospheric oxygen.

Fresh plants cut early in the morning and just before flowering (about June or July) are steeped in clean still water and macerated at 25° to 30°C for 12 or more hours in large vats made of stone. (Every 100 mds. of plant require 4,500 gallons of water). The indican undergoes fermentation under the influence of enzymes present in the leaves, with the formation of indoxyl and glucose. When fermentation is over (10-12 hours) the liquid in the steeping vats which contain ammonia in addition to indoxyl and varies in colour from bright orange to olive green is drained off into the beating (oxidising) vats placed at a lower level. The beating, the object of which is to oxidise, i.e., bring the liquor as freely as possible into contact with the air, is done by mechanical means. If there is any delay in oxidation a considerable loss of colouring matter results and the indigo produced is inferior. As the

oxidation proceeds the indoxyl is oxidised to dark blue particles of indigotin and the liquid has changed from a yellowish colour to indigo colour and the bearing is finished. When the oxidation is complete the insoluble bluish precipitated indigo separated as blue flakes, is allowed to settle, the supernatant liquid being drawn off and run to waste. The indigo mud thus obtained is washed free from soluble matter boiled for short period with water for the purpose of sterilising, filtered, formed into bars, cut into blocks or cubes of about 3 inches square and finally dried.

Improvements in the manufacture of indigo had been brought about by Mr Christopher Rawson and by Mr B. Coventry, who by proper methods of oxidising have sometimes obtained with the help of blower for oxidising the liquid as it comes from the steeping vat—25 to 30 per cent or more of the colouring matter. With the blower, the Bihar factories sometimes obtained 12½ seers of indigo out of every 100 mds. of green plants.

The actual amount of colouring matter, indigotin yielded by the leaf is but small, averaging 0.55% which is equivalent to 36 seers of indigo out of 100 mds. of leaf but the yield from the whole plant is considerably less, since the stalks and twigs contain practically no colour. *I. arrecta* yields more indigo per unit weight of leaf and also yield more leaf than *I. sumatrana* (Mukherji, 1923).

(To be continued).

MEDICINE AND PUBLIC HEALTH

RECENT ADVANCES IN BACTERIOLOGICAL TECHNIQUE

AN useful account of the recent advances in bacteriological methods has been prepared by Prof. J. Chruickshank for the British Council and published in the *British Medical Bulletin*, 1, No. 8 ; 1943, of which a short summary has appeared in *Nature*, January 15, 1944. The account includes the principal advances in the last ten years. The discovery of more efficient selective culture media for the isolation of bacteria, the determination of the stable subgroups or types of bacteria and the development of typing methods which ensure the detection of the probable source of an infection or an epidemic appear to be the major advances of this period under review.

The Vi or virulence antigen of the typhoid bacillus has been an important discovery which has made it clear that anti-typhoid serum made for therapeutic use should contain Vi antibodies. It has been found that the blood of typhoid carriers almost always contains these antibodies. This fact has rendered Vi agglutination test an invaluable aid to the detection of the sources of infection. Meanwhile a Vi bacteriophage which has a specific action on Vi strains of typhoid bacilli has been discovered. This bacteriophage can be used to identify particular strains of these bacilli and, as some epidemiologists have successfully tried, to trace the source of isolated infections or epidemics. Valuable results were also obtained from the typing of diphtheria bacilli.

A definite advance in our knowledge of the activities of the haemolytic streptococci, the staphylococci, and the organisms of the gas-gangrene group has been recorded. Work on the haemolytic streptococci has produced evidences of the existence of thirteen groups of these streptococci. The group A streptococci, of which at least twenty-three types have been identified, are mainly responsible for human infections. It is interesting to note that the same haemolytic streptococci are capable of various manifestations. Recent researches have shown that the supposition that puerperal fever arises largely from infection of the placenta by organisms in the genital passages at the beginning of labour is untenable. The attendants, other contacts and the respiratory passages of the mother herself are to all intents and purposes the main sources of infection. Work on staphylococcus and organisms causing gas-gangrene has also made good progress, thanks to the impetus created by the war. The development of the methods of growing anaerobic bacteria in the presence of air and also on ordinary broth or peptone water containing a small strip of sheet iron represents another important bacteriological progress during recent years.

VACCINATION AGAINST TUBERCULOSIS

ACCORDING to a report in *Science*, Dr Truman Squire Potter, of the Laboratory of Preventive Medicine of the University of Chicago, has shown the increased possibility of preventing tuberculosis by vaccination. The vaccine is made from tuberculosis germs that are killed by suffocating them. It has, however, not yet been tried on human beings. But the striking results of animal experiments indicate that the vaccine will prove effective in human beings as well. In his latest experiments on rabbits, Dr Potter used a vaccine from asphyxiated human-type tuberculosis germs. Of 33 vaccinated rabbits, only four showed minimal lesions of tuberculosis when large doses of virulent germs were injected into their veins after the vaccination. Of 33 unvaccinated rabbits, 25, including three that died, showed frequent severe lesions.

Vaccines against tuberculosis have in the past been made either from living but weakened strains of the germs or from germs that were killed by heat or chemicals. None of these has been generally accepted as safe and effective, although promising results have been reported with B.C.G. vaccine, made from living, attenuated tubercle bacilli.

The suffocation of the tuberculosis germs must be done under carefully controlled conditions which include an absence of oxygen, presence of moisture

and a temperature high enough to keep the germs' metabolism active. Under these conditions the germs die partly as a result of self-sabotage. By continuing their living processes they deprive themselves of oxygen as they breathe, and since no more is supplied them, they suffocate.

Destruction of the germs by this method, Dr Potter believes, is less likely than other methods to reduce or destroy the tuberculosis antigen. Antigen stimulates the body's defensive mechanism so that, when vaccination is successful, the body defences are ever on guard in suitable strength to overcome fresh invasion of the germs that produce the antigen. This is the principle of vaccination in general. In the case of tuberculosis, the problem has been to find a way of getting enough antigen into the body to develop immunity without giving so much or giving it in such form, for example in living germs, that it will cause tuberculosis.

PENICILLIN FOR WOUNDS

RESULTS of penicillin treatment of infected wounds in U. S. Army hospitals are summarized in a report by Major Champ Lyons, M.C., A.U.S., according to a report in *Science News Letter*.

Penicillin can produce "dramatically successful" results in treating septic gun-shot fractures but, Major Lyons emphasized, its position is supplemental in the overall surgical programme. To get these dramatically successful results, the surgeon must combine penicillin with effective blood transfusions and conservative surgical procedures according to the condition of each patient.

Important advantage of penicillin is that it helps to fight anamia in chronically infected battle casualties. Part of this seems to be due to the increased appetite the patient develops while under penicillin treatment, enabling him to eat more blood-building food, and part to the fact that penicillin controls the infection.

This regeneration of haemoglobin, the blood's red colouring matter, proceeds too slowly under penicillin treatment alone, however, in view of the need to economize on penicillin and to reduce the time the patient must spend in the hospital. Consequently blood transfusions must be resorted to. Whole blood is best for this and the quantities needed for each patient are estimated at from one and one-half to three quarts.

The results reported by Major Lyons cover experiences with penicillin in 11 Army hospitals where every detail of the treatment was studied with great care so that as much as possible might be learned about the drug, effective doses, conditions that would be helped and those that would not, and the like.

MALARIA IN BENGAL—A SCIENTIFIC PROBLEM

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THE author in his professional capacity as Malaria Engineer to the Government of Bengal has often been confronted with a common question as to whether his qualifications were that of a medical man or an engineer. Learned professors, engineers, doctors, lawyers—all kinds of men have expressed their astonishment in the knowledge that an engineer could in any way be associated with malaria. Malaria control is erroneously regarded as a monopoly of the medical profession and the popular ideas regarding malaria control are associated with quinine therapy and at best with oiling and paris-greening.

That malaria is a problem in Bengal, nay the first problem, is unquestionable. The solution of this problem requires knowledge of scientific principles which are more engineering than medical. Yet in the absence of any scientifically co-ordinated national planning, the engineers who made 'two blades grow where one grew before' have also made two mosquitoes breed where none bred before. A history of malaria in Bengal is a history of embankments for roads, railways and rivers, insufficient waterways, obstruction to natural drainage of the country and creation of innumerable borrowpits which hold stagnant water and become excellent breeding places for anopheline mosquitoes. There are three conditions to be set right if we want to solve the problem of malaria in Bengal.

LACK OF PUBLIC CONSCIOUSNESS

That there is a lack of demand for controlling malaria in this province would be self-evident to all who would care to feel the pulse of the community. The self governing local bodies who are primarily responsible for the public health in their respective areas have signally failed to do anything. For approved antimalaria schemes of a permanent nature submitted by the local bodies (including Union Boards) the Government usually make a contribution of two-thirds of the estimated cost provided the local bodies come up with the remaining one-third and undertake to maintain the works. The local bodies have so far placed malaria control as the last item in their budget and have not been able to take advantage of Government contributions, and therefore a very considerable amount of budget money allotted by the Government for antimalaria schemes, lapses every year. It may here be emphasised that the local contributions need not necessarily be in

cash but may be in kind e.g., voluntary labour, and that many small schemes might be undertaken which would entail earth work, e.g., in connection with re-excavation of dying streams and silted up channels, filling up of low lands and pits, etc., which could very well be done by volunteers if properly organised. One District Engineer (employee of local board) not only wanted full contribution of the entire cost of schemes from the Government but also wanted contribution for expenses of survey works before he would so much as undertake preparation of schemes which subsequently might or might not be accepted by the Government. He was not prepared to spend anything from the allotted travelling allowance budget for his overseers and subordinate staff for their going out into the fields for survey works for preparing schemes of malaria control because that sacred money was to be more usefully spent for supervision in connection with the more important public works such as construction of roads or providing more comfortable furniture and crockery for the Inspection bungalows! And this is in reference to a district which is notorious for malaria. Some other bodies are so busy with their other nation building programmes that in spite of repeated offers of technical help for preparation of anti-malaria schemes, they have found no time even to reply after the tenth reminder.

LACK OF SCIENTIFIC PLANNING

One of the first principles that a malariologist has to learn is that imitation in antimalaria work is dangerous. Every area has its own problem which requires investigations and the measures of control that are adopted must be specially suited to local conditions. Because certain measures have succeeded in say, Malaya, Java, or Ceylon there is no reason to believe that the same measures applied to Bengal would invariably succeed.

Measures have been adopted piece-meal throughout the province which show a lack of scientific planning. Many organisations are overzealous in removing jungles as an antimalaria measure. Others by applying kerosene oil to a few feet of drains and one or two tanks hope to control malaria. It may be mentioned here that without water there can not be any anopheline breeding and jungles as such do not breed mosquitoes. Not all mosquitoes are dangerous. Out of forty-three different species of

anopheline mosquitoes found in India not more than three or four species are responsible for transmission of malaria in Bengal. Others are quite harmless. Again in a particular locality not more than one or two species are really harmful. A person can not be infected with malaria unless an infected mosquito bites him successfully, and that drinking of water from questionable sources is never a factor in producing malaria.

From the malaria point of view this province may be divided into three, more or less distinct geographical zones.

1. *The foot hill malaria zone.*—The Himalayan foot hill zone when covered with virgin jungles is naturally free from malaria. Human interference by indiscriminate opening up of jungles for tea cultivation and establishment of colonies have very often led to intense malariousness. *A. minimus* is the vector species of anophelids responsible for malaria in these regions. Hill streams and seepage water collections exposed to sunlight and having suitable plant life for supplying food for the larvae are the excellent breeding grounds. Dense shade has been considered to be unfavourable for *A. minimus* breeding. Researches of Muirhead Thomson have established the true significance of shade in controlling *A. minimus* breeding, and removed many erroneous ideas. It has been proved that shade in itself plays no part in controlling *A. minimus* breeding, on the contrary shade is very attractive to the gravid female and the indiscriminate use of shading plants might do more harm than good. The control is entirely due to secondary effects of shade by bringing about mechanical changes. "Although *A. minimus* breeds in association with running water, in the grassy edges where eggs are laid and larvae breed is still water. Larvae of *A. minimus* are unable to resist a current of 0.29 ft./sec. The powers of resistance are not much greater than those of *A. hyrcanus* a still water breeder, and about the same as that of *A. aconitus* and *A. maculatus*. When the grassy edge of a natural breeding place is removed either temporarily by cutting or permanently by shading, the zone of still water along the edges is eliminated and there is an increase in flow. The absence of still water will effectively prevent the gravid female from ovipositing and at the same time, if the water at the edge is moving faster than 0.29 ft./sec. will prevent any existing larvae from anchoring on. This velocity is the absolute maximum compatible with larval security".

It is thus seen that velocity along the edges is the determining factor in controlling *A. minimus*. Flushing the streams and channels by means of sluices or automatic syphons has been a successful measure in other countries. Here again judicious

care and planning are required for achieving successful results. The author has come across several sluices and automatic syphons installed over hill streams, which are complete failures due to lack of proper design and selection of site. There was one sluice whose foundation was not deep enough and had consequently been scoured to such an extent that water was passing below the foundation to the downstream and leaving the whole structure like a more or less hanging wall. No water could accumulate in the upstream side and consequently there was no flushing. The sluices were put in wrong positions and even if they were working properly, only a very small length of the river bed down-stream could have been properly flushed owing to numerous bends and zig-zag course of the river. In such cases it is essential first to train the river by straightening out the bends, and putting in smooth curves where absolute straightening is not possible. During the early stages of river training it will be necessary to put in protective works at points where the new alignment would deviate from the old one, because the river will have a tendency to retrace its original course such straightening of the course would lead to a greater velocity which would manifest itself in tending to scour away the bed and keep it more or less free from excessive deposition of silt. This will considerably reduce the work of the maintenance gang. A greater velocity provided the edges are kept clean, would in itself be an excellent and immediately successful anti-malaria measure against *A. minimus*. After the river has been trained as far as possible it would be possible to locate the exact suitable positions for sluices, if at all found necessary. It is always a good plan to instal only one sluice to start with and watch the results. On the basis of its working additional sluices may be added with any modifications found necessary.

Subsoil drainage may sometimes prove suitable in dealing with seepage water, in such regions.

2. *Inland Plains—Deltaic Regions.*—Stretching from the southern extremity of the foot hill zone down to the coastal regions, is the area where *A. philippinensis* is the principal vector responsible for transmission of malaria. There is no exact line of demarcation between this area and the foot hill zone. *A. minimus* has been found to be a vector in the district of Jalpaiguri and even down to Rangpur. *A. philippinensis* generally breeds in clean water tanks, ponds, borrowpits etc. The numerous tanks and pools of which there is an average one per holding, are excellent breeding places. The species does not generally breed in polluted waters and prefers more or less sunlit areas. Paddy fields in general are harmless so far as this particular species is concerned.

Observations in one research station extending over a considerable number of years have shown the innocuousness of the paddy fields. It has further been found that not more than 3 to 30% of the breeding places (tanks and pools) breed the particular species at any one time. This gives an excellent possibility for 'species sanitation' because a large majority of the breeding places may be altogether neglected based on a searching and regular weekly larval survey of all the breeding grounds. This results in a considerable saving of larvicides, and the author has successfully applied this method in another experimental station.

Oil, parisgreen, or any other larvicide or insecticide, however cheaply applied, is however no solution for Bengal malaria. Flushing the land with silt laden flood water in the deltaic areas appears to be the only cheap, permanent and successful method. This aspect has been clearly dealt with by Dr Bentley. Formerly the deltaic rivers when they were unfettered and free from human interferences like embankments used to spill over their banks during the rainy season. The rise in flood level was gradual and the flood water used to flush the whole country from field to field which ultimately became a vast lake of water. The flood water also entered the numerous tanks, pools and pits. This silt water is inimical to anopheline breeding, or more correctly it created conditions which were unfavourable for anopheline breeding. Silt which is a natural manure used to deposit in the fields and enrich the soil, and clear water used to drain out subsequently through numerous rivulets and channels. This annual flushing not only kept the country free from malaria but also enriched its agriculture. Of course there were temporary inconveniences due to such flooding but the floods were never so disastrous as we experience now-a-days. Owing to putting up of embankments the rivers can no longer overtop their banks and the silt that used to be deposited on the land and thereby gradually raise its level, is now deposited in the bed of the river itself. The result is that the river bed is continually rising but the country level remains the same so that the embankments have to be raised higher and higher to protect the land against flood. The land becomes devoid of the rich fertilising silt which results in deterioration of agriculture so much so that the yield per acre in Bengal is now approximately one-third of what it is in other countries.

Controlled irrigation with flood water or flood flush drainage schemes where possible would certainly solve the malaria problem. The malaria problem in this region is mainly an irrigation and river problem.

Fish plays another important role in controlling malaria. It is the small fry which are more helpful in this respect but the people are so poor and ignorant

that even these small fish are caught in plenty for use as food.

3. *Coastal Regions and Tidal Zones.*—In the coastal regions and tidal areas the vector species responsible for malaria is the saline water breeder *A. sundaius*. In the tidal zone where the saline tidal water during spring tide can get through creeks and canals into nearby tanks and pools or other water collections, conditions are created which are most suitable for the breeding of *A. sundaius*. During the spring tide saline water may enter into remote areas which unless flushed by daily tide increase in salinity owing to evaporation of certain amount of water for a fortnight. Such water collections, with appearance of aquatic vegetation, become favourable breeding places for *A. sundaius*. This species has the fixed habit of breeding in the water collections which are reached by the spring-tide but are not flushed by the daily tides. Hence the rational method of control of *A. sundaius* would be either (a) to completely prevent the tides from getting into water collections and low lying lands or (b) to bring the area completely under the daily tidal influence of the river or sea. There should not be any compromise between the two. The flushing channels should be provided with sluices so that the entry of tidal water into them during flow tide, or drainage from the countryside during low tide, may be controlled at will. The entry of saline water into remote areas can be prevented by keeping the sluices completely closed during spring tide.

The designs of flushing channels require careful consideration. These flushing channels should serve the dual purpose of flushing during the high tide and draining during low tide. For purposes of designing drainage channels, the usual run-off for this part of the country is taken as $\frac{3}{4}$ " per day. Knowing the catchment area to be drained the required discharge for drainage alone can be determined. The figure must be increased to take care of the amount of additional tidal water that would be admitted into the canal for flushing during flow tide and which will have to be drained out during low tide. From the slope of the proposed canal (slope is determined by the ground levels) the necessary width and cross section of the canal can be designed.

If V =velocity of flow in feet per second; C =a coefficient of discharge; A =area of cross section of channel in square feet; p =wetted perimeter of the channel in feet; r =hydraulic radius= $\frac{\text{Area of section}}{\text{Wetted perimeter}}$;
 $= \frac{A}{p}$; S =hydraulic gradient or slope of channel= $\frac{\text{Difference in level}}{\text{distance}} = \frac{h}{l}$, h =fall in feet between points considered, l =distance in feet between points considered; then $V=C\sqrt{rs}$, and Q =discharge in cubic

feet per second (cusec) = $AC\sqrt{rs}$. The coefficient C can be determined from Kutter's formula

$$C = \frac{41.65 + 0.00281 + 1.811}{1 + (41.65 + 0.00281) \frac{n}{s\sqrt{r}}}$$

where n = coefficient of rough-

ness which varies with the nature of surface of the channel. For straight and uniform earthen channels in fair condition 'n' may be taken as 0.025.

Example.—A proposed channel is to drain an area of say six square miles and also serve as a flushing channel for flushing the adjoining area with tidal water. The slope of the channel as determined by the ground levels and the water levels of the river from which it is to be flushed with tidal water during flow tide, is 1 in 2,500 (i.e., a fall of one foot in a length of 2500 feet). Taking $\frac{3}{4}$ " per day as the run-off, the required discharge would be, 6 square miles $\times \frac{3}{4}$ $\left(\frac{1 \times 5280 \times 5280}{12 \times 24 \times 60 \times 60} \right)$ cubic feet per second = $6 \times \frac{3}{4} \times 27$ (1 inch per square mile per day is equivalent to 27 cubic feet per second) = 121.5 cusec. Allowing for a flood water of say 80 cusec the total required discharging capacity of the channel would be about 200 cusec. If the depth of water in the channel is to be say 4 ft. and side slopes of $1\frac{1}{4}:1$, then a channel with a bed width of 16 ft. would meet the present requirements. This channel would give a maximum discharge of 206 cusec as can be found out by applying the given formula. In actual practice it is not necessary to make all the detailed mathematical calculations, as ready-made discharge tables and charts are available for varying conditions of flows.*

LACK OF CO-ORDINATION

Malaria in Bengal is in a large measure due to man-made causes. The Intergovernmental Conference on Rural Hygiene (1937) pointed out that although in some Far Eastern countries a fair degree of co-operation had been developed between health officers and engineers for the avoidance of malaria, yet the engineer-made malaria in other countries was appalling. Such malaria was 'due to improper siting and housing; indiscriminate aggregation of labourers; uncontrolled jungle clearing, excavations such as borrowpits, brickfields and quarry pits; obstruction of natural drainage by road, railway and canal embankments, with culverts too few and too high; impounding of water without regard to leakages, seepages and raised water table levels; irrigation without drainage'. These causes equally apply to Bengal.

* The data are not sufficient to be convincing. Workers in the line may not agree with all the assumptions made.—*Ed. Sci. & Cul.*

Public Works and Public Health Departments, engineers and medical-cum-public health workers in the past used to work in more or less water tight compartments. Much ground-work has been done in Bengal to co-ordinate the activities of the different departments, and engineering schemes inaugurated in the province are first examined by the Public Health Department to ensure that they do not adversely affect the health of the country. Instructions have been laid down for the guidance of the various departments in matters affecting public health with a view to controlling malaria in this province. Much more yet remains to be done. The lack of education and public health consciousness amongst the mass are the serious obstacle. While measures might be adopted for controlling malaria in an area, practically nothing can be done to prevent the people from creating further insanitary conditions e.g., by digging more borrowpits or *dobas*. Of course the Union Boards and local bodies have got sufficient legal powers to enforce public health principles if they seriously want to apply them, but it is rarely done, as in that case the next elections would probably see them out of office. Russel dreams of a golden age in which 'all civil, electrical and irrigation engineers in malarious countries will have some training in public health and specially in malariology as related to their own profession'. Medical officers should also turn more readily to engineers for technical help.

RATIONALE OF PLANNING MALARIA CONTROL

Malaria control for a country must proceed on three different and distinct stages.

Phase I—Investigation.—Medical men should make a survey of the malaria situation and state the extent of malaria in the locality.

Phase II—Scientific Research.—Biologists aided by chemists and physicists should carry on research and studies about the habits of the vector and it is for them to evolve a problem, and a sane and practical problem, which if solved would eliminate either wholly or sufficiently the anopheline vector.

Phase III—Execution.—Engineer should now step in to take up the problem and find out means for solving the problem. As an example, when the biologists at Durrazzo found out that if the salt content of the marsh could be increased to more than 18 parts per 1000, '*Elutus*' the dangerous type of mosquito for that locality would not breed in that water, it was then for the engineer to find out a method of doing it, and he did it successfully.

What then are the known problems in Bengal, and what are the probable answers?

1. FOOT HILL MALARIA—*A. minimus* zone.

Problem.—Increasing the velocity of water to more than 0.29 ft. per second and *A. minimus* would not breed.

Solutions.—(a) Cleaning the edges free from vegetation—immediate results; (b) Dense and complete shading; (c) Flushing after training the rivers; (d) Subsoil drainage to a limited extent.

2. INLAND PLAINS—*A. philippinensis* zone.

Problems.—(a) Deltaic area:—Silt laden water inimical to anopheline breeding. Bentley has shown with numerous facts and figures that in the deltaic regions of Bengal (when the flood water was unobstructed) the prosperity of the people and the absence of malaria were due to a system of irrigation which flooded the land with silt laden water. Even in Egypt the red water carrying silt is associated with prosperity and the white water with malaria and lesser yield of crop. How silt water is inimical to anopheline breeding is not definitely known. Bentley has given several reasons which however can not be taken as conclusive. Much information in this respect is lacking compared to research work done in Italy. Very little is known about the varying silt contents of the different rivers and the degree of turbidity which is most suitable for the purpose of malaria control. Nor do we know exactly (notwithstanding possible reasons given by Dr Bentley) how silt acts as a deterrent. If more exact knowledge were available in this respect, engineers could have offered more satisfactory solutions. Here is a vast field for study and research by scientists.

Solution.—Flushing with silt laden water diverted from the rivers by means of channels and by reviving the natural processes.

(b) High lands—Non-deltaic regions:—In many areas there is no possibility of flood flushing yet the malaria problem is very intense. The tanks and pools are the major breeding places. We know very little, practically nothing, which would help in offering a cheap and satisfactory solution. Here is another big field for research workers.

Solution.—Oiling or paris-greening, cleaning the tanks, herbage packing, insecticidal spray etc. and such other expensive methods can do doubt lead to success, but poor Bengal cannot afford it. Fish seems to be the only cheap solution but in this also there are many difficulties. Will the scientists give us a definite problem to solve?

3. COASTAL AREAS AND TIDAL ZONES—*A. sundaicus* zone.

Researches so far have not given any definite range of salinity in which *A. sundaicus* would breed. It is said to be adaptable to wide range of salinity from very low to very high. Combined with this is the problem of irrigation. Paddy will not grow in water having a salinity over 75 parts per 100,000. Certain types of crops can resist a maximum of salinity of 200 parts per 100,000. The agriculturalists in these areas have put in marginal embankments for excluding saline water from entering into the fields. The results have been that the rivers can not have a free spill. Water remains stagnant in the country side, and stagnant saline water is an excellent breeding ground for *A. sundaicus*. Restoration of free spill would of course control malaria but the crops would at the same time be damaged. Here is a wide field of research for agricultural experts to find out a crop that would acclimatise itself to higher ranges of salinity. Here is a problem in which the interests of the cultivators and public health are at variance which the scientists may try to accommodate. Abandonment of rice cultivation and development of pisciculture would no doubt be a solution but that is not likely to be within the range of practical politics.

Malaria is Bengal's curse. It is the one problem that led to many, one that has crippled us, sapped our vitality and given rise to utter despondency which is about to ruin our very culture. It is a formidable foe which no single effort can control. The difficulties are that we are much behind in the development of *Phase II* of malaria control on which the greatest amount of stress must be laid by scientists and research workers. It is a proved fact that given sufficient funds malaria can be controlled in any locality. But where are the funds? Oil or Parisgreen or any insecticide applied however efficiently and cheaply, is no solution. Poor Bengal can not afford to finance such recurrent expensive schemes to combat rural malaria. It is here that the biologists and scientists must come in and find out some naturalistic method of control which would be sound from practical as well as financial points of view.

Let us all join hands and offer our humble mite. Here then is a great circle where the medical men can freely join hands with the engineers and with no less glory the scientists of all shades—Chemistry, Physics, Biology, Agriculture; and also Educationists and Financial experts.

BOOK REVIEWS

Social Studies and World Citizenship—By L. J. F. BRIMBLE and F. J. MAY. Macmillan & Co., 1943, xii, 158. Price 6s net.

"However people may disagree about the form that the new social order will take, all agree, though often vaguely, that 'things will never be the same again'. With the changes in the social order, changes in the educational world will come simultaneously, and when changes are inevitable, it is incumbent on those who have long wanted and worked for reform to be ready with clear ideas on the forms these changes should take." The book opens with this refreshing preamble. "Things will never be the same again" indeed. Wars are notoriously devoid of anything constructive in the sphere of ideas; but this war, unlike the preceding ones, has vigorously shaken the age-old inertia in the fighters, in the front as well as in the rear. What are we fighting for? they ask. Are we fighting for our betterment or are we to be enlisted once more in the post-war unemployment brigade? And precisely this trend in their thinking will be mainly responsible for the shape of things to come in the peace time. Similarly, in the years to come those who are keenly interested in social problems will feel indebted to the writers who are arduous enough to go deep in search of the bases on which our society is built and also bold enough to face themselves and expose before their readers the facts as they are. New paths in social studies can now be explored only when the classic view of the society as being static is given up and writers begin to realise that society must be studied in its proper perspective of dynamic background.

Once this 'academic tradition' is broken the writers could be made to see the futility in studying society ignoring contacts with the people around him. This conclusion would bring them a step nearer to the stern reality that social studies can only be considered thorough when its economical environment is given the proper place. Quotations are not necessary to prove that social behaviour in Arabia is different from that in U.S.A. and definitely not the same as in the U.S.S.R. A boy who has faced starvation in his childhood would obviously manifest features characteristic to his class differing extensively from one born with proverbial silver spoon in his mouth. It is simple enough to distinguish the members of a feudal zemindar family by their manners and customs from those of wage earners or

industrial magnates. Vices and virtues in an individual or a nation are too closely connected with the problems related to bread and butter. Repugnant though such a notion may be to the sophisticated writers in matters ethical they are, nevertheless, true as conclusively proved by the recent empirical investigations.

Whatever the final analysis of the social structure may be, lack of critical attitude of the writers make most of the books meant to be social studies mere superficial studies. A similar limited vision has led the writers to believe that "Many agencies which can actively foster world citizenship are already in existence; for example, the International Postal Union, Red Cross Organisation, Travel Science, League of Nations, International Bureau of Education . . ." But then the League of Nations and the hosts of International Bureaus, which in the writers' judgment are temples of peace, could not prevent the war, neither any sane person would expect anything better in future not unless the poisonous root of exploitation of one nation by another is exterminated for ever.

It is amusing to note while discussing at length the topic World Democracy the writers have reprinted from *The Times* a letter from an aviator in the R.A.F. written to his mother, ". . . History resounds with illustrious names who have given all, yet their sacrifice has resulted in the British Empire, where there is a measure of peace, justice and freedom for all, and where a higher standard of civilisation has evolved, and is still evolving, than anywhere else . . ." In the opinion of the writers the aviator is "a type which we as teachers together with the parents of our children, must aim at developing for the generations to come." I wonder if the writers mean to build world democracy on the foundations of which they have unconsciously given us a glimpse!

The writers share in the belief pathetically held by most of the ardent educationists that "The failure to teach the fundamentals of the international relations is due either to an innate aversion to teaching such material, or more probably the inertia of educational leaders has kept it out of the curriculum." Under the existing circumstances prevailing in the five-sixth part of the globe education is controlled by the State directly or indirectly and the apparatus of the State is in the hands of the few men at the helm, thus, education becomes a mere system through which the will of these handful of people prevail,

and no amount of enthusiasm expressed by the educational leaders could alter the state of things.

The book opened with a statement which is in harmony with the changing world, and as one turns the pages coming to the close of the book he would be naturally led to conclude 'all that glitters is not gold'.

N. P. M.

Technical Education—By J. C. GHOSH, B.Sc. (Manchester). Preface and Introduction—95 pages, main body of the book—152 pages. Appendices—156 pages.

The book is a collection of different articles by the author published in some daily papers and journals. Main theme is the utility of and necessity

for technical education in India and an earnest appeal to the people to go in more for technical and vocational training for their own economic interest and industrialisation of the country. Such appeals might have been necessary 40 or 50 years ago; the present day problem is the establishment of sufficient number of institutions for technical and vocational training of all kinds and standards to provide for all young aspirants after such lines of training, but one should remember that technical education alone cannot industrialise a country; it simply supplies the personnel for the production side of the industries; a technically trained person is not necessarily a good business man. Moreover under the present world conditions a good and stable national government is a pre-requisite for the industrialisation of a country which cannot be effected piecemeal.

H. L. R.

LETTERS TO THE EDITOR

[The editors are not responsible for the views expressed in the letters.]

PECTIN IN FRUITS OF THE INDIAN PERSIMMON
(*D. EMBRYOPTERIS, PERS.*)

A HOT water decoction of the mature fruits of the Indian Persimmon finds an extensive application in the seasoning of the fishing nets and in applying as a paint on the country boats. While searching for new indigenous raw materials for tannin I turned my attention to this common fruit (Gab). It contains a pyrogallol tannin but great difficulty was experienced in the isolation of it in the pure state in as much as the extract obtained in the usual way when dried on steam-bath turns insoluble in water. While trying to purify it by the addition of alcohol to a concentrated extract of the stuff, voluminous gelatinous precipitate appeared which when carefully washed did not give the usual tests for tannin but it responded to the tests for pectin.

Another method was also found very suitable for the separation of this stuff from the concentrated aqueous extract. On the addition of hydrochloric acid to the above mentioned extract the pectin separates out which can be washed with water and dried. As the fruits appear to contain a high percentage of pectin (about 50% of the weight of the fruit) and the fruits are obtainable in great abundance at a low cost it may form a very good sizing material in the textile industries.

Work is in progress in this laboratory for the isolation of pure tannin and pectin from the Indian Persimmon.

H. G. BISWAS

Sir Prafulla Research Laboratory,
Bengal Chemical & Ph. Works Ltd.,
Calcutta, 3-1-1944.

MEASUREMENT OF CAPACITANCE

The note describes a modification of the De Sauty's bridge for measuring capacitance of the order of $1 \mu\mu$ Fd. at audio frequencies instead of taking resort to radio frequencies and radio methods.

The well known Carey Foster's A. C. bridge¹ fails to measure capacitance of the order of $1 \mu\mu$ Fd. at telephonic frequencies. Instead of trying with the radio frequency methods a modification of the simple De Sauty bridge has been tried in this laboratory.

Hartshorn² has described a modification of the schering bridge where the voltage applied has to be stepped up gradually in order to attain the requisite sensitivity at balance. Moreover it is only applicable

tween the 7th and 18th August in *C. capsularis* and 20th and 26th August in *C. olitorius*.

Off season sowings in winter (October to December) shortened the vegetative phase and the plants remained very short with very few internodes. Sown on 28th September the plants flowered after 36 days in *C. capsularis* with an average height of 3 ft. and 27 days in *C. olitorius* with an average height of about 2.5 ft., the heights of normal season plants being 10–11 ft.

(2) *The effect of Photoperiod.* Sown on 20-4-43 two sets of each species were exposed to short photoperiods of 3 hours less than normal daylight, one set from the germination stage and the second set from when the plants were one month old. It was seen the 1st set of *C. capsularis* and *C. olitorius* flowered in 33 and 28 days and the 2nd set in 47 and 44 days and the control in 114 and 125 days respectively, the earliness in flowering being 81 and 67 days for the 1st and 2nd set of *C. capsularis* and 97 and 81 days for the same sets of *C. olitorius*. Earliness of flowering was associated with dwarfness, fewer internodes and more branches, making the plants bushy.

In the winter with normal short photoperiod, further reduction of the daylight period had no effect, longer photoperiod of 16 hrs. prolonged with artificial electric light however delayed flowering, with increase in heights and internodes.

(3) *The effect of vernalization:* Soaked seeds with swollen embryos were exposed to temperature varying from 2–5°C for 7 days and 14 days and sown with control set. No effect due to treatment on the onset of flower, height and number of internodes could be observed.

Similar experiment was repeated in winter exposing the seeds for 10 and 20 days but there too no difference due to treatment was observed.

(4) *The effect of storage:* Seeds stored for 1, 2 and 3 years were sown along with the 3 different sowings of the time of sowing experiment. Except that the 3 year old *C. olitorius* seeds failed to germinate, there was no effect of storage for 2 or 3 years on height, internodes, branching, onset of flowering etc. in the two species.

(5) *The effect of X-rays:* Soaked seeds with swollen embryos were exposed to two doses of X-ray 500 and 1500 r. units at 100 KV., 10 mil. amp. and sown with control. No difference on the rate of growth, height, internodes and onset of flowering could be seen between the control and treated plants. About 20% of plants treated in 1500 r. units remained short and the stem showed a dichotomous bifurcation at the 10th or 11th internodes generally after 5th week of sowing.

Our thanks are due to Dr J. S. Patel for the supply of pure seeds, to Prof. P. C. Mahalanobis and Mr R. C. Bose for the design of the experiments and to Dr S. Mukherjee for the use of the X-ray apparatus.

J. C. SEN GUPTA
NIRAD KUMAR SEN

Botany Department,
Presidency College,
Calcutta, 25-3-1944.

ESTIMATION OF CAESIUM IN PRESENCE OF POTASSIUM AND RUBIDIUM WITH RARE EARTHS

THE close similarity in the chemical behaviour of potassium, rubidium and caesium has led to numerous attempts to separate one from the other. In most instances, the separations are only partial and none of the methods so far proposed is in any sense quantitative. The standard methods of alkali analysis are the perchlorate, cobaltinitrite and chloroplatinate methods which precipitate all the three alkalis without any separation.

O'Leary and Papish¹ made a critical review of the various methods available for the separation of the alkali metals where they had shown that none of the methods are sufficiently accurate. They proposed an improved method for the quantitative determination and separation of potassium, rubidium and caesium based on the use in succession of 9-phosphomolybdic acid (K-salt being soluble), silicotungstic acid (Cs-salt being insoluble in 6-N hydrochloric acid) and finally weighing caesium as chloroplatinate. According to the authors, "The method proposed does not afford the clean-cut sharpness of separation that is desirable, though it is much more reliable than those hitherto proposed. The average error introduced in the course of the analysis by this method is two per cent.

Sarkar and Goswami² while preparing the triple nitrites of the rare earths $\text{Cs}_2\text{NaR}(\text{NO}_2)_6$ observed that these nitrites furnished a delicate microchemical test for caesium, the limit of identification-being 4×10^{-8} g. The test is specific for caesium; rubidium and potassium do not interfere.

We have recently observed that the reaction is quantitative, caesium being precipitated quantitatively from the solution under specified conditions and have developed a method for the quantitative determination of caesium and its separation from rubidium and potassium in one operation. The precipitate can be directly weighed in a gooch. Even 3 mgm. of caesium have been estimated accurately,

Macro quantities can be estimated with an accuracy of 0.1 per cent. Micro gravimetric and volumetric estimations are in progress.

P. B. SARKAR
N. K. DUTT

University College of Science,
Inorganic Chemistry Laboratory,
Calcutta, 7-4-44.

¹ O'Leary and Papish, *Ind. & Eng. Chem. Anal. Ed.* 6, 107, 1934.

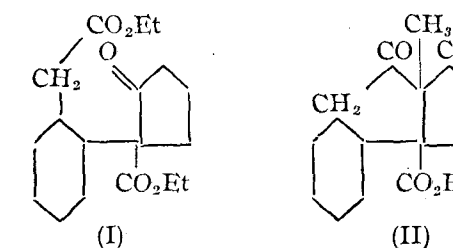
² Sarkar and Goswami, *Jour. Ind. Chem. Soc.*, 608, 1935.

SYNTHESIS OF THE ALICYCLIC SYSTEMS RELATED TO THE STEROIDS

A few model experiments have been carried out to build up a fused system consisting of B, C and D rings with the C_{13} -methyl group and the isooctyl side-chain characteristic of the sterols, starting from cyclohexane derivatives. Ethyl methylmalonate was condensed with isohexyl iodide to give the corresponding malonic ester (122-25°/7 mm.) which was hydrolysed with sulphuric and formic acids to give α -(dimethylheptic acid (115-25°/9 mm.). The acid chloride of the above acid reacted with diazo-methane which was subsequently decomposed with 48% hydro-bromic acid to give the bromo-ketone (103°/9 mm.). Next it was condensed with the sodium-salt of ethyl aceto-acetate kept under ether and the condensation product was hydrolysed with 2% caustic soda solution at 60°C for five hours. On cooling it was acidified and boiled for ten minutes. The product which was isolated from the reaction mixture was 2-isooctylheptane-3:6-dione (122-27°/6 mm.) and not the expected cyclopentenone derivative.

Next methylcyclopentene was oxidised in acetic acid solution with selenium dioxide and the alcohol, isolated by the known method was converted into bromide which was condensed with the potassium salt of cyclopentanone carboxylic ester. A product was isolated boiling at 130-35°/4 mm. which on hydrolysis with baryta gives 2-methylcyclopentenyl cyclohexanone (115-25°/7 mm.) in a poor yield together with a high boiling gummy product (255-40°/4 mm.). Cyclohexyl bromide was condensed with the potassium salt of cyclopentanone carboxylic ester to give cyclohexylcyclopentanone ester (140/50°/8 mm.) which was hydrolysed in a sealed tube with HCl to give cyclohexylcyclopentanone (105-107°/7 mm.) together with a highly crystalline solid residue. Ethyl $\Delta^{1,2}$ -cyclohexenyl acetate was treated with bromine

in tertiary butyl alcohol. Next the element of hydrogen bromide was removed with sodium methoxide when the unsaturated bromo-ester was obtained boiling at 120-25°/7 mm. It condensed smoothly with cyclopentanone carboxylic ester in presence of potassium when the product was isolated boiling at 195-200°/10 mm. Catalytic hydrogenation gave a clear colourless oil boiling at 165-70°/3 mm. (I). It was hydrolysed in a sealed tube with HCl and the free acid was esterified when the keto-ester was obtained boiling at 140-45°/3 mm. The keto-diester (I) was allowed to react with methyl magnesium iodide and the crude hydroxyester so obtained was dehydrated with thionyl chloride and pyridine to give the unsaturated ester boiling at (168-73°/4 mm.). Hydrolysis with methyl alcoholic potash gave the free acid which on treatment with P_2O_5 in benzene solution gave a ketonic product (135-45°/4 mm.) in a very poor yield. This could not be isolated in sufficient quantity but it gave a semicarbazone somewhat coloured melting at 238-42°. The free acid was converted into the chloride, which on treatment with stannic chloride gave a chloro-ketone (II) in a poor yield (140-50°/3 mm.).



Active investigations are in progress with 9-methyl α -decalone systems on the one side and isooctylcyclopentanone carboxylic ester serving as the second component thereby leading to the building up of the complete skeleton of the sterol type of molecules. Encouraging results have been obtained and this will form the subject matter of the next communication.

Our grateful thanks are due to Prof. P. C. Mitter for his kind interest and advice during the course of this piece of work.

P. C. DUTTA
M. C. MITTER

Sir P. C. Ray Fellow's Laboratory,
Department of Chemistry,
92, Upper Circular Road,
Calcutta, 7-4-1944.

THE DAMODAR FLOODS AND AFFORESTATION

I

The commentary on a discussion by the Central Board of Irrigation, on the Damodar floods and the general problem of flood control, appearing on p. 232 of the December issue of "Science and Culture", is likely to give a wrong impression on the value of afforestation in reducing floods. I refer particularly to the remarks:—

"The claim of afforestation as expressed in the above discussion seems to be highly exaggerated and is quite conflicting in its scientific bearing".

Apart from the use of quotations originating in 1931 and 1936 to try and disprove a statement made by a technical expert in 1943, the quotations themselves do not provide very convincing support for the commentary quoted above.

The first held that afforestation should be strongly encouraged but stated that its effect on floods was indeterminate. This was in 1931.

The second quotation read:

"Detension dams, dykes and similar engineering measures are essential to *complete* flood control in localities where the hazard is unusually severe" (the italics are mine).

It is not my purpose to discuss the pros and cons of detention reservoirs, but it is clear that without measures such as afforestation and proper methods of cultivation in the upper catchment, to prevent soil being washed into the rivers, detention reservoirs would soon lose their value, because if the sand washed down is trapped in the reservoirs they will silt up (as has happened to several reservoirs in America), and if the sand is allowed to be carried downstream it will be a cause of floods by depositing downstream.¹ Hence the word *complete* in the second quotation, and it is clear that afforestation and proper land control are intended to be the primary measures to be taken.

Far from being exaggerated, the figures quoted at the meeting of the Board were based on data. Here are some more:

I. In an experiment it was found that more than 24 times as much water ran off from the bare area as from that covered with litter; 3500 times as much soil may be washed by rains from bare soils as from soils protected under a relatively thin cover of leaf litter.²

II. Over a period of seven years the average loss of water by run-off on bare, uncultivated ground, was over 40 per cent of the total precipitation, and over 15 tons of soil per acre were eroded per annum. On being veiled with a complete vegetal cover the average annual loss by run-off during the same period was 0.5 per cent. of the total precipitation, and the loss of soil through erosion was nil.

These experiments clearly demonstrate not only the vital necessity of maintaining the vegetal cover, but also the care that must be exercised in the management of arable land if losses of moisture and soil are to be kept down to any degree of insignificance.³

III. The following are extracts from data of run-off and water absorption for loessial soils Holly Springs, Mississippi, U.S.A.⁴

Plot	% rainfall absorbed	Relative quantity of soil eroded
Oak forest	99	1
Bermuda grass pasture	96	4
Barren abandoned land	52	3519
Cultivated cotton rows on contour	53	1528
Cultivated on slope	41	4300

While quantitative results depend to a considerable extent on local conditions, e.g., ground slope, and character of soil, the enormous influence of maintaining vegetable cover, and of proper cultivation methods, on floods and soil erosion, surely needs no further proof.

Secretary,
Central Board of Irrigation.

Kennedy House,
Simla, S.W.; 4-2-1944.

¹ Remarks of Mr Inglis quoted in SCIENCE AND CULTURE, 9, 232, 1943.
² Scott Leavitt: "The National Aspects of Soil Erosion and Floods and their Control by Vegetative cover", *Journal of Forestry*, Washington, March 1932.
³ Union of South Africa, Dept. of Ag. & For. "Soil Erosion Control in the Union", 1938.
⁴ H. G. Meginnis: "Effect of Cover on Surface Run-off and Erosion, Loessial uplands of Mississippi". (Quoted by R. M. Gorrie: "The Measurement of Soil Erosion and Run-off". *The Indian Forester*, Dec. 1937, p. 841).

II

We have published a letter received from the Central Board of Irrigation. In connection with the various commentaries which have accumulated in course of the controversy on the relative efficiency of afforestation and flood detention dams on flood control with special reference to the Damodar, we note the following important issues:

(1) The topic is extremely controversial, opinions going to extremes; one set of authorities say that afforestation reduces the run off, while others say that it may also increase the flood tendencies (for example, Sherman Woodward, Chief Planner, T.V.A. Headwaters control and use: Upstream Engineering Conference, 1936, p. 210).

(2) Such widely conflicting results cannot be explained away without going into the details of the individual experimental conditions, and any generalisation would be unscientific.

(3) Selected laboratory or controlled field experiments cannot be accepted for generalisation of the statement that afforestation holds 98-99 per cent of the precipitation, for it is not known how far these laboratory or field measures can be actually translated to a large catchment area. It would be more honest to accept the result of the U. S. Civilian Conservation Corps which gives a maximum average retardation of 20-25 per cent only, as observed on 141 natural watersheds of the country, through the adoption of practicable erosion control methods.

Extensive afforestation, planting, terracing, dyking, etc. would obviously increase the figure for retardation of the run-off but that may not be practicable over large natural catchment areas due to the abnormal cost which may run up to astronomical figures, for, these measures amount to putting series of dams round every hill, and every sloping lands on the catchment area.

(4) Mr Glass considered the question and remarked that large expenditure on afforestation would be inadvisable for controlling the flood of the Damodar, as the heavy floods are caused entirely by heavy rainfall from 6 to 12 inches falling within 24-72 hours. In such case the soil is saturated with water and can no more retard the run-off by soaking in spite of its vegetal cover. In such cases, all dams round 'hills and slopes' would give way, and floods cannot be helped.

(5) For mitigation of flood, forest cannot be taken to be equivalent to storage reservoirs as they have often been claimed to be. Professor Barrows has remarked: "Unfortunately, too, the advocates of forestry in their zeal for forest preservation often make broad and unqualified statements characteris-

ing all forests as water conservators and using this often erroneous statement as their argument to justify continued forestation, instead of allowing the worthy objective to stand, as it should, on its own merits".

(6) There is no difference of opinion regarding the efficacy of afforestation on soil conservation. Afforestation would be certainly valuable not only for conserving agricultural soil but also for the safety of the dams which should be erected for conservation and controlled disposal of the water resources of the valley.

Afforestation enthusiasts simply ignore the vast amount of work done in the U. S. A. in the prevention of floods by detention dams. Hundreds of detention dams have been constructed, are functioning properly, and floods have been controlled with the additional advantage of water control in river and on land and for the generation of electricity. Proper de-silting methods have been devised by treating the catchment areas properly, and handling the stored water scientifically. The detention dams on the erodable catchment areas (e.g., The Roosevelt Dam, the Elephant Butte Dam, etc.) are functioning quite regularly and show no sign of rapid deterioration as would be predicted by afforestation experts.

Calcutta, 7-4-1944. Ed.—SCIENCE AND CULTURE.

AN INTRODUCTORY NOTE ON THE CHEMICAL INVESTIGATION OF THE PLANT 'VITEX NEGUNDO' (N. O. VERBENACEAE)

THE plant *vitex negundo* has been used in Indian medicine from antiquity both by Ayurvedic and Unani practitioners. We find a description of the plant together with its uses in such standard books on Indian medicines, e.g., *Pharmacographia Indica*—Dymock, Warden and Hopper, Kirtikar Bose—*Indian Medicinal Plants* and *Nadkarni—Indian Materia Medica*. Although the drug is a very popular remedy for rheumatism, inflammation fever and a variety of other diseases, we find that practically no work has been done on its chemical constituents. There are two closely allied species of the plant—one is called *Vitex negundo* and the other *Vitex trifolia* and we find that the vernacular names (Nishinda—Nirgundi—Mewri—Panika Sambhalu etc.) are applied to both these species. At present we are working on the species *Vitex negundo* which can be differentiated from the species *V. trifolia* by its compound leaves—3 to 5 foliate stalked, the leaflets being lanceolate, acute, entire or rarely crenate, while in the other species the leaves are trifoliate or simple, the leaflets being sessile, obtuse and always entire. The flowers and fruits of the latter species are also slightly larger.

Ayurvedic literature recommends the use of the leaves, bark, roots and seeds of the plant. We have isolated in our laboratory from the leaves an essential oil with the following characteristics: Colour—pale greenish yellow, Odour—very characteristics, Refractive index—1.475 (23°), Specific gravity with reference to water at 23°—0.9215, Optical rotation in a 10 per cent solution in chloroform—nil. The oil when applied to the tongue has some cooling effect.

From the air dried leaves of the plant we have been able to isolate an alkaloid which has been crystallised in the form of its tartarate (M.P. 238°C. Charring 242°C.).

Further work on the constitution of the oil as well as on other constituents of this plant is going on in our laboratory and will be published elsewhere.

N. K. BASU
G. B. SINGH

Department of Pharmaceutics,
Benares Hindu University,
Benares, 16-2-1944.

A NEW BALANCED INCOMPLETE BLOCK DESIGN

If v objects are arranged in b sets of k objects each such that every object occurs in just r sets; and every pair of objects occurs in just λ sets; then we get a 'Balanced Incomplete Block Design'. Such designs are important for agricultural field experiments and in other biological researches where statistical methods are applicable. The parameters v, b, r, k, λ are subject to the relations

$$bk = vr; \lambda(v-1) = r(k-1)$$

and as shown by Fisher $b \geq v$. Only designs for which $r \geq 10$ are of interest. Integral values of the

parameters consistent with the above were given in the first edition of Fisher and Yates tables,¹ together with the known combinatorial solutions. A number of solutions for previously unknown cases were added later by R. C. Bose² and others. These researches have enabled Fisher and Yates to fill in, in the second edition some of the blanks which were left in the previous one. A number of solutions however still remain unknown. I give here the solution for the case $v=16, b=24, r=9, k=9, \lambda=3$ which has hitherto remained unsolved.

(1, 2, 7, 8, 14, 15),	(1, 4, 7, 8, 11, 16)
(3, 5, 7, 8, 11, 13),	(2, 4, 8, 10, 12, 14)
(2, 3, 8, 9, 13, 16),	(5, 6, 8, 10, 15, 16)
(3, 5, 8, 9, 12, 14),	(1, 6, 8, 10, 12, 13)
(1, 6, 7, 9, 12, 13),	(1, 2, 3, 11, 12, 15)
(2, 5, 7, 10, 13, 15),	(2, 6, 7, 9, 14, 16)
(3, 4, 7, 10, 12, 16),	(1, 4, 5, 13, 14, 16)
(3, 4, 6, 13, 14, 15),	(2, 5, 6, 11, 12, 16)
(4, 5, 7, 9, 12, 15),	(1, 3, 9, 10, 15, 16)
(2, 4, 9, 10, 11, 13),	(4, 6, 8, 9, 11, 15)
(3, 6, 7, 10, 11, 14),	(1, 5, 9, 10, 11, 14)
(1, 2, 3, 4, 5, 6),	(11, 12, 13, 14, 15, 16)

As pointed out by Mr H. K. Nandi of Statistical Laboratory, Calcutta, this solution has a special interest because from it cannot be obtained by adjunction the solution of the corresponding symmetrical design $v=b=25, r=k=9, \lambda=3$; as the two blocks (1, 6, 8, 10, 12, 13) and (1, 6, 7, 9, 12, 13) have four treatments in common. So far as I know this is the first example of this kind. Details of the method by which the solution was obtained will appear elsewhere.

K. N. BHATTACHARYA

Statistical Laboratory,
Presidency College,
Calcutta, 1-3-1944.

¹ R. A. Fisher, and F. Yates, Statistical tables for Biological, Agricultural and Medical Research, First edition (1938), Second edition (1943).

² R. C. Bose, On the construction of Balanced Incomplete Block Designs, *Annals of Eugenics*, 9, 353-399, 1939.



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FAMINES, ROYAL COMMISSIONS AND COMMERCIAL COMMISSIONS

THE Central Legislative Assembly and the Council of State have discussed over several sittings the recent famine situation of Bengal, and after all, the powers that be decided to send down a Commission of Enquiry which is expected to be embellished with certain insignia of Royalty or something near regal to it. Post-mortems have always to be performed on every individual dead of causes other than natural. The near million that according to official estimates died in Bengal last year of starvation and the other millions which probably escaped official notice cannot obviously escape this ritual. And perhaps as a mausoleum, a gilded report will crown the ashes of the mass cremation. The poet has sung the doleful dirge:

"Can storied urn or animated bust
Back to its mansion call the fleeting breath?
Can Honour's voice provoke the silent dust,
Or Flatt'ry soothe the dull cold ear of Death?"

The words were indeed pregnant with prophecy. Many a Royal Commission have skipped over the country during racing seasons and gone back to send us an arm-chair or fireside message.

The Famine Commission of 1880 set up after the terrible famines in Orissa (1872), and the South India Famine (1877-1878) to find some practicable means of avoiding famines or at least of mitigating their worst effects was the first body to study seriously the possible methods of improvement. Definite action began a few years later: in 1889 Dr Voelcker was invited to India to advise on the steps to be taken; in 1892 Mr James Mollison was appointed as technical Deputy Director for the Bombay Presidency; Dr J. W. Leather came out as agricultural chemist to the Government of India, for the improvement of agriculture was then regarded as a matter more of chemistry than for any other science; sugar cane diseases were causing much loss to the cultivators in Madras and in 1898 Dr Barber

was brought from the West Indies. Yet the last century ending with 1900 saw no less than 31 famines which carried away 32 million souls (roughly as much as the entire population of Great Britain) to be followed only by another Famine Commission in 1901.

We shall now examine the findings of these august bodies and their wise recommendations. The general conclusions may be stated in their own terms.

"In good years he (the Indian peasant) has nothing to hope for except a bare subsistence: in bad years he falls back on public charity." (*Report of the Famine Commission*, 1901).

"It is not surprising to find that the history of the Indian Agriculture in the last 100 years is the history of progressive and continuous deterioration of the soil." (*Report on the Improvement of Indian Agriculture*, by Dr. J. A. Voelcker, 1892).

And what remedies!!

"The numbers who have no other employment than agriculture are in large parts of the country greatly in excess of those required for a thorough cultivation of the land." (*Report of the Famine Commission*, 1880)*

So get rid of them!!

"We attach the highest importance to the establishment of some organisation or method whereby cultivators may obtain advances necessary for carrying on their business without paying usurious rates of interest." (*Report of the Famine Commission*, 1901).

Gold, silver and inflated paper is a substitute for rice and dhal!!

* The Famine Commission of 1880 clearly recognised that to prevent recurrence of famines, not only was agriculture to be improved, but industries were also to be encouraged. We quote from the report:—

(1) In treating of the improvement of agriculture..... the more scientific methods of Europe may be brought into practical operation in India by the help of specially trained experts; and the same general system may be applied with success both to the actual operations of agriculture and to the preparation of the market of the raw agricultural staples of the country. There does not appear any reason why action of this sort should stop at agricultural

"No remedies are possible except through the spread of education, the gradual growth of provident and self-supporting qualities under the influence of painful experience and the success of the stronger and thriftier individuals in the struggle for life." (*Report of the Famine Commission, 1880*).

A good moral lecture to empty stomachs, but probably through oversight it was not mentioned that loyalty perhaps will fill in the other deficiencies in the attempts to reach the goal!

But our saintly poet Kavir has given a better solution on the same tune:

"A hungry man cannot perform Thy service,
Take back this rosary of Thine.
I only ask for the dust of the Saint's feet,
Let me not be in debt.
I beg for two seers of flour,
A quarter of seer of butter and salt.
I beg for half a seer of pulse (dal),
Which will feed me twice a day.
I have never been covetous
I only love Thy name."

Or perhaps the real solution lies in chanting the Biblical prayer thrice a day:

"Oh Lord! Give unto us this day our daily bread."

Then came the Royal Commission on Agriculture in India in 1926, which promised to inaugurate a new era in the life of the Indian countryside.

Indeed the eleven ponderous volumes of report were meant to pave the way for the enthronement of the farmer in the regal palace of the citadel of India and the grazing of our fair fields and pastures by certain John Bull's bulls. It founded an Imperial Council of Agricultural Research and "One of the conditions laid down was that the Council's activities should periodically be reviewed by some disinterested experts." The honour of being the first to do this fell on the large shoulders of Sir John Russel, Director of the famous Rothamsted Experimental Station and Dr N. C. Wright.

In the first year of tenure of the farmer Viceroy, Sir John Russel spent a pleasant winter in India and gave us the message of hope. And here it is:

"The Council's investigations should be directed to increasing the output per acre of food crops with a view both of ensuring full supplies and of liberating land for the growth of the supplementary crops and of fodder crops for the production of milk."

produce and should not be extended to the manufactures which India now produces on a small scale or in a crude form, and which with some improvement might be expected to find enlarged sales, or could take the place of similar articles now imported from foreign countries.

(2) The Government might further often afford valuable and legitimate assistance to private persons desiring to embark in a new local industry, or to develop or improve one already existing, by obtaining needful information from other countries or skilled workmen or supervision and at the outset supplying such aid at the public cost.

"This increased productiveness is the main problem to which all others should be subordinated."

"More systematic schemes of manurial trials are necessary in order to test the relative values of nitrogen in artificial fertilizers, farm yard manures and composts."

"Green manuring should be more systematically studied."

"A Report on the manurial trials fostered by the Council should be drawn up by the statistician, with recommendations for a more systematic treatment."

But compare this halting reference to the efficacy of nitrogen fertilizers in India with his utterance in his book *'Soil Conditions and Plant Growth'* (1932) considered a Bible among the soil scientists.

"Farmers were slow to believe that 'chemical manures' could ever do more than stimulate the crop, and declared they must ultimately exhaust the ground. The Rothamsted plots falsified this prediction; manured year after year with the same substances and sown always with the same crops, they even now after ninety years of chemical manuring continue to produce good crops."

In his latest speech before the Food Group published in "Chemistry and Industry" June 5, 1943, we read:

"It seems strange that in this 20th century there should still be people who think that ammonia derived from organic matter differs in some subtle way from ammonia derived from gas liquor or produced synthetically. I know of no evidence that organic manures produce healthier or more nutritive crops than inorganic fertilizers."

And his prayer during "Britain's War time Food Production Drive" (1940).

Thanks to our highly efficient chemical industry we have almost unlimited supplies of sulphate of ammonia, and to that extent we are much better off than in the last war when nitrogenous fertilizers were very scarce."

And his last will and testament to India:

"The improvement of Indian agriculture has been attempted by many Governments over a long period of years and by a variety of methods. In the first instance Western methods were introduced on the assumption that as they had succeeded in the countries of their origin they would also succeed in India. Notable examples were the bringing in of twelve American cotton planters by the East India Company in 1839 to show how cotton should be grown, and the importation of steam ploughs and a battery of implements by the Madras Government in 1864 to show how the soil should be cultivated. In general these methods failed. Next followed a period of searching for some general policy or system of organisation; little was actually accomplished, but there was much discussion which no doubt paved the way for future action. Finally it was recognised that Indian agriculture constituted a problem of its own; it could not be modelled on any other system but must be developed to accord with the natural conditions of the country and the requirements of the people. The best hope for improvement lay in the scientific study of these conditions and in experiments to discover agricultural practices that would best suit them."

The truths of science apparently differ at different geographical centres, a thing least expected from a scientist of the order of Sir John Russel, F.R.S.

But perhaps we had no right to expect any return courtesies from our Royal guests. We have had a highly efficient Imperial Service of Agricultural experts brought from the British Isles with a pay not much below that of the reputed heaven-born service; yet so far no scientific approach to the urgent problem of increasing the food production had ever come from that quarter.* While even in the twentieth century India is visited with famine from year to year in some part or other, out in the West, scientists developed methods of nitrogen fixation from the turn of the century. This was heralded by the prophecy of an eminent scientist, Sir William Crookes in 1898. Europe and America built factories to increase the output of fixed nitrogen compounds which have come to be recognised as the indispensable factor in the maintenance of soil fertility by agricultural scientists: De Saussure, Boussingault, Lawes and Gilbert as early as 1840. Then came the remarkable achievement of Haber, which is mentioned in every elementary book on chemistry, as having solved once for all the soil fertility question.

A recent American Chemical Society monograph on "fixed nitrogen" published in 1932 has the following passage:

"At the beginning of the present century there existed a 'Nitrogen problem'. The agricultural and industrial demands for nitrogen compounds were increasing rapidly, and the natural sources of supply were limited. Today, the 'Nitrogen problem', if there be one, is to find a market for the output of fixed nitrogen potentially available."

At about that time well over 2 million tons of fixed nitrogen were available to the agriculturist as a fertiliser.

In the face of these facts one fails to understand why there had been no advocacy for the use of these chemical fertilisers from any of the agricultural experts in our country.

There was always the oft-repeated statement that it is not available for India and importation is too uneconomical. When questioned as to why it could not be manufactured in India the agricultural expert would either quote the economist who could explain rationally the absurdity of that procedure or would quote the equally reactionary statistical pandit who found no statistically significant superiority of synthetic fertilizers over natural manures. Then why waste good public money on such questionable schemes: or lastly by the mere empty statement "Technically it is impossible in India". One also fails to see why the so-called experts were not dispensed with for indolence and inefficiency. The patient tax-payer and the victims of famines expect

* According to well-informed sceptics, the recent 'grow more food campaign' has resolved itself into a 'grow more officer campaign'.

their servants to do what experts and public servants in other countries have done. If only the normal efficiency would have been demanded of the so-called experts, the problem would have been solved long ago. We would have then less of the disgusting attitude "It cannot be done in India" so assiduously taken up by the Brown bureaucrats now replacing the Whites.

It is indeed a pity that such an attitude is considered one of realism more desirable than to pretend that it can be done, out of national self-respect.

This has endowed the entire scientific and technical activity of the country with a lethargy akin to the outcome of opium addiction. However the Indian Scientific World is not without its silver lining. People are not wanting, who believe with Sylvanus Thompson

"What one fool can, another fool too can".

The bulk and excellence of research in the field of science by Indians to which tribute has recently been paid by no less an observer than the Secretary of the Royal Society is a sufficient guarantee that Indian Scientists can undertake what Haber did 30 years ago. They have not hesitated to proclaim the radical solution to the problem.

Dr A. C. Ukil of the All-India Institute of Hygiene and Public Health, Calcutta, suggested the advisability of synthetic fertiliser as early as 1939 in a meeting of the Food and Nutrition Exposition at Calcutta and at a symposium before the Indian Science Congress, 1941.

In 1943, its need was emphasized by members of the Food Production Advisory Committee, Government of Bengal in its various meetings.

Dr H. K. Sen, Director, Lac Research Institute, in a lecture delivered before the Indian Chemical Society in July, 1943, asserted:

"If the State moves expeditiously, the bringing into existence of fixed N₂ industry is a question of half a year only."

Under the darkening clouds of famine over Bengal, the Food Grains Policy Committee in November, 1943, advocated the immediate importation of plants for the manufacture of synthetic fertiliser as the incredible Bolsheviks have done in Russia and stamped out recurrent famines in Russia in a ludicrously short time. The report even asserted that this was the only solution for increasing the yield of rice quickly.

In pursuance of the Resolution of the Nutrition Committee, Sanitary Board, Government of Bengal, a technical sub-committee proposed in a Food Technology Report the fabrication locally of a pilot plant for the manufacture of synthetic ammonia. The

technical sub-committee of the Food Production Advisory Committee, appointed in September, 1943, studied the whole question and in their final report in March, 1944 discussed the present knowledge providing considerable details. They even proposed to do fundamental research on nitrogen fixation with the help of the pilot plant to be fabricated. We understand that blue prints are being drawn for a plant of 100,000 tons of ammonium sulphate per annum according to the latest American modifications of the original Haber-Bosch process.* The radical solution of the famine problem, and of permanent malnutrition problem lies in pushing energetically with these schemes.

Meanwhile we hear a technical commission from England is arriving to advise us on the development of the Fertiliser Industry. It has become a fashion in these days to import experts on all and sundry affairs for short commissions in contrast to the permanent commissions of the past. The most recent consisted of experts on Dehydration. We fail to see why the Indian tax-payer's money is being wasted on such so-called experts from countries which have made the least contribution to the subjects concerned. Dehydration industry in America is something beyond the capacity or dreams of Britain. How could these dehydration experts have been of any help to the development of the Indian Industry on modern lines? Nitrogen fixation industry is another which has developed to a high pitch largely due to the Federal Department of Agriculture in the fixed Nitrogen Research Laboratory, in Washington, D. C. There are a large number of plants built in America with the designs of this laboratory and there is a considerable body of research workers on the subject with international reputation. England, on the other hand, possesses just one synthetic ammonia plant and that built over 26 years ago. No mention is made in the literature of any design or improvement of British origin for the necessity for getting nitrogen out of the air does not arise in England, and the problem never engaged the serious attention of British scientists.†

We cannot but wonder at the technical competence and wisdom of the people in power respon-

* It is reported that the famous Du Pont de Nemours, Chemical Manufacturers of U. S. A., spent nearly a million dollars in research alone for working out the methods for manufacture of synthetic ammonia according to the Haber-Bosch process. As a result of these works, the methods of manufacture are standardised as in the case of sugar manufacture, and standard plants with experts can be had from the U. S. A. They can be set up wherever cheap electricity is available.
† England gets most of her nitrogen from ammonium sulphate which is obtained as a bye-product in coal-distillation. Her needs for synthetic nitrogen is not therefore so great as in other countries, and she has not paid as much attention to the installation of synthetic ammonia.

sible for selecting this commission. There appears to be something rather sinister in this move. The members of this commission are said to be employees of a firm of chemical manufacturers. If that is so it is a case of prosecution, defence, jury, judge and executioner all in one body. The game is obviously set for conveniently carving out a liberal helping of our Sterling Balances in London.

What can a Nitrogen Fixation Commission do in India? Are they to try and find out if nitrogen would care to combine with hydrogen under the climatic, economic and political conditions prevailing in India? Have we not learnt enough of the bitter lessons from such experts in the past? *The best thing for us would have been to send a commission composed of purely Indian scientists and Indian financiers to tour America, Russia and England (if necessary) and see for ourselves what is suitable for us and our pocket.* A competent body of scientists capable of dealing with such a problem, and a body of financiers capable of financing such plants exist in the country, provided import facilities of the necessary machinery are given.

The decision to call foreign experts is therefore not only superfluous, but opposed to the country's interest. As a marked contrast to all these manouvres high praise is due to the wise statementship of the Indian State of Mysore, which imported an American plant, got it installed with the aid of American experts and is according to our information successfully running it with native Mysorians. The best that could happen to such a Commission coming to India is that they are likely to see for the first time in Mysore a plant which will give them some education; and the Indian tax-payer is to pay for the foreign experts' education and be told that they have been educated. Such episodes enacted by the Central Government can only help to widen the breach between the Suzerain and the peripheral authorities. It is said that the various Provincial Governments and the States are likely to participate in the discussions. We hope the Provincial Governments will not walk into the trap so naively laid. Let the provinces go to Mysore, learn what miracles can be effected by development of electric power resources all due to the enterprise of Indian Dewans and see for themselves the capabilities of indigenous skill. Let us get our youngsters trained in a factory built in India* to suit Indian conditions.

* This kind of work, viz., training young chemists in the use of a pilot plant for the manufacture of synthetic ammonia can best be done in a National Chemical Laboratory. But this institution, advertized now for three years by the authorities of the Board of Industrial and Scientific Research, has not yet passed the report stage, and we understand that the Board has after three years of committee meeting discovered that it required a whole-time chemist to plan the laboratories!

NEED AND POSSIBILITIES FOR THE PRODUCTION OF SYNTHETIC FERTILIZERS

"ARGON"

IN 1898 Sir William Crookes, the famous British scientist who rose to be President of the Royal Society, in the course of his presidential address to the British Association for the Advancement of Science drew attention to the fact that the world was facing ultimate starvation, because under the existing conditions of heedless culture, the cereal growing lands were rapidly becoming exhausted of nitrogen. Crookes said:

"England and all civilized nations stand in deadly peril of not having enough to eat. It is the chemist who must come to the rescue of the threatened community. It is through the laboratory that the starvation may ultimately be turned into plenty."

What were the facts which led the famous scientist to make this pessimistic prophecy?

The facts are that plants require nitrogen for building up their bodies, and this they extract mostly from the soil. A part of this loss is compensated for by farm manures, decayed remains of plants, and from air, but there is on the whole an adverse balance as was found by Boussingault as early as 1841 (Table 1). On the whole, regions of the world which have supported civilized communities for a long time—and therefore the oldest centres of civilization—show a great deficiency of nitrogen content in their soil, which in these regions therefore yields less and less, and ultimately the regions tend to become sterile, and cannot support the population. This probably happened in Mesopotamia which, at the time of Herodotus, yielded 200 times the amount of seed put in the soil, but in course of the last few centuries had become mostly a barren desert. This has also happened to soil in the river valleys of India, one of the oldest inhabited regions of the world, and was happening to European soil according to Crookes.

How could the situation be met? The answer was plain and simple:—by putting back the nitrogen in the form of artificial fertilizers and farm manures. The manures are limited in quantity, hence artificial fertilizers must be used. We shall now do well to refer to the possible sources from which the supply of artificial fertilizers may be available.

Potassium Nitrate or Saltpeter is found in large quantities in India, but it was exported till the middle of the last century mostly for the manufacture of gun-powder.

Sodium Nitrate or Chili Saltpeter is found in inexhaustible quantities in Chile, South America. The

TABLE 1
NITROGEN STATISTICS OF VARIOUS ROTATIONS
BOUSSINGAULT (1841)

Rotations.	Nitrogen in manure	Nitrogen in crop	Excess in crop over that supplied in manure per rotation (kilograms per hectare)
(1) Potatoes (2) Wheat (3) Clover (4) Wheat turnips (5) Oats	203.2	250.7	47.5
(1) Beets (2) Wheat (3) Clover (4) Wheat turnips (5) Oats	203.2	254.2	51.2
(1) Potatoes (2) Wheat (3) Clover (4) Wheat turnips (5) Peas (6) Rye	243.8	253.6	109.8
Jerusalem Artichokes 2 years.	188.2	274.2	86.0
(1) Dunged fallow (2) Wheat (3) Wheat	82.8	87.4	4.6
Lucerne 5 years	224.0	1087.0	854.0

export of Chili Saltpeter started from 1830, and gradually killed the export trade of Indian Saltpeter. It has been used since 1850 as a manure in Europe to replenish the nitrogen in agricultural soil. In 1912, as much as half a million tons were exported. The export of Chili Saltpeter formed the chief source of income of the Republic of Chile in South America.

Ammonium Sulphate which is obtained as a bye-product in the distillation of coal is also a valuable source of nitrogen, and in 1912 277,000 tons were produced.

But these quantities were limited, and the sources were showing signs of exhaustion. The way

out was pointed out by Crookes. In the same address, he said:

"The fixation of atmospheric N_2 is one of the greatest discoveries awaiting the ingenuity of the chemists. It is certainly deeply important in its practical bearings in the future welfare and happiness of the civilized races of mankind."

Nitrogen forms 80 per cent of the atmospheric air, and the source is apparently inexhaustible.

FIXATION OF NITROGEN: CALCIUM NITRATE, CALCIUM CYANAMIDE, SYNTHETIC AMMONIA

Priestly observed over 150 years ago that nitrogen and oxygen of air could be made to combine to form oxides of nitrogen which dissolved in an alkali could give us nitrates and nitrites. Its commercial development was made possible only after considerable progress was made in the generation of cheap electrical energy. In 1902, a plant employing this finding was set up near Niagara Falls where cheap power from hydroelectric sources was available. In 1904, two Norwegian scientists, Birkeland and Eyde, built their famous arc method of nitrogen fixation by which nitric acid could be obtained from air, which by neutralization with lime, provided a valuable nitrogenous fertilizer, nitrate of lime, which is very good for acid soils. About the same time the discovery was made that calcium carbide could be made to combine with nitrogen to give calcium cyanamide. This substance could be applied directly to the soil as a nitrogenous fertiliser or the cyanamide could be hydrolyzed with water to give ammonia. But these quantities were limited.

During the first World War the Allies hoped that Germany would have to surrender, as blockade was effective in completely preventing the importation of Chilean nitrate fertilizer and thus cause a collapse of the food front.* The Germans however stood out for over four years and this was ascribed to the German's successful method of fixing nitrogen in a novel and effective way. Fritz Haber, the German chemist succeeded sometime before the war in combining directly nitrogen and hydrogen at high pressures and temperature into NH_3 with the help of certain suitable catalysts. This started as an obscure laboratory experiment and guidance was obtained from mathematical formulae evolved in physical chemistry. But the German industrialists and the State were quick to realize its potentialities. The famous Badische Anilin and Soda Fabrik put all their resources at the disposal of Haber, and after years of effort, just before the outbreak of the first World War of 1914, an industrial plant for producing 7000 tons was put

* The Chilean nitrate is used not only as a fertiliser, but also as a source of explosives used for the prosecution of the war.—Ed. Sci. & Cul.

in operation (The Haber-Bosch process). But by the time the armistice came, Germany was fixing 137,000 tons of NH_3 by this method. Whatever might have been the technical difficulties and the financial implications an achievement of this nature in such a short time opened the eyes of the European nations. Almost all European and North American countries seized on the idea and built up large manufacturing plants and in less than 20 years, a total of 2 million tons of synthetic ammonia was being manufactured per annum. Well over 92 per cent of this fixed nitrogen went into the soil as a fertilizer. That in brief is the romantic tale of the way in which the European countries succeeded in maintaining soil fertility.

SYNTHETIC AMMONIA SOLVES GERMANY'S FOOD PROBLEMS DURING CURRENT WAR

In a recent issue (March 3, 1944), *Science* has published a note on the present food supplies in Germany. Dr J. T. Richter, of the Office of Foreign Agricultural Relations, U. S. Department of Agriculture, stated in the official publication, Foreign Agriculture, that, in his opinion, Germany's production and consumption of food thus far in this war have been at a level far above those for 1914-1918.

"In contrast to the situation in 1914, Germany's food economy in 1939 was well prepared for war. Following a period of sustained expansion, agricultural production has reached a high level. Over 85 per cent. of the nation's food supply was produced from domestic resources, the only substantial deficit being in fats and oils. From 1937 until the outbreak of war, stocks of grain, fats and sugar had been accumulated in considerable quantities." In the years just prior to World War I, German livestock was dependent upon the importation of feed to the extent of about 38 per cent. of the total output of livestock products. In 1939 the dependence on imported feeds was not more than 10 per cent., with the result that livestock production has been considerably less affected in the past four years than during the 1914-1918 period.

"An important factor in the high level of farm production was the relatively large supply, up to 1943, of commercial fertilizers other than phosphates. Especially important was the availability of nitrogen in quantities six or seven times as great as in the previous war. "This excess even after allowance has been made for the drastic reduction in phosphates, may still be estimated as accounting for an annual crop production of over 6,000,000 tons in terms of grain."

In the opinion of Dr Richter, Germany's own production has remained the backbone of its war-time food supply, despite the importation of substantial quantities requisitioned in other parts of continental Europe under German control.

Progress made in the various countries of the world in the production of synthetic ammonia, nitrogen compounds and in the use of fertilizers for

agriculture has been adequately reflected in the following tables:—

TABLE 2
SYNTHETIC AMMONIA PLANTS OF THE WORLD, 1930
(Annual Capacity in Net Tons of Nitrogen)

Country	Direct synthetic		Cyanamide		Total
	Number	Amount	Number	Amount	
Germany ..	9	766,100	5	102,200	868,300
France ..	20	172,300	5	32,100	204,400
U. S. A. ..	8	143,800	1	35,700	179,500
Japan ..	6	98,700	4	56,800	155,500
England ..	1	151,800	nil	nil	151,800
Belgium ..	6	118,700	nil	nil	118,700
Norway ..	2	76,900	1	13,400	90,300
Netherlands ..	3	80,400	nil	nil	80,400
China (1935) ..	1	75,000	nil	nil	75,000
Poland ..	4	47,300	1	26,800	74,100
Canada ..	1	2,200	1	71,400	73,600
Italy ..	9	43,300	5	19,600	62,900
Russia ..	2	35,700	nil	nil	35,700
Yugoslavia ..	1	14,300	2	12,500	26,800
Czechoslovakia ..	2	11,900	1	5,400	17,300
Switzerland ..	1	6,700	3	4,500	11,200
Spain ..	3	7,700	nil	nil	7,700
Sweden ..	1	1,800	2	5,400	7,200
Roumania ..	nil	nil	1	5,000	5,000
Indian States Mysore (1941) ..	1	1,500	nil	nil	1,500
British India (1941) ..	nil	nil	nil	nil	nil

TABLE 3
GROWTH OF WORLD PRODUCTION OF NITROGEN COMPOUNDS
(In Net Tons of Nitrogen Per Year)

Year	By Synthetic Fixation Methods	By Bye-product and others	Total
Early 1913 ..	nil	67,200	67,200
September 1913 ..	7,000	67,200	74,200
1914 to 1918 ..	137,000	72,000	209,000
1924 ..	378,700	659,400	1,038,100
1925 ..	428,300	705,400	1,133,700
1926 ..	548,200	671,700	1,309,900
1927 ..	602,400	639,500	1,241,900
1928 ..	792,600	900,600	1,693,200
1929 ..	1,041,100	1,034,200	2,075,300
1933 ..	1,171,400	479,400	1,650,800
1934 ..	1,226,500	537,500	1,764,000
1935 ..	1,350,600	687,100	2,037,700
1936 ..	1,597,600	758,000	2,355,600
1937 ..	1,801,400	853,500	2,654,900
1938 ..	1,969,700	865,300	2,835,000
1943 ..	..	..	..
British India..	nil	5,200	5,200
Indian States Mysore ..	1,500	nil	1,500

Note: Well over 92% of the production is consumed as fertilizer.

Total World Population ... 2,222 millions
Mysore .. 7 "

British Indian population is nearly 1/5th of world population but produce only 1/560th of world nitrogen.

TABLE 4
FERTILIZERS USED IN AGRICULTURE—CONSUMPTION IN INDIA AND SOME EASTERN COUNTRIES.*
In 1000 metric tons†

	Average for 1928-32	1933	1934	1935	1936	1937	1938
1. Superphosphates for Lime:							
(a) Net consumption							
India ..	3.4	2.5	5.1	5.0	6.4	7.9	8.1
Japan ..	896.6	1009.7	1004.6	1151.0	1242.4	...	...
(b) Home production							
Japan ..	946.9	1116.6	1126.1	1331.6	1437.2	...	...
2. Potash fertilisers:							
(a) Net consumption							
India ..	6.7	3.0	7.0	5.7	3.8	3.9	4.4
Japan ..	33.4	30.8	50.2	84.1	81.5	...	...
3. Nitrate of Soda:							
(a) Net consumption							
India ..	5.7	2.0	3.8	2.2	2.6	3.1	2.7
Japan ..	25.9	19.7	23.4	36.9	47.6	...	...
4. Sulphate of Ammonia:							
(a) Net consumption							
India ..	34.6	41.8	48.2	54.9	74.1	65.5	87.2
China ..	124.4	101.3	49.9	68.6	124.0	163.4	106.4
Japan ..	540.0	551.3	650.4	812.6	1050.4	...	...
Korea ..	105.0	183.6	213.0	273.9	306.6	327.9	...
Neth. Ind. ..	112.0	29.4	43.6	41.1	69.2	102.5	70.5
Formosa ..	61.	72.1	111.8	117.6	147.6	148.5	...
Philippines ..	28.8	38.9	58.2	34.4	47.0	35.9	29.7
(b) Home production							
India ..	14.4	9.8	13.2	17.7	18.0	18.6	14.8
Japan ..	317.2	471.4	494.3	611.8	880.3	...	...
Manchukuo ..	18.0	30.0	30.0	200.0	250.0	...	...
Korea ..	111.9	247.0	310.4	350.4	396.8	422.3	...

* From "Land and its Problems" by Sudhir Sen.

† (One metric ton=2000 lbs.)

FERTILIZERS USED IN AGRICULTURE—CONSUMPTION IN INDIA AND SOME EASTERN COUNTRIES—Contd.

In 1000 metric tons

	Average for 1928-32	1933	1934	1935	1936	1937	1938
5. Calcium Cyanamide:							
(a) Net consumption							
India	Nil	Nil	Nil	Nil	Nil	...	...
Japan	91.5	140.8	104.8	155.6	160.5	...	...
(b) Home production							
Japan	91.7	151.4	138.5	199.7	219.4	...	...
6. Bones and Bone Manures:							
Net exports from India (by Sea)	-60.5	-42.5	-52.6	-67.2	-88.8	-110.1	-56.2 ²
—ditto—	-34.4	-18.1	-26.5	-29.9	-30.8	-38.9	-21.9 ³
Net imports into Japan	+27.0	+22.3	+24.6	+25.8	+26.7	+22.1	+12.4 ²
—ditto—	+35.1	+24.1	+28.6	+29.7	+35.5	+29.5	+21.9 ³

SOIL FERTILITY AND NITROGEN

What has been the effect of all these great scientific work? Europe and the countries which have harnessed science to their needs have maintained the fertility of their soil, whereas countries which have neglected science are getting barren as the following table shows:—

TABLE 5

YIELD OF RICE IN LBS. PER ACRE IN DIFFERENT COUNTRIES
(Report of the Paddy and Rice Enquiry Committee, Vol. I, Government of Bengal, 1935)

Bulgaria	1,904	Korea	1,759
Egypt	3,179	Siam	1,398
Formosa	2,220	Spain	5,542
Indo-China	1,032	U. S. A.	2,138
Japan	2,988	India	828
Java	1,322	Bengal	884
Italy	4,748		

The above table was prepared from figures of yield available in 1935, after which an authoritative statement made in December, 1943 would appear to give the figure of rice production as 738 lbs. per acre which is an average of the production record of the previous 5 years.

The table speaks its own tale. Countries like Spain, Italy and Japan, and Egypt which use fertilizers extract seven to four times as much crop from their soil as we do in India. Even countries like Korea and Formosa which suffer from "Japanese Brutality" get two to two and halftimes as much as India which enjoys the advantage of "Enlightened British Imperialism"! Further comment is unnecessary! What has been said of rice can be said of almost every other crop and the sequel is too tragic to describe.

RECURRENT FAMINES DUE TO LOSS OF SOIL FERTILITY

"In an enquiry into certain public health aspects of village life in India by the Director General, India Medical Service published in 1933, it was estimated that in 40 per cent of the villages in all India the

population was excessive in relation to food supply. According to the same enquiry periods of scarcity of food occur in one village out of every five during a ten year period in which there was no exceptional failure of rain. When the rain fails scarcity gives place to famine; during the last quarter of the nineteenth century there were 18 severe famines which caused 26 million deaths" thus reads a passage in a book "Food and Planning" by J. R. Marrack published in London in 1943. The twentieth century has not shown any improvement over the previous century. Famines of moderate dimensions have occurred from year to year, and the following table gives a rough idea of the expenditure incurred by the Government of India during the period of only 12 years in the last two decades.

TABLE 6

Years.	Rupees.	Years.	Rupees.
1924-25	23,28,535	1931-32	16,39,304
1925-26	14,10,429	1932-33	8,02,936
1926-27	15,49,723	1933-34	3,48,793
1927-28	19,17,890	1934-35	10,20,846
1928-29	23,18,740	1935-36	15,40,436
1929-30	48,93,056		
1930-31	20,02,060		

It is not necessary to refer to the unprecedented famine that swept over unfortunate Bengal. Several millions were victims of starvation and its after effects. The loss sustained by the State in terms of money would probably be not less than 100 crores of Rupees.

All this loss of human material and wealth was entirely preventable if only a fraction of all this cost had been utilised in increasing the productivity of the land. This would appear at first sight to be exceedingly possible. It is evident from table 5 that if only we could produce as much as some of the less progressive countries of the world such as Bulgaria and Korea, we should have been able to have twice the amount of food that is now being produced.

Elmhirst wrote in the *Modern Review* of October, 1922 as follows: "To continue indefinitely taking any of these life forming elements from the soil without adequately replacing them is a robbery not merely of the soil itself but also the future generation which will have to live on it. Thus the damage done to the district of Birbhum and other large parts of India to-day is irreparable."

We are caught in a vicious circle of increasing population and decreasing soil fertility.

PROSPECTS OF FERTILIZER INDUSTRY

To get out of the circle we require large scale fertilizer industries, not only for the manufacture of nitrogen fertilizers, but also for the manufacture of phosphate, potassium and other fertilizers. India possesses all the raw materials needed for the purpose. She requires will power on the part of her rulers, and leaders of Industry to bring these industries into existence. Let us first examine our requirements.

Dr H. K. Sen estimates that a minimum of only 100 million acres of land being suitable for manuring would require on the basis of 20 lbs. of nitrogen per acre, 1 million tons of nitrogen, leaving aside other acres under cultivation of sugar-cane, tea, cotton, etc. which would have their own share.

An authoritative estimate stated in December, 1943 that the requirement is 2.8 million tons of nitrogen.

However we can calculate on a slightly different basis. The amount of food crops acreage of British India is 215 million acres. If at the rate of 20 lbs. nitrogen is used as manure for each acre, the quantity required is calculated to be 2.2 million tons of nitrogen. It is desirable to employ as much as 90 lbs. of nitrogen per acre. We thus have the figures of requirement ranging from 1 million tons to 8.6 million tons of nitrogen per annum.

FARM MANURE AND COMPOSTS NO SUBSTITUTE FOR SYNTHETIC FERTILIZERS

We will now determine the nitrogen available from all sources. An authoritative statement made in December, 1943 gave the availability of farm yard manure as 5.9 million tons with a nitrogen content of 0.4 per cent or 0.024 million tons. Dr N. C. Acharya estimates that with effort it is possible to obtain 10 million tons of compost with the nitrogen content of 0.4 per cent. Even this works out to only 0.04 million tons. These figures demonstrate how little of nitrogen is available from the natural sources. It is only one twentyfifth of even our lowest estimate of requirement.

The supply of indigenous oil-cake manure would also appear to be extremely inadequate. The total quantity of oil-cake produced in the country amounts to about 14½ lakh tons per annum. Half of this is

required for feeding the cattle and the remaining half is insufficient for manuring the intensively-grown crops, such as sugar-cane, potatoes, vegetables, tea and so forth and hardly anything is left for manuring foodgrains, although efforts have been made to utilize part of the available supplies for manuring the foodgrains crops particularly rice.

It was mentioned at one time that India held world monopoly for Saltpeter. The Chilean Nitrate industry not only broke the monopoly but also disorganised the industry so that there is practically no production of this commodity now.

The nitrogen compounds available from coal are however important and as a matter of fact, England which is one of the largest consumers of coal, get most of her nitrogen from Ammonium Sulphate which is obtained as a bye-product in coal-tar distillation. Let us examine the case for India. It is estimated that 5,200 tons of fixed nitrogen are being produced from 4 million tons of coal used in the metallurgical industry. India is producing annually a total of 25 million tons of coal. If the whole of this would have been submitted for retorting we would get a total of 32,000 tons of nitrogen. It is stated also that the retorting is rather wasteful and by improvement we can get instead 60,000 tons of nitrogen. Still further improvements such as by the system of Mond gasification it is theoretically possible to obtain as much as 180,000 tons of nitrogen.

We thus see that even from the complete utilization of ammonia from the entire coal production of India, the amount of nitrogenous compounds available is not even 1/5 of the lowest estimate of the requirement of this commodity.

Judged from a more desirable estimate of 8.6 million tons of nitrogen required for food crops alone, our situation is exceedingly critical. This becomes much more so if we have to fertilize our other cash crops such as sugar-cane, cotton, tea and coffee.

The question is usually asked: Can the Indian farmer afford to pay for the synthetic fertilizer? This is usually answered in a pessimistic manner. The proverbially poor Indian cannot afford this luxury.

USE OF SYNTHETIC FERTILIZERS IS PROFITABLE

However, it can be demonstrated that synthetic fertilizers pay themselves in the form of increased yield.

The normal pre-war cost of ammonium sulphate is Rs. 80/- per ton i.e. 448 lbs. of nitrogen. An application of 20 lbs. of nitrogen per acre has been stated to give an extra 3 maunds of cleaned rice. That is, for less than Rs. 4/- of fertilizer, we obtain 3 maunds of rice. The normal price level for rice is Rs. 5/- per maund. In other words, we get a return of Rs. 15/- for less than Rs. 4/- manure. The lowest level of price for rice was Re. 1/8/- per maund.

Even so we get Rs. 4/8/- and straw for Rs. 4/- manure. Calculating on the present price of Rs. 15/- per maund of rice it should pay enormously. The present price of imported ammonium sulphate is well over Rs. 200/-, in which case we have to pay as much as Rs. 10/- per acre, but then if we calculate on the basis of the present price of rice, it will bring Rs. 45/- worth of excess yield. Even at Rs. 5/- it is well over the cost of fertilizers. An authoritative statement made in December, 1943 showed that in certain cases ammonium sulphate paid itself handsomely even when it cost as much as Rs. 269/- per ton and rice was sold at Re. 1/6/- per maund. These are the figures with imported material. The cost of production of one ton of ammonium sulphate by synthetic ammonia methods is only Rs. 40/- to Rs. 45/- or about half of the pre-war costs. There will then be no question whether such a manure will pay or not.

SYNTHETIC AMMONIA PLANTS CAN BE ERECTED IN INDIA

Among the methods of nitrogen fixation the most suitable one for India is the direct synthetic ammonia method according to Haber with more recent modifications developed particularly in America. The raw materials needed for this industry is available in inexhaustible quantities. According to some of the older methods, we need CaSO₄ or gypsum available only in certain parts of India and that

perhaps in limited quantities. However, modern methods employ the limitless quantities of NaCl that can be extracted out of sea water along the entire coast line of India. In still more recent plants there are no raw materials other than what cannot be obtained from the atmosphere. There will of course be a need for a certain amount of electrical energy which is not anything very considerable. A plant costing 2½ crores of rupees could be built with an output capacity for 20,000 tons of fixed nitrogen per annum. The period of fabrication should perhaps not exceed 2 years.

It should be remembered that Haber during the first World War built one of the very first plants in less than eleven months and was capable of producing 30,000 tons of fixed nitrogen per annum. With the experience of the last 30 years we should be capable of doing something better than what Haber was capable of.

This plant is estimated to produce ammonium sulphate for the price of about 40-45 Rupees per ton which is roughly ½ the pre-war cost of Rs. 80/- and the present price is over Rs. 250/- per ton.

The State should take the lead in building such plants as the progressive Indian State Mysore has done. If however private enterprises come forward the State should do all in its power to help it. Possibilities of obtaining plants from America on lease and lend basis should be explored.

RAYON INDUSTRY IN INDIA

RAYON is the other name for artificial silk. The process of making this synthetic fibre was invented about the year 1883-84 by Count Chardonnet of France and Sir Joseph Swann of England. Since that date research in artificial silk has made such headway that rayon industry has been an established and profitable industry in Europe, America and Japan. Artificial silk in the form of yarn and staple fibre at present constitutes an increasingly important addition to natural fibres like cotton and silk as raw materials for the textile industry. In fact, its introduction has made possible such wide varieties of yarn and piece goods that textile industry has increasingly come to depend on rayon industry all over the world.

Rayon industry is as yet unknown in India. The absence of an indigenous rayon industry to meet Indian textile industry's growing demand for artificial silk has naturally led to a heavy drainage of money amounting to several crores of rupees annually from this country. The monograph on "The Rayon Industry", recently issued by the All-India Manufacturers' Organization, Bombay, in order to indicate the urgency and possibilities of setting up this in-

dustry in India, has published figures for imports of artificial silk yarn and piece goods into this country, which we may do well to reproduce here.

IMPORTS OF ARTIFICIAL SILK YARN OR RAYON IN INDIA (in 1000's of lbs.)					
Year	Import	Year	Import	Year	Import
1924-25	1,171	1932-33	11,002		
1925-26	2,671	1933-34	9,808		
1926-27	5,776	1934-35	16,614		
1927-28	7,510	1935-36	14,911		
1928-29	7,668	1936-37	17,628		
1929-30	7,353	1937-38	31,589		
1930-31	7,119	1938-39	17,200		
1931-32	7,963	1939-40	30,794		

These figures at once disclose the dependence of Indian textile industries on foreign rayon manufacturers. The tremendous rise in the imports of arti-

IMPORTS OF RAYON PIECE-GOODS IN INDIA			
Year	Yards	Value (Rs.)	
1934-35	68,489,000	1,88,02,000	
1935-36	72,999,000	1,87,08,000	
1936-37	99,259,000	2,32,95,000	
1937-38	91,953,000	2,28,63,000	
1938-39	29,616,000	1,04,36,000	

ficial silk yarn from 4 lakhs of lbs. in 1923-24 to about 3 crores of lbs. in 1937-38 is simply disquieting.

If the import of piece-goods be calculated in terms of yarn, we note that India imported about 50,000,000 lbs. of rayon valued at a few crores of rupees in 1937-38. Such a heavy and undue drainage could have been prevented, if there were an indigenous rayon industry, to the immense benefit of this country.

In exploring the possibilities of setting up the rayon industry in India, the monograph has discussed India's position with regard to the supply of raw materials, chemicals, power, technical personnel, labour and such other things required for successful manufacture, to which the attention of the State and our industrialists may be drawn.

RAW MATERIALS

The main constituent of artificial silk is cellulose. It can be obtained from wood-pulp or cotton and cotton linters. In Europe and America rayon is now largely manufactured from wood-pulp by the well-known viscose process. This is because of the easy and cheap availability of wood-pulp in Norway, Sweden, Canada and U. S. A. But high-grade artificial silk can also be economically manufactured from cotton waste by the acetate process. As India commands an abundant supply of short-staple cotton and cotton linters, cotton waste should ultimately be the source of cellulose for rayon industry in India.

Owing to the higher prices of cotton waste and cotton linters, it may be questioned whether the production of rayon from cotton will prove economic and stand competition with the foreign product utilizing wood-pulp. The following consideration indicates that utilization of cotton waste and linters should prove economic in the long run. The present cost of wood-pulp is 1 anna and 9 pies per lb. and that of chemical cotton made out of short staple cotton and cotton linters 3 annas 6 pies and 2 annas respectively. But the α-cellulose content of wood-pulp is 87 per cent, whereas that of chemical cotton is at least 98 per cent, and as such the potential value of chemical cotton is much greater than that of wood-pulp. Moreover, the quality of rayon from cotton is definitely superior to that from wood-pulp. When these facts are properly weighed production of rayon from chemical cotton would appear to be a profitable undertaking.

Besides wood-pulp and cotton waste, there are other sources of cellulose for the manufacture of rayon. Bamboo-pulp is by far the most important of them. Experiments recently conducted in America have proved that rayon can be produced from bamboo-pulp by the viscose process. Some experiments were also conducted with initial success by the Dehra Dun Forest Research Institute to develop a process of making bamboo-pulp suitable for rayon manufacture, and more investigations are needed in

this direction. Bagasse is another important raw material whose suitability for the manufacture of rayon may yet be decided by further research. It is further reported that the lower ranges of the Himalayas abound in good quality spruce from which wood-pulp almost as good as the European or the American variety may be produced. In fact, there are reasons to believe that if the Forest Research Institute, Dehra Dun, concentrate their research on the utilization of Indian woods for the supply of cellulose for the manufacture of artificial silk, production of viscose rayon will also be a practical and economic proposition in India.

CHEMICALS

The important chemicals required for the manufacture of rayon are carbon di-sulphide, caustic soda and sulphuric acid. Carbon di-sulphide is not manufactured in India and plants have to be installed for the manufacture of this chemical. Caustic soda and sulphuric acid are, however, manufactured, but their production rate will have to be increased. The annual production of caustic soda is at present about 5,000 tons, a figure which is likely to be increased to about 15,000 tons in near future. Present production of sulphuric acid has been estimated at about 70,000 tons with possibilities of increased production in the years to come. Other chemicals required are zinc sulphate, sulphate of ammonia, sulphate of magnesia, sulphate and bi-sulphate of soda, and the mono-sulphide and sulphite of sodium, and glucose. It is true that India's normal requirements for chemicals are not met by her insufficient chemical industries. But in view of the possible expansion of her chemical industries and easy availability of imported chemicals from other countries in the post-war period, the problem of the supply of chemicals does not appear to be a serious obstacle to the establishment of this industry in this country.

POWER AND WATER SUPPLY

Cheap electricity is necessary for economic production of rayon. Supply of cheap electricity, however, can be guaranteed if the industry could be established in the vicinity of a hydro-electric station. If this cannot be secured the industry should be situated near a coal producing district so that it can produce its own electricity at a cheap rate.

The process of manufacture calls for an abundant supply of fresh water. Accordingly continuous supply of fresh water is another important condition for the location of the industry. This requirement necessitates the establishment of rayon factories on the banks of big perennial rivers, as the western countries have done. It should be noted in this connection that the large volume of water, after doing its job in the factory, should not be allowed to con-

taminate irrigation canals or water-supply systems, but should be discharged into the neighbouring valley or sea, as this water contains poisonous chemicals.

TECHNICAL PERSONNEL AND LABOUR

The problem of technical personnel and labour does not appear to present serious difficulties. The manufacture of artificial silk is more in the nature of a chemical process than of a textile process. The manufacturing technique has been so much improved in recent years that the whole operation is continuous, automatic and mechanical requiring little skill on the part of labourers. The chemist responsible for the precise regulation and supervision of the various processes should, however, be an expert hand at that. Under him will work a number of foremen and assistant chemists to supervise the work of the operatives. There is no dearth of chemists and scientists with the required technical qualifications and abilities in this country to run such manufacturing concerns, and where further and special training is deemed necessary, instead of importing foreign experts on fancy salaries, our men may be sent abroad to master that particular technique. During the installation of the plant, help and services of foreign technicians associated with the firms supplying the machinery may be easily obtained. It has been estimated that a factory turning out 4 tons of rayon daily will not require more than 750 men on a liberal calculation.

UNIT OF PRODUCTION, CAPITAL OUTLAY AND PROFIT

The monograph has suggested that a rayon manufacturing plant to be sufficiently profitable should have an out-put capacity of about 6 to 10 tons of yarn per day. A plant with a production capacity of less than 6 tons a day can only be set up at the risk of a reasonable margin of profit. Establishment of very big rayon factories does not also appear advisable as the distribution of the product over a wider area necessarily involves heavy freight charges. A number of rayon factories with 10 tons a day as the unit of production may be established throughout the length and breadth of this country. The following estimate suggested in the monograph indicates that a capital outlay of about one crore of

CAPITAL INVESTMENT

	Rs.
1. Land	Free
2. Building	500,000
3. Pulp Making Machinery	500,000
4. Rayon Manufacturing Machinery	5,000,000
5. Customs Duty at 10%	550,000
6. Erection Charges	200,000
7. Unforeseen and Sundry Charges	500,000
8. Working Capital	2,500,000
9. Brokerage, Underwriting Commission and Promotion Expenses	250,000
Total	10,000,000

rupees will be required to establish such a rayon factory. The cost of production per lb. of yarn has also been roughly calculated, as shown below. Thus the cost of one lb. of yarn will amount to about 8.17 as. on a liberal estimate. Since the average

THE COST OF PRODUCTION OF YARN

1. Cost of chemicals and raw materials	5.10 as. per lb.
2. Cost of power	.70 " " "
3. Cost of heating	.45 " " "
4. Cost of labour	.50 " " "
5. Cost of staff	.46 " " "
6. Cost of depreciation charges	.96 " " "
	8.17 " " "

selling price of first grade 150 deniers artificial silk yarn 12.5 as. per lb., in normal times a margin of nearly 4 as. per lb., i.e., 50 per cent, is indicated, according to this calculation. On the basis of 300 working days per year, the annual output of a 10 ton plant will be 3,000 tons or 73,20,000 lbs. of yarn which will produce a net annual profit of more than Rs. 18 lakhs. This profit can be substantially increased if manufacture of transparent paper and staple fibre be simultaneously undertaken, along with the manufacture of rayon yarn. In fact, transparent paper or cellophane is of the same chemical composition as rayon yarn and requires the same chemical processes and almost the same machineries. The cost of a complete machine capable of producing one ton of cellophane paper daily will not exceed Rs. 500,000, including transport charges, customs duty and erection expenses. But a profit of about Rs. 5 lakhs may be derived annually, and as such the production of cellophane paper and staple fibre may be simultaneously undertaken.

India is one of the important textile manufacturing countries of the world and is expected to remain so in future. Textile industry is one of her few important industries whose promotion and expansion should be the concern of all industrialists of this country, and also of the Government. Introduction of artificial silk has revolutionized several aspects of the textile industry and Indian manufacturers have also shown readiness to consume this artificial fibre in ever increasing amount. The growing demand for rayon and the present heavy drainage of money involved in its import from Europe and America are sufficient plea for the immediate setting up of this industry, for which India offers reasonable opportunities.

S. N. Sen.

DEVELOPMENT OF INLAND FISHERIES AS POSSIBLE SOLUTION OF MEAT SHORTAGE

S. L. HORA,

DIRECTOR OF FISHERIES, BENGAL

ADMITTEDLY at the present moment, India as a whole, and Bengal in particular, is faced with the problem of meat shortage. It is pertinent, therefore, to recall how Egypt solved an identical problem in the early years of the war by the development of its inland fisheries. In the *Statesman* of 23rd April, 1942, it was stated:

"Egypt's manner of facing the food problem has interest for India now that central and provincial resources are being reorganized for a 'Grow More Crops' campaign. Egypt's meat shortage problem was so acute that sales were prohibited on three days in the week. This has largely been solved by the development on a remarkable scale of inland fisheries. With the outbreak of war Egypt's fish supply dropped from about 12,000 tons a year to 2,000 tons because of restrictions that had to be imposed on the activities of foreign fishermen. The Department of Fisheries however transferred millions of small fish from the sea to the lakes and the result has been an increase to as much as 40,000 tons a year in supplies."

Through the kindness of Dr Taha, Director of Fisheries, Egypt, I have obtained further details of this remarkable achievement and as the information is likely to prove of great value to all provinces and States, I take the liberty to publish it here in detail so that in this country also development of fisheries may receive the necessary impetus in the "Grow More Food" campaign. Dr Taha has written to say:

"at the beginning of outbreak of this war, the production of the Egyptian Fisheries was seriously affected due to

- (1) Restrictions imposed on Sea Fisheries.
- (2) About 40 foreign motor fishing boats departed as soon as hostilities began. The few native motor boats left were made use of in purposes other than fishing operations. Consequently the production of sea-fisheries dropped from about 12,000 tons to nearly 3,000 tons annually.

The pre-war total production of the Egyptian Fisheries was estimated at 40,000 tons annually drawn from the three main sources:

- (a) Marine Fisheries, responsible for 25%—30% of the total production.
- (b) Lake Fisheries, responsible for about 60% of the total production.
- (c) Inland Fisheries, responsible for about 10%—15% of the total production.

In addition to the war consequences on sea-fisheries, there are other local factors, which tend to limit the yield of Lake-Fisheries. These mainly are:

1. The area is gradually decreasing and the dried land are reclaimed for Agriculture.

2. Quantities of fresh water supply lakes are gradually decreasing according to the agricultural policy. Consequently the level of the lakes is purposely made as low as possible for the adequate drainage of neighbouring agricultural lands. Moreover the development of agriculture has had not only a bad effect on lake fisheries, but also on the inland fisheries due to the necessity of controlling and development of irrigation and drainage systems by the construction of dams, barrages, etc. and also the gradual change of vast areas of Upper-Egypt basins from seasonal to permanent irrigation. These vast basins were considered to be one of the best environments suitable for natural breeding and for the raising up of fresh water fish.

3. Confronting the above-mentioned unfavourable factors, the Department of Fisheries tried hard to maintain the production at its pre-war level. The most successful measures to overcome these difficulties were found in extending the operations of transferring millions of fry of marine fishes, mainly Mulletts and Anguilla, from certain localities near the sea-shore to the lakes. In particular, we mention Lake Mariout which has no connection with the sea. Lake Karoun, an Inland Lake also used to be rich in fresh water fishes; but due to the agricultural policy, mentioned above, the salinity of its water gradually increased until it is estimated at present at about 20% in the larger part of its area. This high salinity has depleted the lake from most of its fresh water species, and the catches were affected to such an extent that they dropped from 4,100 tons in 1920 nearly to 483 tons in 1929.

4. The introduction of fry in this lake has greatly improved the situation and the catches gradually increased to about 2,782 tons in 1936.

5. It is here interesting to note that besides the successful acclimatization of two species of grey Mulletts—*Mugil cephalus* and *Mugil capito*—in Lake Karoun, the latter sp. *M. capito* has definitely spawned and propagated itself in that lake."

Similar causes have affected the supplies of fish in certain parts of India, and for these reasons steps taken in Egypt to augment supplies have practical application to Indian conditions. The fry of various types of mullet are found in large numbers in the estuaries and backwaters and along the sea coast of India. Devanesen and Chacko¹ have already shown that fry of the marine species, *Mugil troschelii*, *M. waigiensis* and *M. seheli* can be successfully acclimatized to fresh water conditions for cultural purposes. Regarding *M. troschelii*, the authors have stated that "Capacity of acclimatization, rapidity of growth, non-cannibalistic habit and the availability

¹ Devanesen, D. W. and Chacks, P. I.—"The Possibility of Culture of certain Marine Mulletts in Freshwater Tanks", *Proc. Nat. Inst. Sci. India*, 9, 249, 1943.

of the fry in large numbers indicate that this marine mullet is a good Indian sea-fish for cultivation in fresh waters".

At the end of Devanesen and Chacko's article, in an editorial note it was pointed out by me that in the estuaries of the Ganges *M. tade* and *M. parsia* are extensively cultured in the salt-water embanked fisheries known as 'Bhasa Badha'. Further, it is known in the Sundarbans that Mulletts grow to a big size only if allowed to enter into fresh waters, especially in the second year of their growth. Facilities are generally provided for the Mulletts to migrate into paddy fields or adjoining freshwater canals for fattening purposes. In the estuaries, however, the change in salinity is more or less gradual and, therefore, the fry of Mulletts get conditioned under natural conditions for life in fresh waters. It must be remembered that during the breeding period of Mulletts (February

to April in Bengal), the waters are simply thick with their fry so that only a little trouble has to be taken in collecting and planting the fry into suitable places of water. It was rightly surmised then that the small marine fish of Egypt transferred to lakes were probably the young of Mulletts.

Extension of 'Bhasa Badha' or salt-water bheris in the deltaic regions of the principal rivers of India is a practical proposition and is likely to result in a great increase in fish supplies of the country. So far as the real fresh waters in the interior are concerned, fry of carp should be collected from rice fields, inundated channels, and pools and puddles in the flooded areas and transferred to tanks and lakes. Species like *Catla*, *Rohu* and *Mrigal* fatten well under suitable conditions and, if properly farmed, will help materially in solving the meat shortage problem in the country.

HINDU ASTRONOMY*

PRABODH CHANDRA SEN GUPTA

HINDU MATHEMATICS

IN Hindu Mathematics, the earliest researcher was Colebrooke whose work is now regarded as a classic in this subject. This work presented to the European scholars the whole content of Hindu Mathematics as contained in Bhaskara II's (1150 A.D.) works, the '*Lilāvati*' and the '*Bījagaṇita*' and the mathematical chapters of the '*Brāhma-Sphuṭa Siddhānta*' of Brahmagupta. Dr Kern brought out his edition of the '*Āryabhaṭīya*' in 1874. Rodet translated and published one section, the *Gaṇita* of this work into French under the name '*Calcul du Āryabhata*'. Dr Bühler published his work '*Indian Paleography*' in the latter half of the last century. In this work he established from Subandhu's work, dated about the sixth century A.D., the use of a symbol for a vacant notational place, viz., the cypher which was a dot in the poet's time as evidenced by the expression '*Sūnyabindavah*' or the dots to which the stars in the sky are compared. In the '*Āryabhaṭīya*' (499 A.D.), the notational places are found mentioned as "sthāna" which means none else than place. In this work are found the Indian rules for finding the

square and cube roots of numbers, which show unmistakable use of notational places. The late Mr Kaye, in his translation of the *Gaṇita* section of the '*Āryabhaṭīya*', used the word "Order" in place of Āryabhaṭa's word "sthāna", and he created quite a diversion by asserting that the Decimal System of Notation was not an invention of the Indian Mathematicians but had a foreign origin derived from the practice of writing from the right to the left which obtained there. This view of Kaye has been successfully combated by the researchers Dr B. B. Dutt, Dr A. N. Singh and late Prof. Sarada Kanta Ganguly.

From the field of Orientalia, the Decimal System of Notation is the greatest gift of the Hindu Mathematicians to humanity. After the conquest of Sind by Mohamad Ibn Kasim, it travelled to the old centre of Mohamadan culture at Baghdad and with the rise and spread of Mohamadan power it spread over Europe. It has immensely simplified the art of calculation all over the world. In India this system was confined to the learned circles alone for some centuries even after the time of Āryabhaṭa I, till it found a place also in Indian Epigraphy. Dr B. B. Dutt published his '*Science of Sulva*' in 1932, in which we find that the beginnings of many topics in the later Hindu Mathematics had been made in the *Sulva* period, i.e., about 600 B.C. In the solution

of Indeterminate Equations of the first and second degrees the achievements of the Hindu mathematicians are also very remarkable. The method employed in solving Indeterminate Equations of the first degree is called '*Kuṭṭaka*' or pulveriser. This method in the complete form is found in the '*Āryabhaṭīya*' (499 A.D.), while in Bhāskara II (1150 A.D.) we have a full treatment of all classes of Indeterminate Equations of the first degree. The famous lemma of Prahma Gupta (628 A.D.), called by him '*Vajrabadha*' was rediscovered by Euler (1707-83) and this method was used by Brahmagupta in solving Indeterminate Equations of the second degree and also by the later Hindu mathematicians in solving comparatively easier problems. The Indian method of *Cakravāla* or the "cyclic method" for the general solution of all Indeterminate Equations of the second degree, following as a corollary* to the lemma of Brahmagupta to whom the credit of its invention which is purely Indian is to be ascribed has yet remained a riddle to many. The rules are found in Bhāskara II's work the '*Bījagaṇita*', but the author lays no claim to originality, when he says "*cakravālamidamjaguh*". This has been sung (by others) as the "cyclic rule". Thus far it can be said that the rules have not yet been found in any hitherto known previous authors. I hope that further researches may show that this achievement is to be ascribed to Padmanābha, if his work be ever brought to light. It is now a matter for research to decide whether the Hindus were also the first to use a symbolical notation in Algebra.

In Trigonometry, the Hindu mathematicians and astronomers used generally the functions of "sine", "cosine" and "versed sine" in analysis. The tabular differences of 24 "sines" in a quadrant are first found given in '*Āryabhaṭīya*' (499 A.D.) calculated by the most elementary methods. The most accurate Hindu value of π is also found in the same work as given by $\pi = \frac{104 \times 8 + 62000}{20000} = 3.1416$. The Hindus by their methods, though very elementary, could solve both plane and spherical triangles† right angled and of other classes. Further in Hindu Mathematics we find the beginnings made of the Infinitesimal Calculus. The researchers in this field have been Bāpudeva in *J. A. S. B.*, (1858) and Sir B. N. Seal in his '*Positive Sciences of the Hindus*'. I have also contributed a paper in the *Calcutta University Journal of Letters*, Vol. XXII, 1931, styled "Infinitesimal Calculus in Indian Mathematics and Astronomy". The idea of Differentiation developed from an attempt of the

Hindu astronomers to find the instantaneous daily motion of planets, and the idea of Integration, to find the surface and volume of a sphere, etc. So far as we can see, in Differentiation the idea of limits was recognized by all authors from Brahmagupta (628 A.D.) to Bhaskara II (1150 A.D.). The idea of the real Differential Calculus thus seems to have originated in India. We have in Bhaskara II an equation which is equivalent to

$$d(\sin \theta) = \cos \theta d.$$

While engaged in translating Brahmagupta's *Khaṇḍakhādya*, the *Alarkand* or *Khaṇḍakāṭaka* of the Arab astronomers, I came across a passage which, properly interpreted, makes it clear that Brahmagupta recommends the use of the Second Difference in Interpolation. On this topic a paper was published by me in the *Bulletin of the Calcutta Mathematical Society*, Vol. XXIII, 3, 1931. It will be clear from my paper under reference that, of the Calculus of Finite Differences also, the first step was taken by the Hindu mathematicians.

Drs Dutt and Singh have undertaken to publish a complete anthology of Hindu Mathematics, of which up to now the first two volumes have been published, and the third volume is under compilation. I trust, when the times are more favourable, these volumes, it is expected, will give the reader a complete history of Hindu Mathematics and all researches thereon up-to-date. If such a private venture is to prove successful, liberal help from the public or a university is perhaps essential. From the very nature of such publications, the venture cannot be remunerative.

In this connection we should not forget to mention the name of Prof. Rangacharya of Madras, the translator and publisher of the '*Gaṇita Sūtra Saṃgraha*' of Mahāvīra. The work has thrown much light on Jaina Mathematics and has been of much help in the study of the history of Hindu Mathematics. The researches of Prof. A. A. Krishnaswami Ayyangar of the Maharaja's College, Mysore, also deserve mention. I now pass on to the progress made on the study of the history of Hindu Astronomy.

HINDU ASTRONOMY

In this branch of Orientalia, the earliest writers were Bailly in his '*Astronomie Indienne*' and Delambre in his classical work '*Astronomie Ancienne*'. Next in point of time was probably Bentley whose work, '*A Historical View of Hindu Astronomy*', is well known. Then came the edition of the '*Sūrya Siddhānta*' by Bāpudeva and Wilkinson. Warren's '*Kāla Saṃkalita*' was perhaps next to appear in this field of research. In 1860 was published Burgess' translation of the '*Sūrya Siddhānta*', in the

* Being the Presidential Address delivered at the Technical Sciences Section of the Twelfth All-India Oriental Conference held at Benares on January 1, 1944.

* P. C. Sen Gupta, "Origin of the Indian Cyclic Method for the solution of $Nx^2 + 1 = y^2$ " in the *Bulletin of the Calcutta Mathematical Society*, 1918.

† P. C. Sen Gupta, "Greek and Hindu Methods in Spherical Astronomy" in the *Cal. Univ. Journal of Letters*, Vol. XXI, 1931.

J. A. O. S. A more important work from the view point of the history of Hindu Astronomy next appeared in the publication by Thibaut and Dvivedi Varāha-Mihira's '*Pañca-Siddhāntikā*', which threw much more light on the history of the *Siddhāntic* or scientific Hindu Astronomy. About the end of the last century appeared the '*Gaṇaka Tārāṅginī*' (1892) of Dvivedi in Sanskrit, Dikṣita's '*Bhāratiya Jyotiḥ-śāstra*' (1896) in Marathi and '*Amader Jyotiṣa o Jyotiṣi*' in Bengali by Prof. J. C. Ray, late of the Cuttack College, being mainly based on the works of Dvivedi and Dikṣita. These works should all have been written either in Sanskrit or English and not in any of the provincial vernaculars.

In the year 1918, Ancient Indian History and Culture was accepted as a subject for the M.A. degree of the Calcutta University at the instance of the late Sir Ashutosh Mookerjee, and Indian Astronomy and Mathematics was formed into a group for special study for this final degree of the University. From this date both teaching and research were provided for in the Calcutta University. In 1925 appeared an edition by Pandit Babuaji Misra of the '*Khaṇḍakhādya*' of Brahmagupta with Āmaraja's commentary. This publication led me to get at the clear position of Āryabhaṭa I as the real maker of the Indian Scientific Astronomy in a publication of mine, "Āryabhaṭa, the Father of Indian Epicyclic Astronomy" published in the *Calcutta University Journal of Letters*, Vol. XVIII, 1928. The other publications by me have been the papers:—

(a) A translation of the '*Āryabhaṭi*' in the *Calcutta University Journal of Letters*, Vol. XVI, 1927, (b) Āryabhaṭa's method of determining the

mean motions of planets, in the *Bulletin of the Calcutta Mathematical Society*, Vol. XII, 3, (c) Time by Altitude in Hindu Astronomy and (d) Hindu Luni-solar Astronomy in the *Bulletin of the Calcutta Mathematical Society* in Vols. XVIII and XXIV respectively. The Introduction to the Calcutta University reprint of Burgess' translation of the '*Sūrya Siddhānta*' published in 1935, has been my last published contribution to the History of Hindu Astronomy.

As to the Hindu *Siddhāntic* Astronomy foreign influence is unquestionable as may be seen from the brief and meagre account of Greek Luni-solar Astronomy under the name '*Romaka Siddhānta*', given in the '*Pañca-Siddhāntikā*' of Varāhamihira. The '*Vaśiṣṭha*' and the '*Pauliṣa Siddhāntas*' of which a summary is given in the same work of Varāhamihira, also point to a foreign origin which may be Greek, Babylonian or Persian. Even the modern '*Sūrya Siddhānta*' has in it the unmistakable influence of Babylonian Astronomy in its conception of the gods of *Manda*, *Sighra* and *Pāta*, as producers of planetary *dhānta*. The chief improvements made by Āryabhaṭa are given in the following tabular form:—

In spite of all these foreign influences Āryabhaṭa I (499 A.D.), the real maker of the Indian Scientific Astronomy had a clear originality in a thorough revision of all the astronomical constants as they came from the foreign sources. These have been set forth in my paper "*Hindu Luni-solar Astronomy*" and in my Introduction to the Calcutta University reprint of Burgess' translation of the '*Sūrya Siddhānta*'. The chief improvements made by Āryabhaṭa are given in the following tabular form:—

Astronomical constants	Āryabhaṭa 499 A.D.	Ptolemy 150 A.D.	Moderns 500 A.D.	Āryabhaṭa's Error	Difference from Ptolemy
Longitude of Sun's Apogee	78°	65° 31'	77° 19'	+ 0° 41'	+12° 30'
Sun's max. Equation of Apsis	2° 9'	2° 23'	1° 59'	+ 0° 10'	- 0° 14'
Sid. Per. of Moon's Node	6794.7459 da.	6796.4558 da.	6793.3911 da.	1.3584 da.	-1.7063 da.
Long. of the Aphelia of					
(a) Saturn	236°	224° 10'	243° 40'	- 7° 40'	+11° 50'
(b) Jupiter	180°	152° 9'	170° 22'	+ 9° 38'	+27° 51'
(c) Mars	118°	106° 40'	128° 28'	-10° 28'	+11° 20'
Long. of Nodes of					
(a) Saturn	100°	90°	100° 32'	- 0° 32'	+10°
(b) Jupiter	80°	70°	85° 13'	- 5° 13'	+10°
(c) Mars	40°	30°	37° 49'	+ 2° 21'	+10°
(d) Venus	60°	55°	63° 16'	- 3° 16'	+ 5°
(e) Mercury	20°	10°	30° 35'	-10° 35'	+10°
Max. Equation of Apsis					
(a) Saturn	7° 53'	6° 30'	6° 57'	+ 1° 4'	+ 1° 23'
(b) Jupiter	5° 24'	5° 14'	5° 16'	+ 0° 81'	+ 0° 10'
(c) Mars	10° 28'	11° 10'	10° 33'	+ 0° 55'	+ 0° 9'

Here the differences between the constants of Āryabhaṭa I and Ptolemy cannot be explained by the precession rate of Ptolemy of 1° per 100 years in the cases of the longitudes of aphelia and nodes of planets, while in the remaining cases independent determination by Āryabhaṭa I must be conceded. These facts ought to be enough proof of the claim for Āryabhaṭa I, being held as the greatest of all the ancient Indian astronomers, as the real maker of the Indian *Siddhāntic* Astronomy, and not a mere borrower from any foreign system of astronomy.

Again the teaching in Hindu Astronomy that at starting point of the Kali-reckoning, the "mean planets" were at the very beginning of the Hindu sphere and that the longitudes, the moon's apogee and node were respectively 90° and 180° of the same sphere, is also to be ascribed to Āryabhaṭa I. The epoch of Kali-reckoning, viz., Feb. 17-18, 3102 B.C., Ujjayini Mean Time, 0 hr. or 6 A.M. of Feb. 18, was most likely arrived at by him by an Indeterminate Analysis. Although at this epoch the "mean planets" did not exactly coincide with the 1st point of the Hindu sphere (the mean vernal equinox of 21st March, 499 A.D.) and the lunar apogee and the node did not have the longitudes 90° and 180° of it, there was something approaching a general agreement with the hypothesis with which Āryabhaṭa I had started. This is borne out by the researches of Bailly, Bentley, Burgess and also by myself. It is thus seen that the astronomical Kali-reckoning was a fiction created by Āryabhaṭa I to simplify his rules for stating his astronomical constants at this epoch. It is clear from the facts stated above that this epoch of 3102 B.C. cannot have any chronological significance.

But as we come down by 3600 years from this Kali epoch to Āryabhaṭa's time using his constants, to the date, March 21, 499 A.D. Ujjayini Mean Midday, (J.D. = 1903397), we have:—

Planet	Āryabhaṭa's Mean Long. Addayika	Mean Trop. Longitudes Moderns	Error in Āryabhaṭa's Mean longs.	Āryabhaṭa True Places	Moderns True Places	Error in Āryabhaṭa's True Places
Sun	0° 0' 0"	359° 42' 5"	+ 17' 55"	2° 6' 6"	1° 37' 48"	0° 28' 18"
Moon	280° 48' 0"	280° 24' 52"	+ 23' 8"	...	...	...
Moon's Apogee	35° 42' 0"	35° 24' 38"	+ 17' 22"	...	...	...
Moon's Node	352° 12' 0"	35° 2' 26"	+ 9' 34"	...	...	...
Mercury	186° 0' 0"	183° 9' 51"	+2° 50' 9"*	352° 4'	349° 4'	+3° 0"
Venus	356° 24' 0"	356° 7' 51"	+0° 16' 9"	359° 43'	359° 18'	+ 25'
Mars	7° 12' 0"	6° 52' 45"	+0° 19' 15"	10° 50'	10° 23'	+ 27'
Jupiter	187° 12' 0"	187° 10' 47"	+0° 1' 13"	185° 57'	186° 40'	- 47'
Saturn	49° 12' 0"	48° 21' 13"	+0° 50' 47"	40° 5'	40° 56'	- 51'

* Maximum error in the long. of Mercury in Āryabhaṭa's system.

The figures show to some extent how far Āryabhaṭa I was accurate as an observer.

Again Āryabhaṭa's year = 365da. 6 hrs. 12 min. 30 secs. and True Sid. year = 365da. 6 hrs. 9 min. 10 secs.

His year was thus in error by about +3 min. 20 secs. But *Pauliṣa Siddhānta* year = $\frac{120}{43831}$ days = 365 da. 6 hrs. 12 mins., which was more accurate but still Āryabhaṭa I, perhaps did not find it to have been so. He did not accept any astronomical element transmitted from a foreign source as correct until and unless it was verified by his own observation or observation records accessible to him.

As to the discovery of lunar inequalities, Āryabhaṭa I (499 A.D.), Brahmagupta (628 A.D.), Lalla (748 A.D.), recognised only one. But on coming down to the time of Muñjala (932 A.D.) we find that this astronomer first discovered the second inequality of the Moon* and Bhāskara II (1150 A.D.) the third inequality. The Hindu form of the "evection" equation is much better than that of Ptolemy and stands on par with that of Copernicus (1542 A.D.)

The other details of Hindu astronomy chiefly concerned with the Hindu astronomical methods of calculation, were improved upon and corrected by Brahmagupta and Bhāskara II. Periodical corrections to planetary positions as derived from the *Siddhāntas*, have been made by Lalla, Sripati, Satānanda, Bhāskara II, Ganesa and Makaranda and in Bengal by Raghavānanda and Rāmaśarma. They have also derived simpler methods of calculation according to the *Siddhāntas*. The outstanding fact from all researches up to date is that the first Hindu scientific *Siddhānta* the *Āryabhaṭi*, was started from the year 499 A.D. and by Āryabhaṭa I.

From the view point of the history of Hindu astronomy, there is a great gap from about 1400 B.C. to 499 A.D., which remains yet to be explored—I

* On this topic two papers have been published in the *Bulletin of the Calcutta Mathematical Society*, one in Vol. XXII, 2 and 3 by Mr Dhirendra Nath Mukhopadhyaya, and the other in Vol. XXIV, 1, by the writer named "Hindu Luni-Solar Astronomy".

mean the period of transition from the astronomy of the *Vedāṅgas* to the age of the *Siddhāntas*. In this period lived the astronomers Garga, Kasyapa, and others whose names and extracts from whose works are quoted by Bhattotpala (966 A.D.) in his commentary on the *Brhat Samhitā* of Varāhamihira. There are works like the *Vṛddha Garga Samhitā* still extant, which should be rescued from the total

oblivion into which they are fast sinking. These astronomers described *cāras* or courses of planets of which we get some idea from the *Pañca-Siddhāntikā*, chapter XVII, and also from the *Arthaśāstra* of Kautilya. It is a very important point for research how far these *cāras* described in these earlier works, could have influenced the first formation of the scientific Hindu Astronomy by *Āryabhaṭ I*.

EDUCATIONAL NEEDS OF BENGAL BASED ON FIGURES OF EMPLOYMENT

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INTRODUCTORY

THERE are various ways by which the educational needs of a country can be surveyed. A practical method of doing it will be to calculate backwards from the figures of employments. Just as the success of an individual depends on how best he can conserve his energy and apply it to different activities of life according to demands, so does the success of a nation depend on how best it can conserve the total energy of its individuals for expenditure in the varied activities of the national life. This requires a careful planning and grouping of the individuals so as to obtain the maximum of collectivized efficiency at minimum of expenses and this is possible only by educating the groups in such a way that excesses are avoided and standards improved. It is necessary to avoid excesses not merely because all excesses are wasteful but because with limitations of human energy and of national income such excesses are bound to lead to inefficiency in training and deficiency in the standard of education.

What has been meant here by excesses in education is this: To a clerical post it is wasteful to employ a person having a high literary education. It is not that the latter person will be incompetent to do the work—though at times this is also true—but in order to avoid wasteful utilization of national energy such a person should not be employed for doing the work of a clerk but should be given some vocation in which his literary abilities might find a fair play. For efficient conservation of the nation's energy, in choosing a clerk we ought to choose a man who has the right training and equipment of a clerical job and it should be the duty of the nation to give a number of men the requisite training so that

they might be suitably employed for such vocations. Similarly a *Joidar* ought to receive sufficient training in scientific agriculture and not made to receive a purely academic training which will lead him nowhere.

It is therefore clear that in formulating our educational needs, the most scientific way of approach will be to examine the country's requirements from the vocational standpoint. It is true that such requirements have no static feature and are directly connected with the nation's outlook. In the predominantly agricultural Tsarist Russia probably 90% of the people of Russia had agriculture as their vocation, whereas in the modern industrialized Soviet Russia a considerable number has changed their vocation from agriculture to industries. Consequently the educational needs of modern Russia differ considerably from those of the past. There is however a limitation to such changes and fluctuations and in any case in making a start, the existing condition may safely be regarded as an index of the country's present requirements, and it may be surveyed every five or ten years when requisite statistics are available from census figures. A more accurate and thorough plan would have been to find out the optimum of each vocation, i.e., the number of men which each vocation can suitably accommodate without any overcrowding. But necessary data for calculation of the optimums are not available, hence the actual figures of employments have been accepted as the optimum of the corresponding vocation.

With the above in view, a thorough analysis of the figures of employments of male populations of Bengal has been made from the Census Report of 1931—those of the 1941 Census being not yet avail-

able and women's education has been left out of the present consideration. Such analysis at once reveals that persons employed in different pursuits can be suitably classified from the educational standpoint into the following three groups:—1. General, 2. Commercial, 3. Technical. From the number of persons employed, an estimate has been made as to

the number of probable annual vacancies and this latter figure has been utilized in the calculation of the number of schools of each type required to satisfy the country's requirements on the assumption that the basic education of the different groups is common in Primary and in some length, of the High School stage.

TABLE 1
ANALYSIS OF THE EMPLOYMENT FIGURES
Estimated figures requiring education (in thousands)

Vocation as classified in the Census Report	Total employed in 1000	General		Commercial		Technical		Remarks
		Low	High	Low	High	Low	High	
1 Non-cultivating proprietors ...	451.7	406.6	36.1	...	4.5	...	4.5	Rest Labourers Do Do
2-3 Estate Agents and Managers ...	1.1	...	1.1	...	...	...	...	
4 Rent Collectors ...	42.3	...	...	42.3	...	...	...	
9-16 Special Cultivation ...	146.6	1.0	.12	...	.1	.2	.1	
17 Forest Officers, rangers, guards ...	1.1	...	.2	...	.12	.12	.1	
43 Cotton spinning, sizing & weaving ...	127.7	1.4	0.2	.2	...	...	.24	
35 Coal ...	24.3	...	...	.24	...	...	.24	
44 Jute pressing, spinning & weaving ...	229.1	1.1	0.3	.3	.15	.3	.15	
51-53 Hides Industry: Leather, bone ...	11.2	.4	.1	.1	...	...	...	
54-56 Wood: Sawers, Carpenters, Basket-makers ...	116.6	3.0	.5	.5	...	.5	...	
57-61 Metal: Smelting, Blacksmith, Brass workers ...	48.5	3.4	.5	.5	...	.5	...	
53-66 Ceramics: Potters, Brickmakers, other ceramics ...	63.2	.8	.2	.2	...	.2	...	
66-70 Chemical products: Matches, Aerated Water, Vegetable oil, Mineral oil ...	35.4	...	...	.2	...	.1	.1	
82-84 Dress and Toilet ...	61.6	.6	...	.6	...	.6	...	
88 Cabinet maker ...	1.8	...	...	.1	...	.1	...	
96-99 Miscellaneous Industries ...	59.1	2.1	...	1.9	...	1.9	.08	
91 Motor car construction and repair ...	1.7	...	...	.08	...	.34	...	
92 Carriage ...	1.1	...	...	.02	...	.11	...	
94 Electric Power and Gas work ...	3.3	...	...	.06	...	.25	.06	
112 Ry. Employees excepting labourers ...	38.6	14.5	4.8	7.3	2.4	7.3	2.4	
107 Employees of Mechanical Vehicles ...	8.2	...	...	1.0	...	3.1	...	
114 Post, Telegraph, Telephone employees ...	10.6	3	3	2	1.0	1.0	.6	
115 Bank, Insurance employees ...	44.4	...	.4	30	10.0	...	...	
116 Brokers ...	8.8	...	...	7	.8	...	...	
117 Textile Trade ...	56.5	...	2.8	25.4	...	...	...	
118 Leather Trade ...	22.7	...	.2	2.1	...	...	...	
123 Other Trades ...	170.0	...	.8	14.4	...	...	.8	
125 Trade in Chemicals ...	3.5	...	.8	1.0	...	...	...	
148 Book Trades ...	22.5	5.0	1.2	5.0	...	...	...	
153 Army (Imperial) ...	2.5	2.0	0.5	...	...	...	...	
157 Police ...	21.2	19.2	2.0	...	...	...	...	
158 Village Watchmen ...	33.5	33.5	...	...	...	...	...	
159 State Service ...	38.5	...	35.0	...	3.5	...	...	
161 Municipal ...	9.2	...	8.5	...	.8	...	...	
162 Village Officials ...	1.1	1.1	...	...	...	...	...	
167 Lawyers ...	17.1	...	17.1	...	...	...	...	
168 Lawyers' Clerks ...	13.5	13.5	...	...	...	...	...	
169 Medical Practitioner ...	28.7	...	28.7	...	...	...	...	
170 Quacks ...	21.3	21.3	...	...	...	...	...	
171 Dentists ...	1.1	...	1.1	...	...	...	...	
173 Vet. Surgeons ...	.5	...	.5	...	...	...	...	
174-176 Professors & Teachers including Clerks etc. in Institution ...	69.0	...	69.0	...	...	...	...	
177 Surveyors & Engineers ...	1.6	...	1.6	...	...	...	...	
178-183 Miscellaneous occupation in Arts & Sciences ...	22.8	20.4	2.4	...	...	...	...	
186 Motor Drivers & Clearers ...	7.2	...	...	...	...	3.6	...	
188 Unclassified businessmen ...	6.7	3.0	.7	3	...	...	...	
189 Cashiers & Accountants ...	194.4	...	...	175	19.4	...	...	
190 Mechanics ...	9.0	...	...	...	...	8.0	7.0	

N.B.—By "High" and "Low" are meant the corresponding education of the College and School standards respectively.

It is amazing that out of a population of over 4½ crores (1931 Census figure) number of persons engaged in vocations requiring secondary or higher education is as low as 1·18 millions. Be that as it may, the total number of persons requiring different types of education, as enumerated in the "Analysis of the figures of employments" given above, may be broadly classified as below:—

TABLE 2

Type of education	No. of persons in thousands
General low	556·9
General high	221·5
Commercial low	320·6
Commercial high	42·5
Technical low	28·2
Technical high	10·2
Total	1179·9

The rest of adults comprising the large volume of cultivators, fishermen and labourers need only be given Primary education with adequate vocational bias. As the complicated question of Primary education is left out of the present consideration, the analysis of the educational needs of Bengal will therefore be confined to Secondary and Higher education only.

ANALYSIS OF THE EDUCATIONAL NEEDS

The figures collected above give the total number of persons engaged in vocations requiring a common basic type of education. It may be argued that the allocation to different groups has been done entirely arbitrarily. Although this is true, it may be claimed that in many cases test verifications have been made by references to particular firms representing a group and the percentage of figure of allotment to different classes has been adjusted accordingly. Consequently the figures are not obtained on an entirely arbitrary basis but has close correlation with the actuals.

Assuming therefore that each vocation can support only the present number of persons, it is clear that for the present, the educational aim of the country should be to keep an adequate supply of trained men so that these figures, which would normally run short by death or retirement can be maintained at their present levels. Now, persons engaged in any vocation comprise all age groups, say between 18 and 60. Taking 18 as the average minimum age of entry and 60 as the average maximum age of retirement from service,* the defection

* Although the age of retirement in State services is 55, as the number of persons engaged in State services is very small as compared to the total, the average age of retirement is estimated at 60, which may be regarded as the age at which infirmity begins.

due to retirement may be estimated by assuming an equi-distribution of number in different age groups, so that the number of retirement in any year is the total number divided by the number of years of active service. This gives the percentage of vacancy by retirement as 100 divided by 42 (60-18) i.e., 2·4.

The defection due to death* may be obtained from the Indian mortality co-efficients for the said age limits and taking their average as shown in the table 3 below:

TABLE 3

Age	Value of co-efficient per hundred
20	·5
30	·7
40	1·0
50	1·5
60	2·9
Average	1·37

The total co-efficient of defective is thus 2·4+1·37=3·77. Hence the number of persons of each education-group required to balance the annual defection is as follows. (Table 4).

TABLE 4

Type of Education	Total No. employed in thousands	Defection Co-efficient	No. of defection=Col. 2 x col. 3 divided by one hundred
General (low) ..	556·9	3·77	20998
" (high) ..	221·5		8350
Commercial (low) ..	320·6		12086
" (high) ..	42·5		1602
Technical (low) ..	28·2		1063
" (high) ..	10·2		384

Consequently the needs of the Secondary and Higher education will have to be formulated in such a way as to impart different types of education to such number of persons as will annually yield the number given above.

Although a classification into different types according to the requirements of each vocation has been made, it will be generally admitted that in the elementary stages they must be the same and the branching into different types should take place at some higher stages of the school education. There may be some difference of opinion as to the stage at which this will happen. But from consideration of age it may be laid down that such branching leading to some degree of specialization will not be of advan-

* Defection co-efficient by death should vary according to nature of occupation but owing to absence of such classification in the Mortality table, the average is taken.

tage until at least the age of twelve is reached which corresponds to Class VIII of High Schools taking the average age of admission into the lowest class (i.e., Class III) as seven years. A general scheme of education is accordingly tentatively suggested in the form a genealogical table given below:—

TABLE 5
Elementary School Education A.
(Up to Class VII).

High School Education leading to Matric General	Technical School Education B leading to Matric technical	Commercial School Education B leading to Matric Commercial
University General	Technical high	University Commercial

Assuming the average defection in class promotion as 4% and the defection in the first stage, i.e., from A to B as 20%, from B to C as 30% a progressive loading backwards has to be made in order to arrive at figures giving the number of students in the topmost class of stage A which will satisfy our vocational needs. This has been shown in the following table.

TABLE 6

Type	No. of persons of Table 4.	No. of Matrics required for col. 2 at 30% defection.	No. in hundreds in lowest stage in B at 12% defection.	No. in hundreds in the highest stage in A at 20% defection.
General high ..	8,350	11,930	135 } 373	170 } 467
" low ..	...	20,998	238 }	297 }
Commercial high ..	1,602	2,290	26 }	32 }
" low ..	...	12,086	137 } 163	170 } 202
Technical high ..	384	550	6 }	8 }
" low ..	...	1,063	12 }	15 }

692

The number of students which institutions imparting different types of education will have to pass out annually being thus known, an estimate of the total number of such institutions can be made, as is given in the table below:

TABLE 7

Type of Education	No. to be catered for the end class in hundreds	No. of institutions required at an average of 30 students in the end class	Type of institution
General (elementary)	692	2,307	A type.
General (Matric)	373	1,240	B type general Commercial B Technical B.
Commercial "	163	543	
Technical "	18	60	

The number of persons required for vocations demanding higher education has been given in column 2 of table 6. This number comprises of all grades of University education from Intermediate to the higher degree examination.

The statistical division of this different grades of higher education has not been attempted here as the main object was to determine the requirements of the Secondary education. Incidentally, however, the statistics so far collected enable us to determine the number of Intermediate Arts Colleges or equivalent Technical Schools as shown in Table 8.

TABLE 8

Type of Education	No. to be catered for	No. of institution required at an average of 100 in the class	Type of institution
General ..	8,350	84	Intermediate Arts College
Commercial ..	1,602	16	Commercial College
Technical ..	384	4	Technical College

CONCLUSION

The analysis given above with all the limitations of imperfect data shows that the present needs of Bengal may be well served by having about 2,300 elementary schools of type A imparting education up to the standard now reached in Class VII of high schools and 1,240 high schools of the General B type teaching Class VIII to the Matric Standard and these are to be supplemented by 540 high schools of B type giving a commercial bias and 60 similar technical schools. These 1,840 high schools are to feed 84 Arts, 16 Commercial and 4 Technical Colleges giving education up to the Intermediate Standard of the University. As after the elementary stage a branching into different types appear to be necessary from vocational considerations, the completion of the elementary stage should be marked by holding some sort of a distinctive examination either under the control of the University or of a separate Board as may be found convenient. This practically means a revival of the M. E. Schools but with this important modification that they should no longer enter as an alternative to the earlier classes of H. E. Schools as they used to do in the past but they should form an integral part of the school education and their final examination has to be passed in order to qualify for high school education. So far as general education is concerned the elementary schools of type A and the high schools of type B may be housed together

for the sake of economy more particularly in towns and sub-divisions and in progressive villages. But elsewhere only the lower type of schools need be maintained. This will not only reduce the total cost but will also offer distinct advantages to villagers in being able to receive their education at centres nearer to homes.

As the analysis has been made on the figures of 1931 Census when the population was 4.5 crores, with the increase in population by nearly 25% as revealed in the 1941 Census, there must have been a pro-rata increase in the number of employments and the figures arrived at in the present analysis must also receive corresponding increase. That is to say, the total number of elementary schools of type A should be about 2,850 and that of type B general 1,500, type B commercial 650 and type B technical 75.

It must also be distinctly understood that though

the present scheme may suffice to serve the present needs of Bengal, a five yearly revision of the scheme will have to be made in order to satisfy the growing demands of the post-war reconstruction period in which an Agricultural India is bound to be gradually transformed if not to an Industrial India but to an India in which industrial and commercial developments will certainly be more marked than developments in any other direction. Education in a progressive country will always be dynamic in character and the static feature which forms the basis of the present analysis can at best represent the condition of things for a limited number of years. For more careful planning better statistics are also needed and Census authorities will certainly render a great service if they care to publish the figures of persons having different standards of education along with employment figures in different vocations.

Notes and News

NATIONAL CHEMICAL LABORATORY

THE Committee of the Council of Scientific and Industrial Research appointed to draw up a scheme for the establishment of the proposed National Chemical Laboratory for India has recently submitted its report which is now released for publication to invite public opinion and criticism. The National Chemical Laboratory, as we find from the report, will be established much after the fashion of the chemical research laboratories in Teddington under the Department of Scientific and Industrial Research, England. While fundamental research will form an important part of its programme, greater emphasis will be laid on industrial research and the development of new processes up to the pilot plant stage. Such researches will doubtless be of direct help to chemical and other industries now badly in need of such investigations. Facilities for research up to the pilot plant stage are at present hardly available with the result that a process successfully developed in a laboratory often proves a failure when worked out on a large scale. With the establishment of the National Chemical Laboratory such uncertainties will largely cease to exist and the manufacturers may be encouraged to undertake with greater confidence the commercial development of new processes. The laboratory will further maintain

the closest co-operation with the laboratories of the universities or other institutions under private or semi-Government management.

It is proposed that the Laboratory should at present provide accommodation and facilities for the following main branches of chemistry: inorganic chemistry including analytical investigations, organic chemistry including drugs and chemotherapy, physical chemistry including high-pressure technique and electro-chemistry, biochemistry including biological products, and chemical engineering. When facilities for investigations in these branches will be created, it will be possible, the report states, to deal with raw materials and problems relating to a number of industries, such as heavy chemicals (acids, alkali, salts, etc.), minerals, fertilizers, organic and inorganic chemicals including solvents, pharmaceuticals and food, fermentation and biological products, resins and plastics, paints, pigments, lacquers and varnishes, oils, fats, soaps and lubricants, essential oils, leather and adhesives, rubber, petroleum, and electro-chemical industries. It is suggested that provisions for work shops and pilot plant equipment should be satisfactory enough to enable the laboratory to undertake ordinarily any type of industrial research.

The fact that the first step represented by the drawing up of the scheme for the establishment of

the National Chemical Laboratory has now been concluded is an encouraging news. But we are disappointed to learn that the actual establishment of the Laboratory will not take place until after the war. The establishment of the National Chemical Laboratory and similar central laboratories, such as the National Physical Laboratory, the National Metallurgical Laboratory, the Central Fuel Research Station and the Central Glass and Silicates Research Institute, as we have repeatedly stressed, is an immediate and urgent necessity. Substantial industrial development of this country will not be possible so long as these central institutes of research do not come into being and start work. Deferring the establishment of these laboratories means postponement of the urgent industrial development of India which we can only accept at our own peril. Schemes are being framed, adopted and translated into practice in other countries, as the war is in progress, for the intensive development of industries as a measure of national preparedness during this war and more particularly for the post-war period. There is danger in delay when other nations are planning not only for the consolidation of home markets but for the capture and maintenance of foreign markets, and as such the execution of the scheme, we strongly feel, should be undertaken here and now.

INDIAN PHARMACOPOEIA

THE recent decision of the Government of India to publish an Indian Pharmacopoeia is a welcome news. The Government have asked the Drugs Technical Advisory Board to prepare the material for a list of drugs in use in India and to recommend standards and tests with which to establish their uniformity, identity and purity. These drugs, although not included in the British Pharmacopoeia, are of sufficient medicinal value to justify their inclusion in an official pharmacopoeia. The list, when approved, will be known as the Indian Pharmacopoeial List and will constitute the official Indian Supplement to the British Pharmacopoeia.

Considerable material is available as a result of the indigenous drug enquiry which has been in progress for a number of years under the direction of Lt.-Col. Sir R. N. Chopra. Any further investigation that may be necessary to determine the standards to be laid down can be carried out at the Bio-Chemical Standardization Laboratory or, by arrangement, at other Government laboratories. A Committee, with Sir R. N. Chopra as the Chairman, has been set up to examine the material for the list and report to the Board and includes the following members: Dr P. Kutembiah, Dr R. N. Prasad, Dr B. B. Dikshit, Dr A. K. Sen, Mr. S. N. Bal, Mr M. L. Schroff,

Dr Sudhamoy Ghosh, Dr B. N. Ghosh, Dr B. Mukerji and Secretary, Drugs Technical Advisory Board.

THE VALUE OF RESEARCH IN PURE SCIENCE

LAST year there was published a biography of the late Sir J. J. Thomson, written by Lord Rayleigh.* It is a book that every research student should read. At the present time, when the question of organizing scientific research in India is receiving so much attention, the following quotation from Lord Rayleigh's biography is well worth reproducing. It relates to an occasion in 1916 when Sir J. J. Thomson, as President of the Royal Society, headed a deputation which was received by Lord Crewe who was then Lord President of the Council. Sir J. J. Thomson delivered a speech which seems to have made a considerable impression. The most significant part of it was as follows:—

"I shall, this morning, look on research in pure science from a frankly utilitarian point of view, not because I think it is the only, or even the most important aspect of the question, but because it is the aspect which must, quite legitimately, appeal most forcibly to the Government responsible for the material welfare of the country.

"By research in pure science I mean research made without any idea of application to industrial matters but solely with the view of extending our knowledge of the Laws of Nature. I will give just one example of the 'utility' of this kind of research, one that has been brought into great prominence by the war—I mean the use of X-rays in surgery. Now, not to speak of what is beyond money value, the saving of pain, or, it may be, of life to the wounded, and of bitter grief to those who loved them, the benefit which the State has derived from the restoration of so many to life and limb, able to render services which would otherwise have been lost, is almost incalculable. Now, how was this method discovered? It was not the result of a research in applied science starting to find an improved method of locating bullet wounds. This might have led to improved probes, but we cannot imagine it leading to the discovery of the X-rays. No, this method is due to an investigation in pure science, made with the object of discovering what is the nature of Electricity. The experiments which led to this discovery seemed to be as remote from 'humanistic interest'—to use a much misappropriated word—as anything that could well be imagined. The apparatus consisted of glass vessels from which the last drops of air had been sucked, and which emitted a weird greenish light when stimulated by formidable looking instruments called induction coils. Near by, perhaps, were great coils of wire and iron built up

* The Life of Sir J. J. Thomson, by Lord Rayleigh, Cambridge University Press, 1943.

into electro-magnets. I know well the impression it made on the average spectator, for I have been occupied in experiments of this kind nearly all my life, notwithstanding the advice, given in perfect good faith, by non-scientific visitors to the laboratory, to put that aside and spend my time on something useful.

"This example illustrates the difference in the effects which may be produced by research in pure or applied science. A research on the lines of applied science would doubtless have led to improvement and development of the older methods—the research in pure science has given us an entirely new and much more powerful method. In fact, research in applied science leads to reforms, research in pure science leads to revolutions, and revolutions, whether political or industrial, are exceedingly profitable things if you are on the winning side.

"Granting the importance of this pioneering research, how can it best be promoted? The method of direct endowment will not work, for if you pay a man a salary for doing research, he and you will want to have something to point to at the end of the year to show that the money has not been wasted. In promising work of the highest class, however, results do not come in this regular fashion, in fact years may pass without any tangible results being obtained, and the position of the paid worker would be very embarrassing and he would naturally take to work on a lower, or at any rate a different plane where he could be sure of getting year by year tangible results which would justify his salary. The position is this: You want this kind of research, but if you pay a man to do it, it will drive him to research of a different kind. The only thing to do is to pay him for doing something else and give him enough leisure to do research for the love of it. Now this kind of research has been done in the past and will, I think, for some time to come continue to be done mainly in the Universities; and the best way to promote it would be to ensure that University teachers have leisure and opportunities for research, and that their salaries are not so low that they have to spend all their spare time in examining, if they are to earn enough to live upon. These men, however, require laboratories as well as leisure, and one of the results of this progress of Science has been to make laboratory equipment and apparatus far more costly than was the case a generation ago. Our Universities, as no one knows better than you, my Lord, suffer from an 'eternal lack of pence' and have not always at their command the funds necessary for the proper equipment of their laboratories. Money could be well spent in helping them to do this. There are other laboratories besides those at the Universities which are hampered by lack of funds. The National

Physical Laboratory cannot afford to pay adequate salaries to its assistants, with the result that many highly trained men have left or are on the point of leaving to take more highly paid posts with private firms.

"The amount required to assist research in pure science is but small in comparison with that required for industrial research—the modesty of its requirements puts it in some danger of being overlooked altogether. In farming the cost of the seed is not a very considerable item in the cost of the production of crops. But pure science is the seed of applied science, and to neglect it would be on a par with the action of the farmer who spent large sums on ploughing and manuring his land and then omitted to sow the seed."

THE INDIAN PHILOSOPHICAL CONGRESS

THE Eighteenth Session of the Indian Philosophical Congress was held at Lahore on the 20th, 21st, 22nd and 23rd of December, 1943. The Congress was opened by the Hon'ble Sir Manohar Lal, Finance Minister, Punjab. Professor P. N. Srinivasachari, President of the Session, delivered his address in which he surveyed the progress made in the several branches of Philosophy and indicated lines on which fresh developments could be effected with synthesis as the guiding principle. On the 22nd and 23rd the Congress sat in its different sections and papers on a variety of subjects were presented for discussion. On the 21st there was a symposium on 'Has Philosophy a Method of its Own?', and on the 23rd another on 'Is Beauty Subjective or Objective?' Each day of the Session concluded with a public lecture. Professor A. R. Wadia spoke on "Sociology as Applied Philosophy", Kwaja Abdul Hamid on 'Iqbal—or the Ego as a Creative Being', Prof. P. N. Srinivasachari on "The Soul of India" and Dr. B. L. Atreya on "Psychological Research and its Bearing on Philosophy."

At the General Body Meeting held on 23rd December with Rajasevasakta A. R. Wadia in the chair, resolutions were passed recording the deep sorrow of the Congress at the premature demise of Mr. S. S. Suryanarayana Sastri who had been the secretary of the Congress for several years, and of Mr K. R. Sreenivasa Iyengar who had also rendered distinguished services to the Congress. It was further resolved to perpetuate the memory of the late Mr S. S. Suryanarayana Sastri by the institution of a prize which will be awarded every year for the best essay on a prescribed philosophical subject written by a student of philosophy of an Indian University. The Executive Committee has been authorized to take steps towards collecting donations for this purpose

from the members of the Indian Philosophical Congress and other friends and admirers of the late Mr Sastri.

POST-WAR FOREST PLAN FOR INDIA

A post-war plan for forestry aiming at increasing the area under forest to about 20 to 25 per cent of land in each Province and State is suggested in a note prepared by Sir Herbert Howard, Inspector General of Forests, for the consideration of the Reconstruction Committee on Agriculture, Forestry and Fisheries. This percentage of forest land is commended as appropriate in the interests of proper land management to control floods and erosion and to secure a very desirable measure of afforestation of the dry belt in the west. Secondly, this would provide the necessary timber and fuel for the ordinary agricultural village consumer both to supply his direct wants in the matter of small timber and at the same time to release cowdung for manure.

Sir Herbert emphasizes the importance of the provision of timber and fuel for the village consumer. At present, he says, there are numerous areas devoid of forest where the wants of the ordinary agricultural villager remain entirely or almost entirely unfulfilled. The plan visualizes the creation of another 100,000 square miles of forests in British India. At present only 106,000 square miles of land is dedicated to forests which represent something like 13 per cent of the total area of British India.

Even in Provinces where the problem of supplying the agricultural village consumer with his timber and fuel is most acute, it is stated that there are great possibilities of increasing the area under forests to supply these particular wants. Also that area may be properly distributed throughout the province so that every agricultural village has its neighbouring minor forest. These minor forests would be under quite short rotations of 15 to 20 years and the first return of fuel should come from thinnings within five years of formation. At present in the Provinces of Northern India the forests generally occupy only a narrow strip along the Himalayas.

One of the chief reasons for the destruction of forests over large portions of India and the prevention of re-afforestation and regeneration, Sir Herbert Howard says, is the excessive grazing which takes place over such large areas. Grazing, he suggests, must be regulated while the tree crops are being established. If grazing is regulated, the areas will give a far greater weight of grass in a few years than they ever produced while being continually grazed.

Sir Herbert endorses the existing forest policy that areas necessary for the preservation of the

general climatic and physical conditions of the country must be kept as forest and that the minimum amount of forest necessary for the general well-being of the country must be preserved or created. He suggests that the working plan position should be examined immediately after the war and steps taken to rectify over-felling which, though not excessive as a total, has been sufficiently concentrated to upset existing plans of management. In some Provinces fresh working plans can be made immediately, whereas in others it may be necessary to start with rough working schemes to be converted into proper working plans at leisure.

Proper classification of the land is recommended and it is stated that a very large proportion of the problem in India is afforestation where possible and proper control of grazing where afforestation is impossible. Proper control of grazing will make afforestation unnecessary over large areas where control alone will allow nature to re-establish forest.

It is recommended that the problem of floods, erosion and desiccation should be dealt with together under the Forest Department in close liaison with agricultural and irrigation officers. A small Reconstruction Forest Policy Committee should be set up in each Province to draw up their own programme. Heads of these Committees should meet together so that common problems can be discussed and brought into a similar plan for each province.

The note also deals with the organization of Forest Research and the future of Forest Education.

CENTRAL SERICULTURAL RESEARCH STATION IN INDIA

THE Central Sericultural Research Station, long under contemplation, has now been established for the benefit of the Sericultural Industry in India as a whole, with the main station located at Berhampore and the sub-station at Kalimpong, both in Bengal. In general, its function will be the improvement and development of all stages of the industry up to cocoon production, and with this end in view the following research programme has been provisionally laid down:—

(A) Mulberry.

(1) Collection of all varieties of mulberry found in India as well as varieties from foreign countries and growing them side by side for the purpose of comparative study.

(2) Botanical classification of the varieties into well-defined types.

- (3) Study of the various types regarding—
 - (i) Growth in relation to soil and climate,
 - (ii) Budding season,
 - (iii) Leaf yield,
 - (iv) Food value of leaf for the silk worm,
 - (v) Response to manures,
 - (vi) Susceptibility and resistance to diseases and pests,
 - (vii) Suitability for use as stock or scion in grafting.

(4) Trial of types considered suitable in the hills and the plains as well as in the different sericultural areas in India.

(5) Supply of parent stock to the various Sericultural Departments all over India with a view to helping them to arrange for local production on a scale sufficient to meet their own demands.

(B) *Silk Worms.*

(1) Trial and selection of univoltine races of worms collected from different countries with a view to obtaining races suitable for being reared in Kashmir, Jammu, the Punjab, Kalimpong, Khasi Hills and similar hilly regions elsewhere.

(2) Trial and selection of univoltine races suitable for use in production of first generation crosses as at present practised in Madras and Mysore.

(3) Production of improved fixed multivoltine races through hybridization (such as the Nistid and Nismo races successfully produced and established in Bengal) and further improvement of such races through infusion of more univoltine blood.

(4) Maintenance of the races obtained as a result of work under (1), (2) and (3) above.

(5) Supply of parent stocks of worms to different Sericultural Departments in India. (Thereafter it will be their responsibility to multiply the stocks and arrange for production of seed on a scale sufficient for supplying the local rearers).

(C) *Rearing of Silk Worm.*

(1) Investigation of response to different types of mulberry used as food.

(2) Investigation of response to different climatic conditions in the hills and plains.

(3) Trials to determine how more than one crop of univoltine cocoons can be reared during the year in places like Kashmir, Kalimpong, Khasi Hills, etc., as has been done in Japan.

(4) Study of the relationship of the deficiency in food value of the leaf with diseases of silk worms.

(5) Study of conditions which contribute to or prevent the occurrence of diseases in worms under rearing.

(6) Production of cocoons with large silk content and highest reeling property without loss of worms through diseases brought about by physiological derangements owing to climatic influences or defects and deficiencies of food or through diseases caused by infection and parasites.

Furthermore, facilities have been provided for training a few science graduates in higher sericulture. They will have an opportunity of practical acquaintance with all operations in the silk industry subsequent to cocoon production, viz., reeling, testing of raw silk and silk fabric manufacturing processes in the various filatures in the District, at the Peddie Silk Reeling Institute, Malda, at the Silk Conditioning House at Calcutta, and in the Bengal Silk Technological Institute.

ANNOUNCEMENT

We are glad to inform that Mr. Alamohan Dass has become a Patron of the Association by donating a sum of Rs. 1,000/- to the funds of the Association.

Further, our thanks are due to the reputed firm of Messrs H. Datta & Sons Ltd. who have kindly consented to become a Patron of the Association and have already placed at our disposal a sum of Rs. 500/-, being a part of their contribution.

ACKNOWLEDGMENT

We acknowledge with thanks the receipt of the following:—

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1. A Hand Book for the Identification of Insects of Medical Importance,—John Smart. 2. British Contributions to Indian Studies—Sir Atul Chatterjee and Sir Richard Brown. 3. Experiment and Theory in Physics—Max Born. 4. Intermediate Practical Physics—D. B. Sinha. 5. Land and Its Problems—Sudhir Sen. 6. Plant Viruses and Virus Disease—F. C. Bawden. 7. Soviet Russia—K. S. Herlikar. 8. The Development of William Butler Yeats—V. K. Narayanamenon. 9. The Life of Childhood—Michael Fordham. 10. The Loom of Language—Frederic Bodmer. 11. Rabindranath Tagore on Rural Reconstruction—Sudhir Sen.

SCIENCE IN INDUSTRY

PLASTICS TO REPLACE RUBBER

CLAYTON F. RUEBENSAAL and Earl H. Sorg, of the Martin Plastics Research Laboratory, have developed, according to a report of the *Scientific American*, February 1944, a new elasto-plastic, known as Marvinol. The new plastic, though neither a synthetic rubber nor a rubber substitute, bids fair to replace rubber in the manufacture of several products in which rubber is at present exclusively used. It has already proved superior to rubber, both natural and synthetic, for the manufacture of automobile inner tubes, elastic gloves for home, hospital, and laboratory use, and many general and industrial uses.

Marvinol is a vinyl-type plastic. It has almost all the important properties of a plastic, such as its thermo-plastic nature, superior abrasion resistance, and ability to withstand constant flexing without fatigue and impermeability to gases and liquids. Furthermore, unlike common vinyl plastics, Marvinol is stable in the presence of strong sun-light and at high temperatures and is unaffected by dilute acid or alkaline solutions. This stability at high temperatures and in the presence of acid and alkaline solutions has been made possible through the use of a non-extractable plasticizer in the compound. In fact,

this plasticizer has enabled the new plastic to retain its elasticity, resiliency and flexibility, properties for which its use in place of rubber has now been so eagerly suggested. Marvinol has an important advantage over rubber in that it has no tendency to oxidize or age, and that 100 per cent of the material is reclaimable.

The usual standard rubber working machinery can be employed to process the new material. Marvinol stocks can be compounded and mixed on regular open rubber mills, and extruded, moulded and calendered on the same machines as are used in dealing with rubber. The operation of vulcanization is, however, completely done away with in using the new plastic for the manufacture of rubber-like goods.

Marvinol has not only proved a better material to manufacture rubber-like goods with, but has successfully bridged many gaps hitherto not filled by synthetic rubbers. The product has proved specially successful in the manufacture of inner tubes, gloves for surgical, laboratory and household use and a number of articles for air-craft use. Nipples for nursing bottles, moulded goods, fountain pen sacks which ink will not stain or adhere to, bulbs for eye-droppers, hot water bottles, soles, heels, and pencil erasers are also reported to be made of Marvinol.

Meanwhile, Resistoflex Corporation, according to the same paper, has developed another synthetic plastic which is destined to be of great use in the air-craft industry. The air-craft industry is now greatly in need of a suitable flexible material which can handle aviation fuels, such as toluol, xylol and benzol. The failure of rubber to handle these aviation fuels has led to the development of a series of 'campar' plastics which have been described as 'transparent, flexible, rubber-like plastic materials, 5 to 20 times more wear-resistant than natural rubber, and the most solvent-proof rubber substitute yet developed'.

SOYABEAN FIBRE PLANT

ONLY a few months ago production of fibre from soyabean was no more than a laboratory curiosity. The erection of the first soyabean fibre plant at Cincinnati by the Drackett Co., as reported in *Chemical and Engineering News*, is a clear indication that the method of making fibre from soyabean has passed the laboratory stage and lent itself to production on a commercial scale.

The process involved in the production of soyabean fibre may be briefly stated. Soyabean oil is first extracted from soyabean by a method developed several years ago, leaving the soyabean meal which is largely used for livestock feed. This meal contains as much as 50 per cent protein. Required amounts of protein are then extracted from the meal to give a powder-like product which is liquified and converted into a mass of the consistency of molasses. The liquid is subjected to a great pressure and made to pass through very fine platinum spinnerets to emerge in the form of hundreds of thin filaments. These filaments are then chemically treated and at the same time stretched and hardened. Finally the fibres are dried and cut into desired lengths.

The soyabean fibre thus prepared is reported to be resilient, strong, durable and as warm as wool. It can be made either moisture-absorbent or moisture-resistant. The fibre may be used singly to be woven or spun into fabrics or may be blended with cotton or wool. Blankets, felt hats, underwear, hosiery, suitings and upholstery fabrics have already been made of soyabean fibre with success. Conspicuous as these initial successes are, further technical study of this new fibre and of new and more efficient manufacturing processes as well as of potential new uses is necessary and is in progress.

TITANIUM

UNTIL recently titanium used to be listed among the unimportant and least useful elements. In an all-out drive for the fullest utilization of world's

mineral resources, rare and unimportant elements of yesterday are becoming indispensable today. Such has happened in the case of titanium whose increasing uses in peace as well as in war have brought this so-called rare element to the limé-light. In an article in *Discovery*, December 1943, Dr J. Chatt has summarized the various uses to which the metal has been applied during recent years.

Though often referred to as a rare element, perhaps because of its rare uses, titanium is, in fact, one of the commonest and most abundant of elements constituting the earth's crust. The available supply of titanium far exceeds that of sulphur, carbon and chlorine and is about four times as great as the world's combined supply of chromium, copper, lead, manganese, mercury, nickel, tin and zinc. As a matter of fact, next to aluminium and iron it is the most abundant metal known. The metal is distributed in several parts of the world in the form of ores, of which the most important are ilmenite (ferrous titanate) and rutile (titanium oxide). But large quantities of ores rich in titanium are rarely to be met with. India (Travancore) occupies the leading position among the titanium producing countries which include Norway, Sweden, Portugal, Canada, South Australia, Malaya, Senegal, Brazil, U. S. A., and U. S. S. R.. World production of titanium, excluding U. S. A. and U. S. S. R. which have not published production figures, amounted to 43,600 tons in 1931 and 264,000 tons in 1937, indicating the growing importance of the metal. In 1938, Travancore alone produced 252,220 tons.

Titanium as a metal is not so valuable. But it forms important alloys with iron, aluminium and other metals. Alloyed with titanium steel develops great strength and resistance to abrasion. The great affinity of titanium for nitrogen and oxygen is often utilized in removing these harmful impurities from molten steel. All aluminium alloys are said to be improved by small amounts of titanium. Titanium dioxide is the most important of titanium compounds and has received several important applications. Rutile, the naturally occurring dioxide, is employed in electric welding. The pure dioxide obtained from ilmenite is used as a pigment, known as titanium white, and also in paints, enamels, lacquers, and glazes. It has better covering capacity which exceeds that of white lead, and is further non-poisonous and, unlike white lead, not blackened by traces of hydrogen sulphide in air. The high refractive index of titanium dioxide has recommended its use in paper making to prevent printer's ink showing through. In small amounts, it is used in rayon, rubber, linoleum, plastics, leather, soap, face powders, face creams, tooth pastes, etc., where opacity is required to be developed.

Titanium dioxide has a high dielectric constant with the advantage of low dielectric loss. It has already been used in the manufacture of insulators, and particular mention may be made of magnesium titanate which is now employed as the dielectric in high frequency condensers.

Other titanium compounds have also formed useful applications in textile and leather industries. The compounds are used as mordants for dyeing fabrics. Potassium titanium oxalate stains leather to various shades of brown and produces a less brittle

product than when iron salts are used. The ability of titanium tetrachloride, a strongly fuming liquid, to produce dense smoke screens has made it an important war chemical. It is reported that in 1918, in connection with the last Great War, 160 tons of titanium were alone used for the production of titanium tetrachloride.

If titanium is little known today despite its various and growing uses, it is because none of its uses has so far proved spectacular enough to attract widespread attention.

RISE AND DECAY OF THE INDIGO INDUSTRY IN INDIA

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(Continued from the last issue)

EXTRACTION OF INDIGO—DRY PROCESS

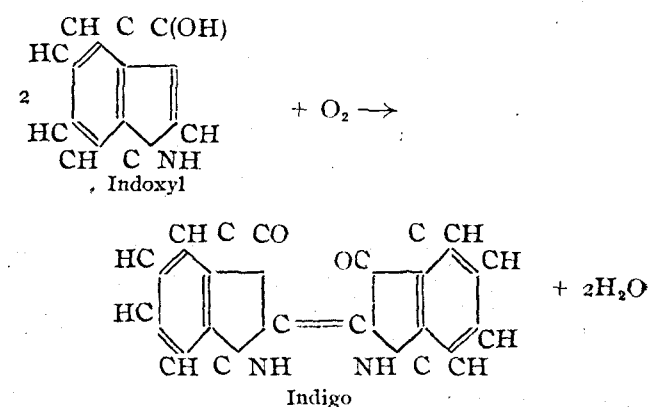
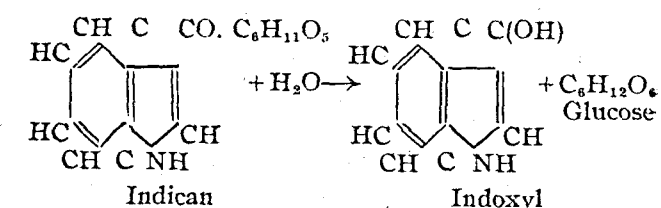
In Madras the dry leaf process of indigo manufacture is still pursued to a limited extent. During the first century of the industry as fostered by the East India Company, the dry process was universally adopted. It was even upheld that to that fact was attributable the high merit of the Indian as compared with other indigoes. During the second century, when the industry had been carried from the West Indies back to India (Bengal), the wet process alone was employed.

In the dry method the bundles of freshly cut plants are dried and the leaves separated from the stem by beating. When kept dry the leaves undergo a great change in the course of a few weeks, their green tint turning into a pale blue-grey colour. They are then subjected to steeping and fermentation and allowed to macerate for 2 hours when the *indican* present in the plant splits through hydrolysis into *indigotin* and *indiglucin*. The fine green liquor is then drawn off into the beating vat, when the matured indigo is precipitated and subsequently concentrated by boiling and compressed into cakes and dried in the usual way. Dry system of indigo manufacture have distinct advantages. For a small manufacturer it has great advantage of being attended to at the most convenient time and the indigo may be more uniformly made. Moreover the fermentation process in the case of fresh leaves is here superseded by a much shorter period of simple maceration (Watt 1908).

CHEMISTRY OF INDIGO

Indican occurring in the leaves, when hydrolysed yields glucose and indoxyl. The latter is oxidised to

indigo (See p. 493). The equation representing the reaction is as follows:—

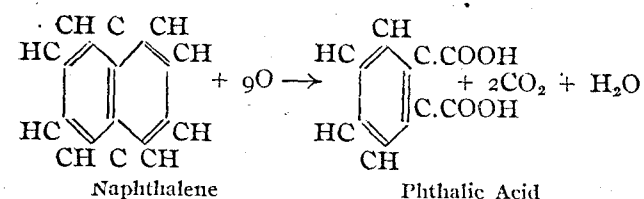


SYNTHETIC INDIGO

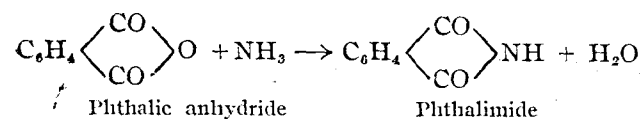
The method that has proved a commercial success has at its starting point a reaction discovered by Heumann in 1890. (See p. 490).

The starting material in Heumann's synthesis of indigo is naphthalene (C_{10}H_8). This is first converted into phthalic acid by oxidation with sulphuric acid in

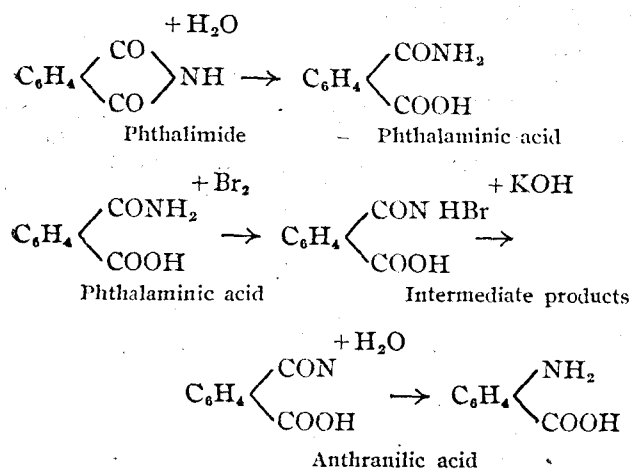
the presence of mercuric sulphate which acts as a catalyser:



The anhydride of this acid, when heated in a current of dry ammonia yields phthalimide:

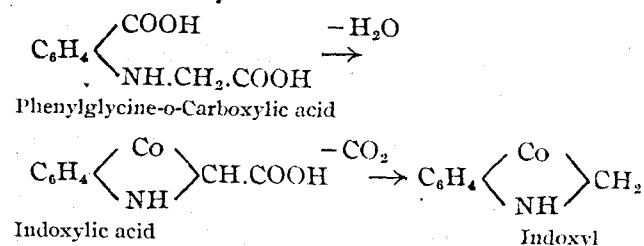
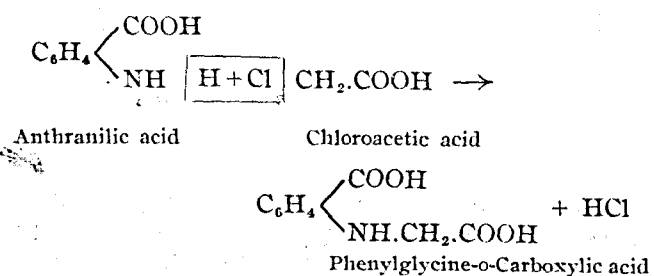


Phthalimide is then warmed with bromine and potassium hydroxide. The alkali hydrolyses the phthalimide, yielding phthalaminic acid, which subsequently by the action of bromine and potassium hydroxide is converted into anthranilic acid.



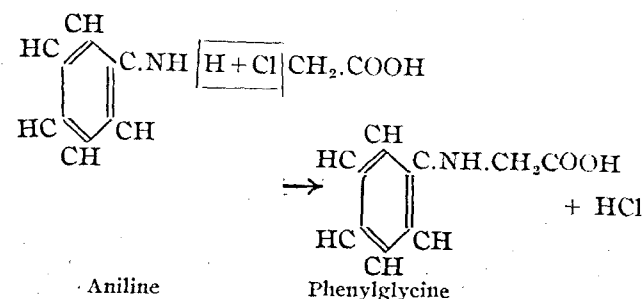
The anthranilic acid is treated with chloroacetic acid to obtain phenyl-glycine-o-carboxylic acid.

This acid when fused with caustic potash yields indoxyl, indoxylic acid being formed as the intermediate product.

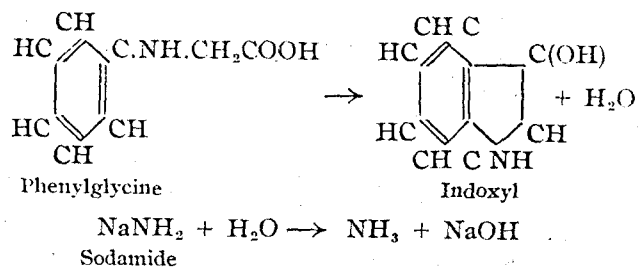


The fused mass, containing indoxyl, is dissolved in water and a stream of air is passed through the alkaline liquid, when indigo-blue is precipitated (Compare preparation of natural indigo).

Another synthesis carried out on a larger scale is as follows: Aniline is treated with monochloro-acetic acid when phenyl-glycine is obtained.



Phenyl-glycine is fused with sodamide at 180° to 240° when indoxyl is produced, which may be converted into indigo-blue as in the above synthesis.



ARTIFICIAL versus NATURAL DYES

When the colouring matter was derived chiefly from vegetable sources, the processes were lengthy and laborious and the results uncertain; the use of imported synthetic dyes equally shortened and simplified operation and gave more certain results, thus enormously reducing the cost.

Attempts made since the last Great War to replace the synthetic dyes have apparently established the fact that vegetable dye-stuffs are incapable of meeting the demands of the industry on its present scale, and the change in taste brought about by the brighter synthetic dyes renders it difficult to find a market for the thinner and duller though perhaps

more pleasing colours of vegetable origin. The quality of synthetic dye is inferior and the price is abnormally low but it is easier to handle and apply and is used for poorer grades of cloth, when permanency is not essential.

Natural indigo as extracted by the wet process consists of blue lump containing 60 to 80 per cent of indigo blue or indigotin and small quantities of other colouring matters, such as *indigo red*, *indigo brown*, *indigo green*, 'indigo gelatin' and ash. These are to be regarded as impurities and may be removed by successive treatment with water, dilute acetic acid, caustic soda and alcohol.

The artificial indigo of commerce manufactured in the Badische Aniline Factory in Germany is almost pure indigotin containing no indigo red, indigo brown or indigo green, which is also a disadvantage as these substances have some beneficial effects in dyeing. For silk, the natural indigo still produces better results than the synthetic substitute. But owing to better business methods, the synthetic product enjoyed a rapidly expanding market driving natural indigo from the places where it was least remunerative.

One of the principal disadvantages under which natural indigo has to compete with the synthetic product is that the former is in the form of dry cakes which have to be converted into paste before being used for dyeing purposes, while the latter is sold as readily available paste. (Banerjee 1896; Watson 1907)

CAUSES OF INDIGO CRISIS

The crisis in the indigo trade has thus been brought about in various ways:—

- (1) The quarrel between indigo planters and raiyats on the one hand and Zamindars on the other.
- (2) The extension of indigo cultivation in the U. P., the Punjab and in Madras and the consequent competition which reduced the price to the lowest level.
- (3) The manufacture of the dye by a synthetic process in Germany.

With regard to the unwillingness of cultivators to grow indigo, it is to be noted that the growing of the crop instead of impoverishing their land actually made it better suited for the growing of cereals and if indigo is cultivated on one-fourth or one-sixth of the cultivators' land in rotation, it would be of mutual advantage to the planter and the cultivator. Further, indigo refuse is the manure most easily obtained and is very valuable as one of the best fertilisers. It is less suited for indigo itself, than for rotation crops such as sugarcane, tobacco, poppy, cereals and oil seeds. Indigo plants forced by indigo

manure to very active growth gives a poor percentage of dye matter and is liable to injury from insect pests. (Mukherji 1923).

Suggestion for the improvement of indigo industry, to effect a reduction in the cost price of indigo and thereby secure a profit to growers and manufacturers have been put forward from time to time since the discovery of the synthetic dye.

SIR EDWARD LAW'S RECOMMENDATIONS

Sir Edward Law (formerly Finance Member to the Government of India) in 1905, in view of the unfortunate falling off of the production of indigo suggested as follows:—

- (1) That the plantations should be placed on a sound financial basis, and cease to remain in a position where requirements for cash in seasons of dear money could only be satisfied by transferring profits from the pockets of the planters to those of the money-lenders,
- (2) Economy in management,
- (3) Selection of seed and propagation of the qualities yielding the highest per cent of indigotin and best suited to local conditions of climate and soil,
- (4) Rotation of crops to obtain good profits from the land when not under indigo and thereby reduce the cost of cultivation of the plant, and
- (5) Chemical improvements in manufacture.

Sir George Watt observed "There would seem no doubt that each one of the conditions of improvement indicated by Sir Edward are of vital importance and what is sure to the point, hardly any of them, have been successfully and completely investigated." (Watt 1908).

Not much satisfactory progress however followed the recommendations of Sir Edward and the indigo trade gradually declined as already explained before, till we come to the period of the last Great War.

INDIAN INDUSTRIAL COMMISSION'S RECOMMENDATIONS

The Indian Industrial Commission, with Sir Thomas Holland, F.R.S., as its President, was appointed by the Government of India in 1916. The commission was instructed "to examine and report upon the possibilities of further industrial development in India", and they submitted in 1918, the following ways, neglected in the past, that offer prospects of success with regard to the indigo industry in the future:—

- (1) *The Application of Scientific Agriculture.*—
 - (a) the adoption of phosphatic fertilisers and other improved methods of soil treatment,
 - (b) the breeding of plant varieties able to withstand the wilt disease,
 - (c) the organisation of seed farms under suitable

climatic conditions outside indigo growing districts. (d) the rotation of indigo with other crops of marketable value.

(2) *The Process of Manufacture*.—(a) the recent recognition of the fact that the precipitation of indigo is essentially due to a ferment, the cultivation of which under suitable conditions may permit of a great increase in yield, (b) the preparation of a standardised product for the market.

(3) *The provision of improved financial facilities*. Evidence put before the Commission in Bihar, left the impression that natural indigo, if cultivated and manufactured on scientific lines, offers prospects of great improvement, probably sufficient to enable it to hold its own in competition with synthetic indigo.

It was further observed "By careful management under favourable financial conditions several planters have prospered, in spite of the absence hitherto of the advantages which the application of scientific agriculture might bring them and, though it is impossible to estimate the prices at which synthetic indigo will be placed with profit in future markets, there is no doubt that the prospects before the natural product are sufficient to justify experimental work and enterprise in organisation along the lines indicated above." (Govt. pubn. 1918).

INDIGO CESS

"In 1918, by an act of the Imperial legislature an indigo cess was imposed at the rate of one rupee per bazar maund (of 82½ lbs. avoirdupois) on all Indian indigo exported, the proceeds of the duty to be expended by the Government of India, for scientific research work in connection with the cultivation and manufacture of indigo, a corresponding cess being imposed on all exports from Travancore to ports outside British India or to Aden. The rate of cess was changed to Rs. 1/8/- per cwt. of 112 lbs. avoirdupois with effect from April 1, 1921."

Since 1860, there was a general export duty of 3 per cent *ad valorem* but the duty on indigo was remitted in 1880.

"Investigations were conducted at the Pusa Research Institute by the Indigo Research Chemist to the Government of India but it was terminated and the cess abolished with effect from 1st August, 1923. In 1922-23 the cess yielded £533, and in the four months from April to July, 1923, £212 only. At one time it was anticipated that the expenses of the London Indigo Committee will also be met from the proceeds of this cess". (Saksena, 1937).

RECOMMENDATIONS OF DAVIS AND REID

Davis, the Indigo Research Chemist to the Government of India, while reviewing the position

and future prospects of the natural indigo industry (1918) remarked "that very great improvements can be made" and "that the future of natural indigo is by no means a hopeless one provided steps are taken to realise such improvements as are clearly possible." The fate of natural indigo will be determined by several factors each of which has its own special importance. (Davis 1918). These are:

(a) Improvement in Agriculture, (b) Improvements in methods of marketing the product, (c) Improvements in actual manufacture, either by chemical or bacterial means, (d) Improvements by botanical selection, (e) Improvements in business organisation.

Reid in a paper on the "Ten years practical experience of Java indigo in Bihar" (1917) indicated the lines on which research work would appear to give the best results.

(a) The first and most important point is a supply of pure seed. If a full supply of seed was obtainable and the sowing rate increased, the result on the return of finished indigo would be very marked. To grow Java indigo for seed would never give best results in Bihar, for the following reasons:—

(i) the country is subjected to periodical flooding at the time when the seed plant must be in the ground.

(ii) It is very doubtful whether any remedy will be found for diseases such as 'wilt' and 'Psylla'.

It was suggested that if a regular and full supply of Java seed is to be secured some other locality would have to be discovered for seed growing.

(b) the second line of research appears to be increasing the wilt resistance power of the plant by selection and after that is obtained,

(c) research should be directed to improving the indican content of the leaf (Reid, 1917).

The seed problem was acute in 1913 and the industry was in danger of extinction from this cause alone. The supplies had fallen low and insufficient for sowing while the price had reached a point which seriously reduced the margin of profit.

According to Howard (1920) the solution of the problem of seed production was found to be in the growing of a special seed crop and in obtaining the seed from most vigorous plants.

RESEARCH WORK ON INDIGO

A large amount of attention has been devoted in the past, both by Government and by the planters, to the improvement of the indigo industry in Bihar. Investigations have been in progress since 1898 with the object of increasing the yield of indigo per acre and thereby assisting the industry to meet the com-

petition of synthetic product. Rawson, Bergthiel, Bloxam, Leake and Parnell carried on their investigations at Sirsiah Experimental Station which was closed in March, 1913.

Bihar Planters' Association wisely decided to close the station and asked the Imperial Government to continue the work which was transferred to the Botanical Section of the Pusa Institute.

From the beginning of 1898 to the end of 1913 the sum of £54,207 was expended on indigo research work in Bihar. Of this large sum £32,052 was contributed by Government and the remaining £22,155 by the Bihar Planters' Association.*

Earlier workers dealt exclusively with the chemistry of the manufacturing process, and some botanical aspect. Very little work was done on purely agricultural side and on the physiological aspect of the role of indigo-producing principle in the plant. (Howard, and Howard 1914).

LOCALISATION OF INDIGO PRODUCING SUBSTANCES

Leake (1905) commenced research into the species of the plant grown and the localisation of the dye within the plant tissues, but his studies were brought to a sudden end by the severance of his connection with the Planters' Association. Bloxam attained some progress in his chemical studies of the dyes.

Parnell (1915) worked on the physiology of indigo yielding glucosides i.e., with the biology of indicans in particular and glucosides in general. In *Indigofera* sp. the glucoside is practically confined to the leaf and youngest parts of the stem though a small amount varying in different species occurs in some of the reproductive organs. In *I. arrecta* the maximum per cent content occurs at a very early stage in the development of the leaf. The actual amount in any leaf increases during growth to a maximum at maturity and remains constant till leaf falls when the whole is present in the fallen leaf. In the light of present knowledge no definite function can be assigned to indigo-yielding glucosides in the plant and indican seems to be a bye-product of the plant's metabolism (Parnell, 1915).

DEFICIENCY OF PHOSPHATES OF BIHAR SOIL

As early as 1902 Rawson pointed out in his report on indigo that Bihar soils were decidedly deficient in available phosphate and in 1907 Dr Leather made a series of analysis of soil from indigo areas in Bihar. In a report to the Bihar Planters' Association (1908) Leather states "The chemical analysis of the soil showed them to be almost uniformly deficient in available phosphate".

In spite of this warning, phosphate manuring has been used only in isolated cases and the neglect

* Badische Aniline und Soda Fabrik Company spent a sum of £900,000, exclusively for research work in connection with the manufacture of synthetic indigo. (Chakravorty, 1944).

of this has been the main cause of certain difficulties in indigo cultivation and the undoubted falling off in later years.

Davis (1917) in a report to the Government on the indigo industry of Bihar reiterated this abnormal deficiency in phosphate of the soils of Bihar and its effect upon the growth (quality and yield) of indigo.

Howard (1920) however, did not support the view that manuring with superphosphates will increase the growth of Java indigo. On the other hand the growth of indigo crop depends mainly on (1) soil aeration and (2) organic matter.

Howard further, contrary to our previous ideas, observed that Java indigo seriously depletes the supply of soil nitrogen and behaves very much like a cereal. The soil loses more nitrogen than it gains. Intense colloidal condition of the soil often prevents percolation altogether. The pore spaces become water logged for long periods and a condition is established which profoundly affects both the bacteriology and the chemistry of the soil and the plant reacts immediately. At first there is a cessation of root action, followed sometimes by the destruction of the absorbing system except or near the surface. In Java indigo, the establishment of colloidal condition was eventually followed by the general wilting of the crop. (Howard and Howard 1927).

The cultivation of Java indigo in Bihar fell from 10,000 to 15,000 bighas between 1910 and 1914 largely on account of the wilt disease and the difficulty of obtaining seed. Investigations on the causes of indigo wilt and its prevention was carried out by Howard (1915-1921).

Java indigo introduced into Bihar from Java in 1898, at first did exceedingly well, yielding heavy crops of leaf rich in indican as well as abundant seed. After some years, however, the plant began to show increasing signs of want of vigour and finally began to die of wilt during the second half of the rainy season. At the same time, the yield of seed diminished. The degeneration was progressive and by 1913 many planters had already abandoned the cultivation.

INDIGO WILT AND ITS CAUSE

Wilt appeared after the first cut during July and August, the severity of attack depending on the season. The plants die off in stages, the process taking place slowly. Neither insect, fungi or bacteria have been found to be responsible for the trouble. Howard's investigations indicate that wilt results from the destruction of the fine roots and nodules under circumstances when regeneration is impossible. When the roots and nodules of an indigo plant have suffered extensive damage wilt invariably results from any cause which interferes with normal root regeneration. The chief source of damage to the active roots and nodules arises from the complete cutting back of

the plant. This results in the destruction of practically all the fine roots and nodules and root regeneration is necessary before new growth can take place. Root regeneration becomes difficult due to poor soil aeration, due to lack of sufficient reserve material in the tap root and due to too low soil temperature and wilt follows. (Howard, 1920, 1924).

SELECTION WORK

The details relating to the flowering, pollination and occurrence of natural cross-fertilisation in Java indigo and bearing of these facts on the improvement of the crop was also dealt with to a considerable extent by Howard.

The crop is composed of a mass of heterozygotes, differing widely in habit, time of flowering, root range, and amount of leaf surface. There is a great falling-off in vigour observable in the plants raised from self-fertilised seed. These circumstances and the ease with which the land becomes contaminated with the seed of previous culture, render the improvement of Java indigo by the methods of pure line selection a time-consuming and a very difficult undertaking.

Attempts to cross Java and Sumatran indigo at Pusa failed. On several occasions plots of these two crops have been allowed to flower side by side in October and November but no natural crosses have been observed in succeeding generations.

The progressive degeneration of the indigo crop has been found to be due to a gradual change in the gametic constitution of the crop, which has been in progress since Java indigo was first introduced in Bihar.

All the species of indigo examined at Pusa rarely set seed under net. In a single generation from self-fertilised seed there is a marked falling off in the size and vigour of the offspring, so that both self-fertility and natural cross-fertility have to be considered in any improvement by selection.

The stoppage of selection, the mixing of kinds which is a characteristic of Indian agriculture and the resulting crossing with types which do not suit Bihar completely altered the botanical composition of the crop and rendered it unsuitable for growth under monsoon conditions. (Howard, 1919).

When the Bihar Planter's Association lost their interest in indigo plantations, the few remaining firms formed the Indian Indigo Association in 1920, to look to their own interest. Since the abolition of the indigo cess in 1923, there was an unspent balance of Rs. 1,500/- in the fund in 1925, which was available for expenditure on problems connected with the improvement of indigo. The amount was handed over to this association for meeting the cost of London experiments on research for a dyeing process of natural indigo which would be shorter and less com-

plicated than the existing process (Report of the Indigo Association, 1926).

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MEDICINE AND PUBLIC HEALTH

OX BLOOD FOR BLOOD TRANSFUSION

THE possibility of using bovine plasma in human beings in states of shock, hypoproteinaemia and protein deprivation and loss, calling for blood transfusion, has been recently demonstrated by Dr Edwards and his collaborators in a series of experiments (*Brit. Med. Jour.*, January 15, 1944; also for a shorter report see *Nature*, January 29, 1944). Increasing pressure in blood banks and their limited supply have led to a number of substitutes for human plasma. But such substitutes do not satisfy all the three requirements essential for successful blood transfusion. These three requirements are: (1) it should be retained in the circulation and eventually be metabolized, (2) it should exert an osmotic pressure same as that of the plasma and (3) it should be non-toxic, free from antibodies and non-antigenic. Although bovine blood has some commendable characteristics, it is not without difficulties. The satisfactory fact about bovine blood is that its total protein most nearly approaches that of human plasma. But it contains a much higher percentage of fibrinogen, and its albumin-globulin ratio is lower, resulting in a lower osmotic pressure of bovine blood. These considerations make crude bovine serum unsuitable for use. In fact, the use of crude serum has been found to produce serum sickness and a tendency to haemolysis of the human red cells.

Dr Edwards and his collaborators have adopted a method of processing bovine serum which is claimed to fulfil the above requirements. The process consists in heating the serum to 72°C to destroy the anti-bodies and in adding 0.2 per cent of formalin and ammonia to render the proteins uncoagulable. The serum known as Despeciated Bovine Serum (D.B.S.) has an osmotic pressure comparable to that of filtered human plasma and is well retained in the circulation. It has not developed signs of deterioration after long storage (9 months) in a refrigerator. The report of a preliminary trial on 26 patients is encouraging and recommends its safe use in human beings.

The possibility of the tuberculous infection or *Brucella abortus* of bovine serum has also been given due consideration. This can be solved on the report of the meat inspector, making it possible to discard the blood of the grossly infected animal. Furthermore, as Dr Edwards suggests, the blood may be subjected to Seitz filtration during the process of manufacture to remove any of these organisms infecting the blood.

VITAMIN SUPPLIES IN PREGNANCY AND CHILDHOOD

IN his article "The Role of Vitamin Concentrates in War and in Post-war Food Relief in Europe" in *Nutrition Abstracts and Reviews*, Vol. 13, No. 1, July 1943, V. P. Sydenstricker has dealt with the vitamin requirements of pregnant women and children. The effects of malnutrition in pregnant women seem much more subtle than any symptoms or signs which can be detected clinically or any disturbance of metabolism that can be measured in the laboratory. It is only rarely that gross deficiency disease develops during pregnancy, even among the women of a chronically malnourished population. Nevertheless it has been shown that improvement of the nutritional status during pregnancy can reduce maternal morbidity and cause a marked decrease in the incidence of abortion, premature delivery and stillbirth. The most striking results were obtained in the experiments performed in Toronto (1941), in which pregnant women received a liberal dietary supplement of milk, cheese, oranges and canned tomatoes and, in addition, wheat germ, vitamins B₁ and D and iron. Toxaemia occurred in only 3.5 per cent of a group of 90 women, and there were no miscarriages or stillbirths. In the control group of 120, the incidence of toxaemia was 7.6 per cent, there were 7 miscarriages and 4 stillborn infants. In the much larger group of about 3,000 primiparous women studied in London (People's League of Health, 1942), no supplement of food was furnished, but the women took liberal amounts of a preparation of B vitamins, ascorbic acid and vitamins A and D as well as iron, calcium and a mineral mixture containing iodine, manganese and copper. The incidence of toxaemia, as judged by the presence of hypertension or albuminuria, was 27.1 per cent in the treated cases as compared with 31.7 per cent in a control group of equal size. The corresponding values for incidence of prematurity were 20.1 and 23.9.

These results were obtained in times of peace when there were no restrictions on the amounts and varieties of foods obtainable except the money available for their purchase. In war, with animal protein and fats rationed and citrus fruits unavailable for adults, it would seem not only desirable but necessary to make vitamin concentrates as well as iron and calcium available to all expectant mothers. Codliver oil or other sources of vitamin A and D and synthetic ascorbic acid are particularly necessary. The use of wheatmeal bread and potatoes as chief sources of

calories makes it unlikely that supplements of the B group of vitamins are generally required.

The present status of children in Britain is probably better than that of any other group of the civilian population. The needs of small children are provided for by the universal distribution of cod liver oil and good sources of ascorbic acid in addition to milk. There may be justification for concern over the ascorbic acid intake of children of school age, particularly during the late winter and early spring. Should there be any evidence of deficiency there should be neither hesitation nor delay in making ascorbic acid universally available for as long a period as necessary. Indiscriminate dosing of children with mixed vitamin concentrates in an effort to prevent upper respiratory infections or for "tonic effect" has no experimental or clinical support (Kuttner, 1940). It may in fact do harm by exciting disgust for food.

ROLE OF VITAMINS IN BLOOD FORMATION

It is generally known that the production of blood cells requires the proper supply of iron, protein, glucose, haemoglobin, xanthopterin, excessive amounts of cobalt and the anti-pernicious anaemia factor of liver extract. There are now clear evidences that certain vitamins also play important part in the production of blood cells. *Science News Letter*,

February 12, 1944, reports that at least two vitamins of the B complex group, riboflavin and the pellagra-preventing niacin, appear to be necessary for the production and regeneration of blood. Dr C.A. Elvehjem and his associates, of the University of Wisconsin have found that dogs supplied with a synthetic diet containing all the known essential nutrients except riboflavin develop anaemia and quickly respond to a corrected diet containing adequate amounts of riboflavin. The results of these experiments therefore suggest that riboflavin is indispensable for normal growth and development.

The requirement for niacin for the building up of blood cells has been demonstrated in dogs. Dr Philip Handler and Dr William P. Featherston, of Duke University School of Medicine, have shown that such anaemia is specially due to the deficiency of niacin and can be corrected by the administration of adequate amounts of this vitamin. They advocate that niacin is necessary for the proper production and maturation of red blood cells. This vitamin is known to play an important role in the respiration of all cells of the body. The lifetime of blood cells appears to be very short and the rate of turnover is quite rapid. Consequently the requirements of niacin for the manufacture of blood cells might be correspondingly great. A niacin deficiency, besides producing the usual symptoms of pellagra, might also lead to anaemia because of the inadequate supply of this vitamin for development of the red blood cells in the early stages.

PRACTICAL AND PUBLIC HEALTH ASPECTS OF NUTRITION

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NUTRITION AND HUMAN WELFARE

IN planning a social order under which everyone will attain freedom from want, freedom from fear and freedom to attain a full life, one is faced from the outset with the question of the need for proper and adequate nutrition. The importance of food for health is now recognised by all Governments. It is no doubt somewhat difficult to assess accurately the effect of diet on health in different classes as faulty diet of the poorer classes is usually accompanied by other unfavourable conditions associated with poverty such as bad housing, an increased incidence of infectious diseases and unfavourable psychological factors. Results of feeding tests in which environmental conditions apart from food are unchanged

show that improvement of the diet is followed by a striking improvement in health and also in the rate of growth of children. Some have pointed out that heredity also is another factor to be considered in relation to physique and susceptibility to certain diseases. However, in many of the investigations on the influence of heredity, the correlation found was probably more between environmental factors than inherited genes. Investigations on people belonging to the same stock but living in colonies and the mother country show that food markedly affects not only stature but bodily configuration. An increase of 2-3 inches in the average stature of children leaving school, the remarkable fall of infant mortality and tuberculosis death rates and other indications of the great improvement in health in Great Britain in the

last twenty years have been primarily due to improvements in the diet. The correlation between quality of diet and health and physique has been beautifully brought out in the famous experiments of McCarrison at Coonoor. McCarrison's results show that the marked differences in the physique of the people of the different provinces in India were due mainly to the differences in their diets.

There is no longer any doubt that faulty diet is the cause of deficiency diseases in people and of much ill health not sufficiently severe to be classed as disease. Faulty diet decreases resistance to some infections, is a predisposing cause of some chronic diseases and also causes some forms of mental depression and other abnormal psychological states. In planning for human welfare, therefore, food must be treated as the first and most important material requirement for the fuller life of the new world order.

As a result of the deliberations of various expert bodies set up by the British Medical Association (1933), by the Department of Home Economics of the United States Department of Agriculture (1933) and by the League of Nations (1935), we now possess accepted standards of dietary requirements—of requirements for calories and proteins—and general statements on mineral and vitamin requirements. The requirements of minerals and vitamins have also been placed on a quantitative basis by recent nutritional investigations in Europe, America and India. A good deal of information is available on the clinical signs of minor degrees of deficiencies and methods for assessing the state of nutrition have also been developed. Investigations carried out under the auspices of the I. R. F. A.—on protein and mineral requirements in Indians at Dacca and on vitamin requirements at Coonoor—show that these yardsticks to measure the adequacy of nutrition can also be applied to the population in India.

MORBIDITY AND MORTALITY STATISTICS

The broad facts regarding the health and physique of people brought out from surveys of diet and state of nutrition can be obtained from morbidity and mortality statistics. As the quality of the diet deteriorates there are increases in the infant mortality and tuberculosis death rates and also in the incidence of diseases due to faulty diet. Morbidity statistics, except perhaps in the case of one or two diseases, are entirely lacking in India. The infant mortality rate for 1938 in British India as given in the Report of the Public Health Commissioner is about 170 per 1000 live births compared with 53 in England (it was 97 per 1000 live births in 1928) and 80 in Scotland. These figures point out in a most significant manner the appalling malnutrition prevalent in India. Incidentally the need for improving

the machinery for collecting morbidity and mortality statistics cannot be over-emphasised.

THE STATISTICAL POSITION WITH REGARD TO FOOD PRODUCTION

A study of the data on the food production in India is of great help in assessing the extent of under-nutrition in the country. The figures are admittedly imperfect and relate to a crop year which runs from the 1st July to the 30th June next and thus neither corresponds to the calendar year nor to the financial year. Moreover, information is entirely lacking for about 47 per cent of the total area covered by the Native States and also for the Tribal Area of the North West Frontier Provinces and British Baluchistan. While area statistics are fairly reliable, the same cannot be said about the standard normal yield per acre and the condition factor, all of which together determine the figures about annual yield. In contrast with Western countries where about 30-40 per cent of the total calories yielded by ordinary diets is derived from cereals, about 90 per cent of the total calorific value of the Indian dietaries is obtained from this source. Hence in India data about production of cereal grains require close examination to determine if the food supply is adequate for the population.

The area under cereal crops in British India is, according to the latest census figures, about 147 million acres and the total area under all food crops including sugar about 215 million acres. The aggregate yield of the grains is about 55.8 million tons of which about two and a half million tons are required for seed. About 53 million tons cereals are thus available for human consumption. If the population of British India be taken as 296 millions the needs of the entire population can be met by about 60 million tons of cereals per year. British India is thus faced with an annual deficit of about 7 million tons of cereal grains. There is no doubt that children would consume less cereals but against this must be considered the wastage during processing, storage and transit and also the quantity of grains consumed by cattle and poultry. The food production data show that a considerable fraction of the population do not, even in normal times, get enough food to cover fully its calorie requirements.

The over-all deficit is not a correct index of the degree of scarcity in urban areas. Generally only the balance of what is left over after meeting the requirements of the producing rural areas goes to the urban areas and not a fixed percentage of the total production.

Considering the provinces individually, the deficit provinces are Bengal, Bombay, Madras, Bihar, Assam and North Western Frontier Provinces while

provinces producing more food than their requirements are the Panjab, United Provinces, Sind, Central Provinces and Berar, and Orissa. A close examination of the figures for the production of different cereals in the various provinces clearly shows that even with Inter-Provincial transport of food grains it will not be possible to meet the deficit of a particular grain in one province with a surplus of the same food grain from other provinces. The food problem in India is thus not merely of increasing the production of food to secure an adequate supply for the entire population but also of adjusting the food habits of people so that rice-eaters should be prepared to consume a certain amount of wheat and probably also of millets. As already mentioned the figures of food production are very rough. It is very desirable that better data should be available and periodical estimates preferably twice a year—should be drawn up showing the quantity of food produced in the country.

RESULTS OF SURVEYS OF DIET, STATE OF NUTRITION AND INCIDENCE OF DEFICIENCY DISEASES

The conclusions about under—and mal-nutrition among the people of India from production data are fully corroborated by the results of surveys of diet, state of nutrition, incidence of deficiency diseases and other investigations. About 100 diet surveys have been carried out in various parts of India. Each of these surveys makes a quantitative investigation of all the foods consumed by a group of 15 to 30 families in a given area over a period of 10-20 days and they show what foods are consumed by a particular class of the population. A considerable margin of error is inevitable in analysing the results of dietary surveys specially regarding the intake of vitamins. Such surveys, however, are the best available means of getting information on the highly important question of the extent to which people of the different classes and in different parts of the country are undernourished or malnourished. These surveys show that 30-40 per cent of the families do not get enough food to meet the calorie requirements. The diet is also qualitatively very deficient. In addition to his staple cereal the poor Indian takes only small quantities of pulses (0.5-1.5 oz. daily) and vegetables and the consumption of milk, fish, eggs and meat is, except in certain areas, practically negligible. The intake of animal proteins is very little and the diets are usually deficient in calcium, vitamin A and carotene, and the various factors of vitamin-B₂ complex. The Indian can afford to take very little vegetable fat and negligible quantities of animal fat. These dietary deficiencies are reflected in the health of the people, in abnormal rates of infant and childhood mortality, in the height and weight of children and in

the incidence of various diseases. The nutritive value of the typical Indian dietaries has also been tested by carefully controlled metabolic experiments on human subjects and the defects mentioned above have been fully corroborated.

There is also a widespread existence of food deficiency diseases which are preventable by corrections in the diet. Diseases due to deficiency of the one or other of the vitamins are night-blindness and xerophthalmia, beri-beri, angular stomatitis and rickets and osteomalacia. The anaemias specially the anaemias of pregnancy associated with malnutrition are also quite common in India. Malnutrition also decreases the resistance to diseases like tuberculosis, and leprosy which are also prevalent on a large scale in India.

PUBLIC HEALTH NUTRITION WORK

Attention to proper nutrition of all classes of people should, therefore, be a prominent feature of the public health work in India. The vastness of the country and the multiplicity of problems make it desirable that there should be a common centre of guidance, inspiration and advice. The public health departments in all the provinces and States should have nutrition officers and the centre should be kept constantly in touch with the situation in the provinces and States. Morbidity and mortality figures should always be ready at hand. Surveys of diet and state of nutrition should be undertaken at regular intervals.

Education on the importance of food for health, on the relative nutritive values of different foods and on the methods of constituting balanced diets from available materials should be a prominent feature of the public health propaganda work. Lantern slide lectures and exhibitions should be arranged even in the remotest villages and also at village fairs. Poverty no doubt is the most frequent cause of inadequacy of diet but sometimes ignorance, carelessness and apathy are also responsible for faulty diet. Special attempts should be made to approach the housewife who is responsible for the preparation of the food. Appointment of lady health visitors who would do this work is an urgent necessity. The baneful effect on the future generation and on the entire family, of the mother denying herself and reserving the best of the food for the rest of the family should be pointed out to her.

CO-ORDINATED MEASURES FOR IMPROVING NUTRITION

There is an enormous gap between the food supplies in the country and the physiological needs of the population. The first obvious step to be taken to remedy this state of affairs is to increase the food

supply of the country to provide sufficient energy-giving as well as protective foods for the entire population. A food policy based on human needs would have a profound effect upon agriculture and economic problem. Increments to food supply must either be grown in India or imported from abroad. Imports no doubt act as a safety-valve in years of bad harvest. Moreover, the absence of imports reacts adversely on the food situation to an extent which is out of all proportion to the actual magnitude of imports. But so long as the war lasts and for some years after it has ended, India will have to rely mainly on her own resources. After the war the world will be faced with general shortage of food and transport. A bold policy of food production is therefore, imperative. To ensure the supply of "enough food" the production of cereals has to be increased and to ensure "the right kind of food" steps have to be taken to increase the supply of milk and milk products, eggs, fish, citrous fruits and green leafy vegetables.

So far as increased production of cereals is concerned, the enormity of the problem will be realised if we consider that "an increase in the daily consumption of as little one ounce per capita would involve an addition of some 4 million tons per annum to the available food-supply" for the whole of India.

The available supplies of food can be increased by

- A. Development of Agriculture,
- B. Development of Animal Husbandry and Fisheries and
- C. Prevention of the milling of rice to a high degree.

A. Development of Agriculture.

Production of food can be increased by

- I. Increasing the output of the cultivated areas,
- II. The utilisation of agriculturable waste lands, and
- III. Replacing cash crops by food crops.

I. Increasing the output of cultivated areas:

The yield of crops in the cultivated lands can, according to the agricultural experts, be improved by (1) using heavy yielding and better varieties of seeds, (2) greater use of manures and fertilisers, (3) better supply of water, (4) better control of pests and diseases, (5) prevention of soil erosion, (6) the use of better agricultural implements and (7) the selection of right type of soil for a particular crop and the employment of a better system of crop rotation.

(1) *Better Seeds*.—While spectacular results have been obtained in plant breeding work so far as sugar cane and wheat are concerned, the same cannot be said about rice. A few heavy yielding strains have

been developed by Dr Hector at Dacca but the better varieties of seeds are not available in adequate amounts. Investigations at Dacca University have shown that the nutritive values of different strains (of rice) are different and the cultivation of those strains that combine in them the qualities of heavy yielding and higher nutritive value should be encouraged. In each province a central organisation and general sub-stations for the multiplication and distribution of seeds of approved varieties of crops and vegetables, of sugar cane and of named varieties of fruit trees should be set up.

(2) *Manures and fertilizers*.—Intensive cultivation is impossible without intensive manuring. The yield of rice per acre in India (968 lbs.) is about half that in U. S. A. (1680 lbs.), less than half than that in China (2434 lbs.) and about one-third that in Japan (3070 lbs.). This is to a great extent due to the scarcity of manures and fertilisers. India produces about thirty thousand tons of ammonium sulphate while the rice fields alone should receive 7-8 lakh tons of the material per year. It has been pointed out in the Gregory Report that application of three and a half lakh tons of ammonium sulphate to 80-90 lakh acres of suitable land would increase the production of rice by about eight lakh tons per annum. The need for measures for starting factories to manufacture ammonium sulphate in requisite quantities cannot be over-emphasised.

Nitrogenous fertilizers usually give the best returns. Concentrated organic manures, oilcakes and fish manure also give good returns. Cheap and efficient manures can be prepared in large amount by the composting of organic matters in the farm-yards and of the large quantities of town refuse and also of night soil. The step recently taken by the I. C. A. R. for the training of staff in methods of composting is a move in the right direction. The work should be taken up by the urban municipalities throughout the country without any delay. The practice of burning cow-dung as fuel should be stopped and cheap fuel should be made available.

(3) *Irrigation and drainage*.—Manuring can be successful only if there is an assured supply of water. Under the desert conditions such as those prevail in North Western India, irrigation is essential and it is also useful in other regions. Irrigation protects crop production from the vagaries of the monsoon and is an insurance against uncertainties of weather. Experts should indicate the means of utilising waters from the canals, from the great rivers, from wells fed by underground supplies and from tanks filled by rain. Opening of a great dam or barrage would also necessitate the selection of new varieties of crops suited to the new conditions and the designing of new cropping

schemes. Proper drainage of land is as important as irrigation. Large tracts of land in Bengal suffer from inundation and considerable volumes of water are often left stagnant thereby seriously interfering with the production of crops.

(4) *Control of pests and plant diseases.*—Insect pests and plant diseases cause serious loss to agriculture in this country. The loss can be minimised by developing resistant varieties of crops and by obviating the attack of the pest by changes in soil condition, by better drainage and by changes in methods of cultivation by earlier or later sowing. The disease-producing insect or fungus can also be destroyed by chemical or biological methods.

(5) *Prevention of soil erosion.*—Virgin soil maintains a cover of dense grass or forest which protects it against the disintegrating effects of rain and wind. With the increase in population, increasing demands are made upon soils and as a consequence the protecting cover is removed and forests are cut down to provide more lands for cultivation. The soil is then liable to be carried away by rain and also by wind. The affected area becomes useless, great ravines are scooped out as for instance in U. P. (8 million acres) and the soil that is washed away may injure the land on which it is deposited. Moreover the rain drops which would have soaked into the soil when the vegetation cover is intact, are lost as run-off water, carrying with it a heavy load of most fertile and absorptive surface soil and gradually increasing in volume and eroding capacity with subsequent showers. These little muddy waters as they find their way into the tributary stream or the main river, deposit at decreasing velocity some of the coarser particles on the river beds which are elevated in a few years to such an extent that the excess water pours over the country in uncontrolled flood causing destruction of life and crops and dislocation in the country's most vital links of communication. Deforestation of the catchment area of a river has been in fact the principal cause of soil erosion and recurrent floods. Heavy grazing also causes removal of the vegetation cover and soil erosion. A tract of land near Brindaban once most fertile has, as a result of continual over-grazing, been practically converted into a desert—a cattle-made desert extending over several hundreds of square miles in the heart of the world's most fertile plain. Wind also causes not inconsiderable loss of soil from the bare ground. In the bare fallow fields in the foothills of Northern India, except properly levelled land, a single storm leads to the loss of soil at the rate of 1¼ tons per acre. Clean cultivation of sloping land also causes soil erosion and ploughing along the contour lines instead of across them is to be recommended. Afforestation of the top slopes and bunding or terracing also have beneficial effects.

II. Utilisation of 'cultivable waste' lands:

It is also possible to increase production of food crops by bringing fresh lands under cultivation. Total 'cultivable waste' lands other than the 'current fallow' which is necessary to maintain soil fertility, amount roughly to 110 million acres. Assam, the Central Provinces, the Panjab, Madras and Sind are the provinces where these are mostly to be found. With a programme of land reclamation which would include anti-malarial and other public health measures and also provision of suitable labour, there is no reason why 80 million acres out of these lands should not ultimately be sown with food grains. Planned migration for agricultural colonization, as has recently been permitted by the Assam Government from the more densely populated areas, should also be encouraged. It is a matter of long-range scientific planning, is certainly an all-India issue and should be directed from the centre.

III. Replacing cash crops by food crops:

This would undoubtedly increase the amount of available food. India's agricultural economy requires careful planning by regulating the acreage under various food and non-food crops. Allocating acreage of a crop like jute and cotton to rival provinces is bound to give rise to controversy and should be considered as a part of the long range post-war reconstruction policy.

B. DEVELOPMENT OF ANIMAL HUSBANDRY AND FISHERIES

The inclusion of milk specially in the dietaries of infants and children and of expectant and nursing mothers has been deservedly a prominent feature of the nutritional propaganda within the last few years. In a country where the diet is mainly vegetarian, a satisfactory maintenance of human health is impossible without the consumption of milk and dairy products. Including the consumption of ghee and butter which is confined only to the relatively richer classes, the average milk consumption per day per person in this country is only about 10 oz. The production should be at least three times as much to ensure a satisfactory standard of health and physique in people. The difficulty is not lack of sufficient number of cattle in this country which possesses 300 million animals excluding pigs and poultry. The United States of America which possesses the second largest animal population in the world contains only 140 million animals excluding pigs and poultry. The small amount of milk produced by the average cow in India is the greatest limiting factor to an increased consumption of milk. Proper feeding and management would greatly increase the milk yield. The milk yield of the best Indian cows compares very favour-

ably with that of the average English dairy cattle and the yield can further be improved by selective breeding.

It must not be forgotten that agriculture in India is wholly dependent on the cattle population for the bullock draws the plough, supplies the manure, threshes the corn and also pulls the cart. The need in India is for better cattle. Provision of fodder for the cattle is an urgent problem. This is hardly possible unless the productivity of the Indian soil is increased which will permit a part of the lands to be used for the production of fodder crops.

Attempts should also be made to develop the industry of meat production. This would provide additional nutritious food and also an outlet for animals not required for milk production and for work in the fields. Prejudice against the taking of meat has no scientific basis and should be got rid of by education and propaganda.

Reference should also be made to the value of eggs as food and the need for developing the poultry industry in India cannot be over-emphasised. The egg is a valuable protective food, and a rich source of high quality proteins, vitamins A, D, B, riboflavin and of iron and in a way supplements milk. It would not be difficult to develop this industry in this country. Striking results obtained in the egg yielding capacity of hens by careful and selective breeding should also be attained with the duck.

The development of fisheries would provide another important and valuable source of highly nutritious food. This industry has got immense potentialities. The sea fisheries—both coastal and deep sea—of Indian waters can provide a vast quantity of food and fish manures as a by-product. The shark can supply the entire amount of vitamins A and D needed in this country and obviate the necessity of importing codliver oil.

THE ROLE OF SYNTHETIC VITAMINS AND VITAMIN CONCENTRATES IN RAISING THE LEVEL OF NUTRITION

The question of attempting to improve the nutrition of the entire population by the use of vitamin concentrates and synthetic vitamins has been frequently raised. There is no substitute for a good diet of ordinary mixed foods but when natural sources are not available in adequate amounts, the synthetic vitamins and vitamin concentrates can of course play an important role. Young children and pregnant women very frequently require certain vitamin supplements even during normal times. The availability of synthetic products in India presupposes an industrialisation of the country. Yeast and shark

liver oil, on the other hand, will be available and full use should be made of them. The shark liver oil industry developed in this country during the present war should be protected from foreign competition. Liver extracts also can play an important role and it should be possible to have large supplies of these made in India. Margarine and vegetable fats should be fortified with vitamin concentrates.

NEED FOR NUTRITIONAL RESEARCH

All progress is based on research and the knowledge that has accumulated from nutritional investigation during the last decade has thrown into clear relief the contribution which nutritional research can make to human welfare. In all civilised countries faced with food problems very large sums are being spent on research to solve the immediate and pressing problems as also on long-range research. India has her own peculiar problems in nutrition and it will be an extremely short-sighted policy not to give adequate funds for nutritional research.

FOOD DEPARTMENTS—CENTRAL AND PROVINCIAL

Not only should sufficient food be produced in the country but also it should be fairly and equitably distributed among the entire population. The task of distribution is primarily administrative and this and related problems can best be tackled by the creation of permanent food departments in the centre and also in the provinces and States. The Central Food Department should formulate and initiate policies which should mostly be carried through by the provincial food departments over which the centre must have sufficient control. Intelligence and statistics bureau in the central food department should be a very important section which should maintain intimate contact with all phases of the food situation. There should be a half-yearly stock-taking of all the available foods in the country. There must be licensing and registration of the regular trader and information about what supplies he has received and from whom, to whom he has sold, should always be available. Knowledge of stock in the possession of agriculturists should also come into the possession of the Government. The department should arrange for the transport of food grains through a movements officer. If faulty diet is to be eliminated, the purchasing power of the poorest must be related to the price of a diet adequate for health and hence the necessity of price control. Rationing 'ensures the equitable distribution of an insufficient food supply' and it may be necessary to introduce and continue rationing in India as a general policy. In this and other spheres of administration the food department must have the benefit of the advice of nutrition ex-

perts. Some of them should be permanently attached to the department. The experience and knowledge of the others may be utilised by forming an Advisory Board on which they may be invited to serve. The success of the department demands that it should be efficiently and adequately staffed. Publicity and propaganda should be an important feature of the department.

THE POPULATION PROBLEM AND NUTRITION

The problem of the relation of food supply to population is a very intricate and highly controversial one. The prevailing view seems to be that the growth of population and the growth of food supply in India not having kept the same proportion in their rise, there is a lag between food and population with the result that a condition of over-population and even of saturation has been created. Closer examination will however, show that there is no justification for this extremely pessimistic view.

Undoubtedly there is a slight shortage of food supply in the country at present. The acreage per capita under food crops in India is about 6.86 acre compared with 4.2 acres in U. S. S. R., 3.3 acres in U. S. A. and 0.36 acre in China and compared with East's minimum of 2½ acres per head as representing the area necessary for producing enough food. Utili-

sation of cultivable waste and great and fundamental changes in agricultural technique which would vastly increase the productivity of the cultivated areas can surely create a satisfactory food position in India.

The population problem cannot be discussed only in terms of food supply within the country. If that were so, England would have been saturated with population nearly 2½ centuries ago. The ability of a country to maintain an optimum population depends upon its agricultural, as well as commercial and industrial wealth. It should be the aim of post-war reconstruction programmes to increase the per capita income of the Indian people by 100 per cent and to provide a more balanced economy. Instead of the contribution of industry, agriculture and the services to the national income being as it present 17.53 and 20 per cent respectively, the percentages should rather be 35, 40 and 20 respectively. This would necessitate a rapid development of industries. Economic considerations play a very important role in matters of nutrition and an inadequate family resources are the greatest single cause of defective nutrition. The population problem in India does not necessarily mean the problem of birth-control. The most obvious and urgent problem to-day is to raise the standard of life, of education, of sanitation, of agricultural production and of vitality through vigorous and persistent State action.

BOOK REVIEWS

"Geology of India and Burma"—By M. S. Krishnan, M.A., Ph.D., A.R.C.S., M.A.I.M.E., Geological Survey of India. (The Madras Law Journal Office, Madras) 1943, pp. XVI+518. Price Rs. 15/- net.

Dr M. S. Krishnan must be congratulated for bringing out a comprehensive and up-to-date text book of high standard on "Geology of India and Burma" for the students and the educated public who are interested in this science. The first text-book on this subject was the official Manual of the Geology of India in two volumes by H. B. Medlicott and W. T. Blanford published by the Geological Survey of India in 1879. This was revised and rewritten by R. D. Oldham in 1893 which was out of print by 1910. Although the Manual was an excellent official record of work upto that time it soon became out of date and besides its voluminous size the method of

treatment was not suitable for average student. The latest and revised edition of this Manual has however been prepared by the Geological Survey of India after half a century and is now ready for the press but would be published possibly after this war is over.

In 1910 a very small book on this subject entitled "A summary of the Geology of India" was published by E. W. Vredenburg, an officer of the Geological Survey of India. As this was too short a summary of a subject which was gaining importance it could not satisfy the student community as well as other inquirers. The publication of this book was however discontinued after second edition. So the active workers in this line were forced to search for and collect information from the innumerable issues of the *Records* and *Memoirs* of the Geological Survey of India—a very difficult task for the diligence of the

average student. Moreover these official publications are not easily accessible and are only to be found in very few libraries of this country.

It was in 1919 that the first handy volume of an excellent nature on this subject, written in a masterly way, was published by D. N. Wadia, the then Professor of Geology, Prince of Wales College, Jammu (Kashmir) and the subsequent editions have since been supplying adequate information to the student community.

Quite recently in 1943 M. S. Krishnan, an officer of the Geological Survey of India, has brought out another text-book on "Geology of India and Burma" which is quite welcome to the students and others interested in this science. A new book on Indian Geology needs no apology for its appearance especially because this subject is attracting greater attention of the various institutions of this country and an increasing number of students.

Krishnan's book under review consists of 518 pages in all and divided into 20 chapters. The first chapter of 40 pages on Physical Geology of this country deals briefly with climate, mountain systems of peninsular and extra-peninsular India, glaciers, rivers, lakes, earthquakes and volcanoes. The origin of mountains, lakes etc. and an account of change of some of the river courses would be of great interest to the readers.

The second chapter consisting of 33 pages gives a very good summary of the structure and tectonics of India and Burma, a subject of great importance to every student of Indian Geology and this constitutes a special and additional feature of Krishnan's book. It may, however, be said that in several cases the generalisations are only tentative ones and need verification and confirmation by further field work and investigations. A few diagrams illustrating the structural features would have been very helpful to the younger students. A paragraph regarding the evolution of the configuration of India through the various geological periods illustrated by sketches would have been of greater attraction to the readers. The local students of Bengal will find much interest in the story of the evolution of the Bay of Bengal.

The third chapter gives a general review of Indian stratigraphy and includes several tables showing the general geological formations and stages and a detailed scheme illustrating the correlation of the geological succession in different parts of India and Burma.

In chapters IV and V a detailed account is given of the Archaeans of the Peninsula including Ceylon and the extra-peninsular region including Burma. About 60 pages have been adequately devoted to this important subject. The proper correlation of the

Archaean formations at different places has ever been a great problem to the Indian stratigraphers and the student community was always in a great fix in obtaining a clear understanding of this subject as no suitable and systematic account could be found on a small compass in any of the previous text books. Dr Krishnan who has a first hand knowledge and sufficient experience in several of the places where this formation exists has done good justice to this subject by summarising all available information and in giving his suggestions on various points.

The division of the Archaean group into an Archaean system and a Dharwar system as has been done by Wadia has not been carried to the extent of describing each as a separate unit, since the two are very closely associated and since the granites and gneisses may merely represent certain horizons within the schistose members. A good summary of Mysore Archaean complex has also been given and the latest views of B. Rama Rao regarding the sedimentary origin of a considerable portion of the Dharwars have been included. Much credit is due to the author for the way in which he has presented this complicated subject and for the inclusion of several tables showing correlation. This is another attractive feature of the book under review. Krishnan has admitted that the complexity of the Archaeans prevented him from attempting more than a broad indication of correlation and that further intensive work would be necessary in order to put forward an acceptable scheme of detailed correlation.

The chapter VI gives a very brief account of the economic mineral resources found in the Archaean formation. The economics of each of the geological systems are given at the end of the respective chapters. This is another special feature of this book and is considered to be decidedly an improvement on the old practice.

A major portion of the important economic minerals of India is found in the Archaean formation because extensive mineralisation took place along with the widespread igneous activity in the different parts of this country during that old geological period.

This chapter would have been of greater interest if it included a fuller and more complete account of the economic minerals together with a map of India showing their distribution. A point may be raised as to whether we should include lateritoid manganese ore deposits in the Archaean formation or within the Pleistocene deposits. From the standpoint of the geological age it should be included within the Pleistocene system.

The chapters VII and VIII deal with the Cuddapah and Vindhyan systems together with the economics at the end of each chapter.

The Palaeozoic Group is described in chapter IX. The Salt Range geology is discussed and the interesting account about the age of the Saline Series has been given.

There has been certain amount of controversy between two officers of the same department on this problem. Fox showed that in certain clear sections in the *cis*-Indus Salt Range the Saline Series lies below the Cambrian succession without much visible signs of disturbance. Gee on further work found evidences of a *nappe* and advocated an Eocene age for the Saline Series but recently he has revised his opinion and now supports a Cambrian (or Pre-cambrian) age for that of the Punjab Salt Range. Future work only can reveal the truth.

The sedimentary formations have been described with the help of a number of geological sections. A new and useful feature in this book is that each sedimentary group is illustrated by plates of characteristic fossil types.

The chapter X of 54 pages gives an adequate information on the Gondwana system which is the chief coal bearing formation of India. The two-fold classification of the Gondwana system as adopted by the Geological Survey of India has been adhered to in this book. The tripartite classification as adopted by Vredenburg and Wadia has also been discussed. Though the occurrence of arid continental deposits containing Triassic reptiles and amphibians make the tripartite division plausible, the evidence of the flora is entirely in favour of a two-fold division. Geological sketch map of Jharia and Raniganj coalfields, a map showing the distribution of the lower Gondwana coalfields and a number of tables and plates showing the important plant fossils are given to illustrate the chapter. The names of the more important coal seams occurring in the Jharia and Raniganj coalfields and the nature of the Barakar and Raniganj measure coals have been given. The estimates of the coal reserves of these two coalfields and the classification of coal adopted by the Coal Grading Board have also been included.

The remaining 10 chapters deal with the younger geological formations. Chapter XV gives a very good account of the structural features, petrographic and petrological characters, chemical composition of the Deccan Traps. The age of the Deccan Traps has been discussed from the fossil content of the inter-trappean and infra-trappean beds as well as from the recent radio-active characters of the traps.

The chapters XVI to XIX give a balanced description of the systems of the Tertiary Group found at different places of India and Burma. The Eocene System contains important deposits of coal in Assam,

N. W. India and Burma. The story of the upheaval of the Himalayas has been nicely presented.

In chapter XX the Pleistocene system is discussed. The Pleistocene Ice Age and the results of recent work by H. De Terra and others have also been incorporated. The characteristics and origin of the Indo-Gangetic alluvium and other alluvial deposits have also been dealt with as well as the recent changes in the coastal tracts. Lastly a short account of laterite, its characters, composition, mode of formation and uses have been enumerated.

A selected bibliography has been given at the end of each chapter for reference and 16 pages have been devoted to the Index of the book. An addition of a geological map of India would have enhanced the value and usefulness of the book to a very great extent. The second edition might possibly include one.

Finally one word may be said with regard to certain geological formations derived from topographical names, *e.g.*, Kadapa, Bundair, Vempalle, Varkala, Damodar etc. Krishnan has introduced these terms which are not yet accepted or included in Holland's "Geological Terminology". In this connection it has to be remembered that once the name of a geological formation is coined and incorporated in the bibliography it should never be changed in future and such terms should have priority of claim and should be considered to be absolutely rigid. If this view is not accepted by all it is desirable that definite and specific terms should now be standardised and accepted once for all in order to avoid several confusing terms for one particular formation.

The get up and printing of the book under review have been quite satisfactory and upto the mark and considering the high cost of printing and scarcity of good paper due to war conditions the price has been quite reasonable and is well within the reach of almost every student. Few inaccuracies and printing mistakes have however crept in possibly due to the unusual hurry in getting the book through the press and it is hoped that these defects would be eliminated in the second edition.

The book is really brought up to a very high standard as it contains a summary of almost all the important recent work done on Indian stratigraphy and if the few suggestions for improvement that are given in this review are carried out in the next edition the book will surely be of immense value and of great use to all who are interested in this subject. There is every reason to believe that a book of this nature will be very popular among students and other workers in Indian stratigraphy.

N. N. C.

Indian Ephemeris of Planets' position—according to the Nirayana or Indian system for 1944 A.D.
—By NIRMAL CHANDRA LAHIRI, M.A. Published by the Bharati Mahavidyalaya, 170, Manicktalla Street, Calcutta. Pages 56, Price Re. 1/-.

Astronomical Ephemeris contains tables showing planetary co-ordinates for each day. The present Ephemeris under review contains daily longitudes of the Sun, the Moon and the planets, sidereal time for noon, latitudes, declinations and meridian passages of planets for each alternate day, and many other astronomical data mainly required by the astrologers. Students of astronomy would also be benefited by this booklet, as the planetary position given therein would help them to identify the planets. The longitudes and latitudes of principal stars that have been given in this Ephemeris will be found very useful for researchers in Hindu astronomy. As the booklet is intended for Indian students, the planetary positions on the Nirayana basis have been given instead of on the Sayana or tropical basis. We hope that it will prove very useful to those who are interested in astronomy as well as in astrology.

M. N. S.

Intermediate Practical Physics—By D. B. SINHA, Bodern Book Agency, Calcutta. Price Rs. 2/-.

The writing of a practical book on science course always seems to be a difficult job. It is particularly so if such a book is intended for young students going for the first time to cultivate their acquaintance with science and its methods. Creation of the habit of systematic observation and methodical procedure during the conduct of an experiment with a real dislike for mechanical approach without understanding and, above all, of an abiding interest in the principles and methods of science should and must be the aim in writing a practical book on a science subject, on physics in particular. It is not unoften that such books fail to fulfil this aim and that new publications are hardly any improvement on old ones. Mr Sinha's 'Intermediate Practical Physics' appears from these considerations to be a real improvement on the number of practical books now in existence. The happy choice of experiments, the simple and accurate description of the methods, reproduction of neat diagrammes, tables and graphs, wherever necessary, and various notes and suggestions for success in experiments are largely calculated to fulfil this aim which alone justifies its publication, and as such the book deserves wide notice among teachers and students of Indian universities.

S. N. S.

LETTERS TO THE EDITOR

[The editors are not responsible for the views expressed in the letters.]

ON BALANCING PARAMETERS

It has been observed in the papers,^{1,2} written by the author that the design of experiments consists of the fundamental problem which is sought to be solved with the help of the problem of balancing, which depends on the information supplied by the design on estimable parametric functions. Information on any parametric function can be obtained by comparing its efficiency with the efficiency of its estimate from a standard design. We say that there is balance with respect to a set of independent parametric functions if the information as calculated above is the same on all. It has been already shown that if there is balance with respect to a set of independent parametric functions then the information on any linear function of the parametric functions is equal to the loss on any one of the latter functions. A discussion of the problem of balancing which consists in the choice of balancing parameters is given in this note. The details of the proofs of the various statements will be given in an elaborate paper to be published in *Sankhya*.

The fundamental problem is that there are v treatments (variatal or factorial) to be tested in b blocks of sizes $k_1, k_2, k_3, \dots, k_b$, the i -th treatment being replicated r_i times and the i -th and the j -th treatments occurring together λ_{ij} times. The analysis of this general design has been given by the author¹ and it was found that the estimating equations are

$$\sigma^2 Q_i = V(Q_i) - E \text{cov}(Q_i, Q_j) \dots (2.1)$$

where Q_i = the sum of observed yields on the i -th treatment—the block means in which it occurs.

In the case $k_1 = k_2 = \dots = k_b = k$, the equation (2.1) becomes

$$Q_i = \sum_{j \neq i} a_{ij} t_j \dots (2.2)$$

where $a_{ij} = \gamma_i(k-1)/k$, $a_{ii} = -\lambda_{ii}/k$ and t_j is the j -th treatment effect.

The matrix $A = (a_{ij})$ plays the fundamental role in our investigations. The following properties have been found out.

- (a) The rank of A is less than v and is equal to the number of Q 's which are linearly functionally independent.

- (b) There exists a dual relation between the Q 's and the t 's such that if

$$\sum C_i Q_i = 0 \dots (3b.1)$$

then the parametric function

$$\sum C_i t_i \dots (3b.2)$$

cannot be estimated, so that the number of degrees of freedom confounded is equal to the number of independent linear functional relationships among the Q 's.

- (c) There cannot be any non-vanishing linear function of Q 's whose expectation is zero.
 (d) A linear combination of non-estimable and estimable parametric functions is also non-estimable provided the co-efficients are not such that the linear function of non-estimable functions becomes null.
 (e) If the rank of $A = (v-r)$ then
 (i) the co-factor of a_{ii} is +ve and is independent of i
 (ii) the treatment differences are uniquely estimable and

$$V(t_i - t_j) = \frac{\text{co-factor of } \begin{pmatrix} a_{ii} & a_{ij} \\ a_{ji} & a_{jj} \end{pmatrix}}{\text{co-factor of } a_{ii}}$$

- (f) If, in general $\sum a Q$ and $\sum b Q$ are the estimates of $\sum lt$ and $\sum mt$ then their variances and co-variances are

$$\begin{pmatrix} \sum a l & \sum a m \\ \sum b l & \sum b m \end{pmatrix}$$

- (g) Every design can be broken up into parts in which (e) holds good.

This result is independent of the restriction of the equality of block sizes.

With the help of (e) it has been found that the balancing parameters introduced in the case of partially balanced³, intra and inter-group balanced⁴, quasifactorial⁵ and balanced factorial^{6,7} (symmetrical or asymmetrical) designs come out as solutions to a mathematical problem. Several hybrids of these designs have been incidentally found out.

Certain methods have been developed to investigate into the role of the balancing parameters in the confounded arrangements of the symmetrical factorial designs and the conditions under which the principle of the generalised interaction⁸ holds good have been studied.

Some results in the third paragraph are true, in general, for the estimating equations of a set of observational equations with expectations as linear functions obtained by the method of least squares.

C. RADHAKRISHNA RAO

Statistical Laboratory,
Calcutta, 18-1-1944.

¹ Rao, C. R., Thesis submitted to the Calcutta University, 1943.

² *Current Science*, 12, 322-23, 1943.

^{3,4,5,6,7} Nair and Rao, *SCIENCE AND CULTURE*, 7, 313, 1941
7, 361, 457, 568, 615, 1942.

RADIO INVESTIGATION OF AIR MOVEMENT IN THE UPPER ATMOSPHERE

INVESTIGATION of eddies and circulation in the earth's upper atmosphere may be greatly aided by reduction of observations of long-range very-high frequency radio signals. It is fairly well known that propagation of wave trains of the order of 60,000 kes./sec. is possible from small plane areas, or patches, or clouds of extremely high ionic density within the "E" region. This is commonly referred to as sporadic "E", (E_s).

A consideration of a particular manifestation of E_s has been examined by the writer. Very extensive observations in North America on June 5, 1938 and July 22, 1938 have been reduced. On both occasions the apparent skip distance was observed to drift at a specific rate of speed.

The skip distance, or the far boundary of the zone of silence, on the first occasion progressed 850 km. in 1 hour and 50 minutes. On the latter occasion, it was observed to progress over 900 km. in 1 hour and 40 minutes.

With correlating data from the Cheltenham Magnetic Observatory on the virtual height (115 km.) and ionic density (exceeding 3.5×10^6 free electrons per c.c.) an estimate of the lateral drift of the sharply-defined discontinuity was prepared. The average velocity of drift was found to be 120 km./hour. In the first case the eddy was indicative of an easterly air current. In the latter the flow was apparently from the southeast.

Through the co-operation of Dr Charles P. Oliver, Director of the Cook and the Flower Astronomical Observatories, twenty-five selected long-enduring meteor trains were applied as a partial confirmation of this hypothesis¹. It was immediately

noticed that the predominant drift over the North American continent was to the north, tending west. The average of the two values, measured and assumed for night trains at 88 km. was 194 km./hour. Although there were indications of increasing circulation with increasing heights no specific inferences could be drawn. Undoubtedly, however, considerable instability exists in this region.

The findings of Dr Oliver were in opposition to those of Kahlke². Turbulence and eddies of 100 km./hour at heights from 60 to 110 km. are among his 26 observations. Kahlke and Barnard³ utilizing 80 examples found a prevailing easterly movement at night, indicating a west wind.

Theoretically, if the atmosphere at 40 km. becomes a few degrees warmer during the daylight hours, air circulation will be from the night areas to the daylight areas at certain heights. At nominal altitudes above this the prevailing wind shall be continually 180 degrees out of phase. The establishment of these heights can be greatly aided by reduction of variations in the skip distance during periods of E_s .

O PERRY FERRELL

U. S. Army Forces,
Chittagong, 15-2-1944.

(A.S.N. 32268682)

¹ *Proc. Amer. Phil. Soc.*, Oliver, C. P., 85, 2, 1942.

² *Meteorschweife und Hochatmosphärische Wind stromungen*, *Ann. Hydrogn*, 49, 294-299.

³ *Sidereal Messenger*, 1, 174-180.

TOTAL ALKALOIDS IN *ALSTONIA SCHOLARIS*

I

THE letter published by Mr J. N. Rakshit in *SCIENCE AND CULTURE* (9, 302-303, 1943-44) under the above caption needs some comments since he makes certain statements which are open to correction.

The author suggests a new method for the isolation of total alkaloids and has further recommended this method for commercial and pharmaceutical valuation. He has by his method, discovered the presence of 2.9 to 11.2 per cent of 'total alkaloids as sulphates' in the dried bark, whereas all previous workers^{1,2,3} have never found in any of the ten *Alstonia* species so far studied, e.g., (1) *Alstonia constricta*, (2) *A. macrophylla*, (3) *A. somersetensis*, (4) *A. villosa*, (5) *A. verticillata*, (6) *A. scholaris*, (7) *A. angustiloba*, (8) *A. congensis*, (9) *A. gillettii*, (10) *A.*

spathulata any figure higher than 1.61 per cent (variation—0.1 to 1.61 per cent) as 'total alkaloids'.

We need not at all refer to our own finding⁴ which have only corroborated the above. The authorities on alkaloids did not of course "presume" that all water-soluble substances having basic properties were 'alkaloids' and hence they never attained a figure as high as 11.2 per cent.

The author has taken his second stand on the better antimalarial action of the 'total alkaloids' isolated by him in comparison to those isolated by 'standard' methods. We shall eagerly await the publication of these figures which have been "investigated by medical men exhaustively" but it is perhaps quite pertinent to remark that a "febrifuge" is not necessarily a specific "antimalarial". A temporary reduction in temperature is often brought about by a host of so-called 'antimalarials' but a real anti-malarian from natural sources to replace quinine is yet to come.

A. T. DUTT

Department of Chemistry,
School of Tropical Medicine,
Calcutta, 22-2-1944.

¹ Henry, 'Plant and Alkaloids', 3rd Edition, 1939.

² Wehmer, 'Die Pflanzenstoffe', 1930.

³ *Jour. Chem. Soc.*, 2626, 1932; 287, 1934; 1227, 1934; 1353, 1938.

⁴ Mukherji, Ghosh and Siddons, *Ind. Med. Gaz.*, 77, 323, 1942.

II

The following fundamental properties of vegetable alkaloids were missed by former investigators on this drug:

- (1) *Solubility*—Several prominent alkaloids (like morphine) are quite sparingly soluble in immiscible solvents, which were used in extraction of bases from *Alstonia* barks.
- (2) *Stability*—Some alkaloids are weak and cannot stand alkalis, and this fact was formerly recorded by Sharp¹.

Consequently attempts to support the previous results cannot be justified. Pending completion of my research I note that some of the *Alstonia* alkaloids are like morphine in solubility, and delicate like several others present in opium. The so-called authorities will miss most of morphine if they apply their old method to opium or poppy capsules for extraction of total alkaloids.

Medical men, including Dr Bidhan Chandra Roy had already expressed their views in daily papers about curative properties of these long over-looked alkaloids. I however, did not notice any report from these men with vast private practice whether they tried the drug on the monkey or the bird. It will not be wise in this connection to ignore that some cases of malaria are, self-terminating, and an appreciable proportion of popularity of quinine is due to this fact.

J. N. RAKSHIT

Calcutta, 15-4-1944.

¹ Sharp, T. M., *Jour. Chem. Sec.*, 288, 1934.

EFFECT OF VERNALIZATION AND PHOTOPERIOD ON LATE SOWN AMAN PADDY

THE extensive loss of aman paddy by floods in different parts of Bengal is well known. In these areas the cultivators try a second crop, after the flood has subsided. But the yield of these sowings is very meagre, owing to the shortness of the vegetative period. Experiments in the Department of Agriculture show that the flowering of aman paddy is fixed within a short range of time, in the latter half of October in var. Bhasamanik and Jhingasail, even with wide difference in sowing time (February to August), and if the sowing be greatly delayed (October to December) plants remain vegetative in the winter, flowering in March-April. Sircar¹ observes that aman paddy flowers with the approach of short days of winter and has reported an earliness of flowering in plants exposed to short photoperiod.

It thus becomes a great interest to investigate how far late sowings after the flood has subsided can be made to flower earlier and produce better yields by presowing low temperature treatments and by photoperiodic effects. The following experiments were therefore designed, growing a high yielding var. Bhasamanik in suitable pots with sufficient number of replicates. Seeds of all the treatments were sown on 2-9-43 and the results are given below.

Vernalization: Seeds were soaked in water for 48 hours and vernalized at 2-4°C. in a moist chamber for 10 and 20 days and sown in pots with untreated seeds as control. It was found that the treated plants in both the sets flowered about 10 days later and the plants showed general deterioration in their growth and general vigour.

Photoperiodic effects: Seeds vernalized at 2-4°C. (1st set) were sown with untreated seeds (2nd set) in pots and exposed to 8 hours sunlight daily,

by transferring the pots to a dark room for about 3 hours in the afternoon for 20 days. Seedlings of these two treatments as well as those which served as controls were transplanted after 20 days. It was found that in the 1st set exposed to short photoperiod after low temperature treatment flowering was delayed by 9 days and in the second set exposed the short photoperiod by 16 days. In this case also the treated plants showed a deterioration in their vegetative growth and general vigour.

It is thus seen that presowing low temperature treatments and exposing the seedlings to short photoperiods in late sown aman paddy delays the onset of flowering and there is no increase in vegetative growth and yield. It will however be of interest to investigate how far presowing high temperature treatment is of influence to aman paddy in view of the fact that Hedayetullah and Sen² recorded an earliness with increased yield due to such treatment and there are similar records with many other tropical plants.

J. C. SEN GUPTA

NIRAD KUMAR SEN

Botany Department,
Presidency College,
Calcutta, 27-3-1944.

¹ Sircar, S. M., Photoperiodic response in one variety of winter paddy, *Jour. Ind. Bot. Soc.*, pp. 41-50, 1942.

² Hedayetullah, S. and Sen, Nirad Kumar, Vernalization of Rice, *SCIENCE AND CULTURE*, 9, 668, 1941.

THE SEED STRUCTURE OF IPOMOEIA, A CRITICISM

An abstract of a paper by Dr Woodcock¹, which has just come to hand, says that in *Ipomoea rubrocaerulea* Hook. the ovule "has no distinct integument and the micropyle is formed by an invagination at the end of the ovule next to the funiculus". The statement regarding absence of a "distinct" integument is astonishing as it is not borne out by the figures or descriptions of any of the previous workers on the family or even the genus *Ipomoea*. Kenyan², Juliano³ and Raghava Rao⁴ have all reported a massive integument and a long and narrow micropyle in a number of species of *Ipomoea*.

Unfortunately Dr Woodcock's full paper is not available at the time of writing but from the summary (prepared by his own self), it appears that he did not study the initial stages in the development of the ovule. An integument is certainly present but the nucellus is ephemeral. The micropyle cannot be an "invagination" but a continuous

passage extending from the surface of the ovule right up to the embryo sac. After fertilisation has been accomplished it begins to be occluded and is probably not anatomically demonstrable except in the distal region of the ovule, thus giving the false impression of having arisen as an "invagination". In non-median sections it may not be seen at all and either the integument may then be mistaken for the nucellus, which is however no longer present, or no distinction between the two tissues may be apparent even to a trained observer.

Even so recently as 1938, Houk⁵ failed to see a separate nucellus and integument in coffee and in his confusion stated that the tissue in this region should be regarded as "integument-nucellus". Mendes⁶ and several other workers have however proved that both nucellus and integument are formed quite normally but the former soon disappears as is usual in most Sympetalae. In another genus, *Fouquieria*, Johansen⁷ described a "massive" nucellus, but Khan⁸ has shown that what he was looking at was the inner integument and that the nucellus had disappeared long before.

The morphology of the seed is so difficult that it is often quite impossible to understand it correctly without first studying the stages leading to its development. If one has only the older stages before him, he is very apt to mistake two adjacent tissues for each other, or get into a muddle in trying to account for two tissues (integument and nucellus) when one (the nucellus) has already degenerated and disappeared.

Botany Department,

Dacca University,

Dacca, 11-4-1944.

P. MAHESHWARI

¹ Woodcock, E. P., Seed development in morning-glory (*Ipomoea rubrocaerulea* Hook). *Papers Michigan Acad. Sci. Arts & Lett.* 28, 209-212, 1943.

² Kenyan, F. M. G., A morphological and cytological study of *Ipomoea trifida*. *Bull. Torr. Bot. Club*, 55, 499, 512, 1929.

³ Juliano, J. B., Morphology of the sweet potato, *Ipomoea batatas* (Linn.) Poir. *Philippine Agri.*, 23, 833-858, 1935.

⁴ Raghava Rao, K. V., Gametogenesis and embryogeny in five species of the Convolvulaceae. *Jour. Ind. Bot. Soc.*, 19, 53-70, 1940.

⁵ Houk, W. G., Endosperm and Perisperm of Coffee with notes on the morphology of the ovule and seed development. *Amer. Jour. Bot.*, 25, 56-61, 1938.

⁶ Mendes, A. J. T., Cytological observations in Coffea IV. Embryo and endosperm development in *Coffea arabica* L. *Amer. Jour. Bot.*, 28, 784-789, 1941.

⁷ Johansen, D. A., Morphology and embryology of *Fouquieria*. *Amer. Jour. Bot.*, 23, 95-99, 1936.

⁸ Khan, Reayat, The ovule and embryo sac of *Fouquieria*. *Proc. Nat. Inst. Sci. India*, 9, 253-256, 1943.

CULTURE OF *DAPHNIA*

REARING fish in ponds depends much on proper food supply. Among various kinds of food, microscopic crustaceans form an ideal food for fish in general and some of the major Carps¹ in particular. The acute demand of the three fundamental ingredients of food material namely, carbohydrates, proteins and fats can readily be got in a crustacean like *Daphnia*—the microscopic water-flea.

Culture of such minute crustacean like *Daphnia* is essential as they are thinned out at least for two periods during a year i.e., in July-August and December-January. The flourishing periods for *Daphnia* have two seasons in a year, one from February to April and another from September to November. Their rate of growth goes down after April as majority of them cannot stand a temperature higher than 82°F. *Daphnia longispina* forms the best type of food-crustacea as it can stand the greater range of temperature from 70°F. to 82°F. and also alkaline water, while other allied crustaceans like *Bosmina*, *Moina* and *Ceriodaphnia* cannot tolerate such high temperature nor high alkaline water. Most of the *Daphnia* have decided tastes regarding food. *Daphnia longispina* prefers green algae whereas *Bosmina* and *Ceriodaphnia* like Diatoms and Protozoa. For this sort of variation regarding preference of food one must acquaint himself with the food-habit of a particular crustacean before he can try for its culture.

Breeding of *Daphnia* has two definite forms of reproduction: (1) asexual, (2) sexual. The first form of propagation is done by parthenogenetic females which can produce eggs that develop into adult forms without being fertilized by a male. The number of eggs in such females varies, in minute *Ceriodaphnia* the number is only two, but the usual number in large *Daphnia* is more than twenty. Such eggs are nourished in the brood-case till they are hatched out as minute adults. This mode of reproduction goes on regularly until the advent of the unfavourable circumstances, such as, variation of temperature, accumulation of excessive metabolic waste products, external enemies, over population and scarcity of food. With the advent of unfavourable conditions mentioned above normal females and males are hatched from such parthenogenetic eggs. These normal females can produce one or two large and opaque, thick-walled eggs. These are called the winter-eggs although they have nothing to do with winter season, specially in a tropical country. Such winter-eggs are lodged in special chamber called ephippium till the next favourable season for development.

From the above data it is evident that in order to have a controlled breeding of *Daphnia* we should

concentrate our attention to have an artificial culture of parthenogenetic females which can produce *Daphnia* for the greater period in a year. To have a dense culture of *Daphnia* several kinds of fertilizers such as soyabean, dried milk products, raw meat, blood, manure of chicken, have already been advocated by previous workers. The above fertilizers are admirable for aquarium but they are almost useless for bigger waters such as ponds and lakes, not only for their procurement but also due to excessive cost in a poor country like India.

In order to have a continued mass culture of *Daphnia* at a minimum cost, the following methods may be adopted. If we have five large cement tanks or five earthen 'gamlas' with thin cement coating, then these can be used as vessels for culturing *Daphnia*. Green algae and cow-dung can be used as a manure for culturing such *Daphnia*. The satisfactory result can be had within twenty one days, by adding five gallons of deep green water (algae) and ten pounds of fresh cow-dung in hundred cubic feet of water. We should not start culturing *Daphnia* in these 'gamlas' all at once but should use each 'gamla' at an interval of five days, so that after three weeks we will be able to use the culture of the first 'gamla' for a period of five days. By that time the second 'gamla' will be matured for use for a period of next five days and so forth; so that after five such operations, we should repeat the entire process again with first and the next four in a linear series. This method will enable us to give a continued supply of *Daphnia* without the advent of unfavourable circumstances mentioned above which develop the normal male and female from parthenogenetic eggs ultimately forming winter-eggs.

The most useful and everlasting way of maintaining the seeds for culturing *Daphnia* which has not been recorded by previous workers is to keep the winter-eggs which can be had readily by drying up of the culturing 'mamlas'. These winter-eggs will lie in a dormant state for a good length of time and on getting in touch with water they will readily germinate. We have observed in many occasions such germination of winter-eggs on coming in contact with water.

Lastly we like to suggest another easy method of culturing *Daphnia* which in reality turning a curse to a blessing. We have often observed that whenever the covering plants like water-hyacinth or pistia are removed from the water surface of a pond to the adjacent area for drying and when these dried water-hyacinth or pistia are again put into the pond either accidentally or wilfully they act as a very good manure for culturing *Daphnia*, a few of which are already in the pond. They act as seeds and germinate to a huge quantity that it can serve the purpose of

feeding the fry and fish in adequate quantity in any pond.

We have much pleasure in thanking the Adair Dutt Research Fund Committee of the Indian Science News Association for the scholarship which enabled us to carry out the work.

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the factor or factors that might be responsible for accelerating this fermentation by *L. bulgaricus* even at 37°C.

Our thanks are due to Dr U. P. Basu for his interest in this work.

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ON THE LACTIC ACID FERMENTATION OF MOLASSES
BY *LACTOBACILLUS BULGARICUS*

ONE of the most important uses for *Lactobacillus bulgaricus* has been in the commercial production of lactic acid from some cheaper source of carbohydrates such as whey. But the production of the acid is in many cases a slow process. Recent researches^{1, 2, 3, 4} however tend to show that the fermentation may be accelerated by incorporation of some accessory nutrients like riboflavin, pantothenic acid and/or nicotinic acid. Pan *et al*⁵ have noticed that in the fermentation of molasses by a selective strain of *L. delbruckii* malt sprouts alone serve as the proper nutrient source. In order to shorten the period of fermentation attention has also been diverted towards certain other factors such as the concentration of sugar, maintenance of pH on the acid side, and the temperature of the fermentation.

In connection with a lactic acid fermentation work that is being carried out in this Laboratory, it is being noticed that a mash made from inverted molasses and adjusted to contain a sugar concentration of about 10 per cent, undergoes fermentation with a culture of *L. bulgaricus* maintained on sterilized skim-milk, even when incubated at 37°C—the necessary nutrient being supplied from yeast extract. Substituting the yeast extract by a concentrate from liver extract, the sugar is being found to undergo about 60 per cent conversion within 24 hrs. and to complete fermentation to lactic acid within 48 hrs. The pH, of course, was maintained on the acid side with the addition of sterile calcium carbonate. Malt sprouts gave no better result. The importance of liver extract has been previously noticed by Snell, Strong and Peterson³ in lactic acid fermentation. The optimum temperature of fermentation by *L. bulgaricus* has generally been found to vary from 43°C to 50°C. Accordingly, further work is in progress to find out

A NOTE ON THE PRELIMINARY STUDIES ON THE
EFFECTS OF X-IRRADIATION UPON GROWTH
AND DEVELOPMENT OF JUTE PLANT

THE effects of X-rays on seeds and seedlings of various plants have been studied by a number of workers. The results obtained in different cases show contradictory statements and so from these it is not quite possible to make any definite conclusion about the effect of X-rays on seeds and seedlings in general. Several investigators have shown that radiation produces cytogenetic alterations in plants. Koernicke^{1, 2}, Gager³, Komuro⁴ and Pekarek⁵ have shown that as a result of exposure to heavy doses of X-rays the following nuclear changes may take place: striking chromosomal disruptions, clumped, broken or fragmented chromosomes, chromatin bridges between daughter nuclei, nuclear aberrations, etc. In comparison to the large amount of work done on nuclear alteration, very little has been done to show the variation of form and changes in internal structure. Johnson⁶ has observed in Sunflower and Tomato, the elongation of cells of the radicle tip, great vacuolation of cells, and absence of nuclei from many cells, increase of xylem at the expense of the pith, greater suberin development in the hypocotyl region, etc. As regards the external features, she has noticed the following changes: fasciation in stems, leaves and flowers, abnormality in the shape and size of the leaves, development of many lateral branches thus causing the plant to assume a bushy appearance, abnormalities in flower parts, delay in fruit development, changes in the internal structure of fruits such as, greater development of placenta and an almost total absence of seeds.

The present work was undertaken to study the general external and internal structure and behaviour of Jute plants (*Corchorus capsularis* (D. 154) and *C. olitorius* (Chinsura green) raised from irradiated seeds.

Two sets of experiments were carried on, one with dry seeds and the other with seeds soaked in water for a period of 6 hours. Seeds were treated with different doses of X-rays varying from 202.5 r to 6720 r and three different kinds of rays were given, namely, soft, medium and penetrating in different cases.

A detailed account of the results obtained will be given in a fuller paper to be published elsewhere, but a summary of the results is given as follows. (1) Plants raised from irradiated seeds appear to lose their vitality during early stages of their growth but later on their growth rate becomes enhanced. (2) Some of the irradiated plants show bifurcation of the tip at an early stage of growth and some assume a bushy appearance on account of vigorous lateral branching. (3) Some plants have two or three leaves in one internode in contrast to the normal alternate phyllotaxy of the plant. (4) In some cases delay in flowering caused by irradiation is marked. (5) Amount of woody tissues (xylem) increases due to irradiation. (6) Number of fibre cells appear to be increased in some cases, but the shape and size of the fibres are found to be unchanged. (7) Action of X-rays on moist seeds is more vigorous than that on dry ones.

The present study on the effects of X-rays on Jute seeds both dry and wet show some characteristic changes though none of them is dominant and no particular effect is common to every individual. In our experiments the rate of germination was enhanced in the seeds of *Corchorus capsularis* treated with soft heavy doses and light penetrating doses, but no such effect was observed in those of *C. olitorius*. According to Altman⁷ and others, and Koernicke, growth of seedlings became rapid when they were treated with weak doses of X-rays; but I have found that the rate of growth of all the irradiated seedlings was very slow to start with but after a time they revived and began to grow vigorously. Johnson observed changes in the shape and size of the leaves, but no such change has been observed in jute plants.

I take this opportunity of thanking Dr N. Das Gupta of the University College of Science, Calcutta for kindly making arrangements for exposing the seeds to the action of X-rays. The exposures were given in the laboratories of the University College of Science, the Science Association and in the Chittaranjan Sevasadan.

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ON THE SPONTANEOUS FISSION OF URANIUM

DURING the course of their investigation on the chemical properties of the so-called "transuranic" elements, Hahn and Strassmann¹ suggested that uranium nucleus breaks up into two parts of comparable sizes, a barium nucleus ($Z=56$) and a krypton nucleus ($Z=36$). The first theoretical interpretation of this observation was given by Meitner and Frisch². According to them the nucleus is like a liquid drop subject to the following forces: (i) a short range non-electrical force, only acting between the neighbouring particles; this is proportional to the total number A of the particles in the nucleus, (ii) a force analogous to surface tension, also proportional to some power of A and (iii) a repulsive coulomb force, proportional to the square of the number of protons Z , and is opposed to the surface force. Just as a drop of liquid, when set into vibration may split into two drops, so might a nucleus. This becomes more probable for heavy nuclei, because of an effective reduction of surface tension, resulting from increasing nuclear charge. The actual nucleus will be stable so long as the sum total of the electrostatic and surface tension energy has a minimum for the spherical shape. With increasing size and charge of the nucleus, this minimum would flatten and would be expected to disappear for some critical value of Z . Nuclei of greater Z would break apart. Bohr and Wheeler³ have considered the stability of a nucleus (A, Z), against small arbitrary deformations, and have shown that there is a limiting value of $\frac{Z^2}{A}$, beyond which a nucleus is no longer stable with respect to deformations of the simplest type. They show that this ratio is greater by 17 per cent than the value of $\frac{Z^2}{A}$ for U^{238} . Such nuclei are therefore near the limit of stability and it is possible to calculate the potential energy necessary to deform the nucleus sufficiently to produce division. The value

of this deformation potential has been calculated for Th, Pa and U nuclei and they are found to vary between 6.9 (Th^{233}) to 5.0 (U^{235}) MeV. When a neutron is captured by such a nucleus, a compound nucleus in an excited state is formed and if the energy of excitation is greater than the energy of fission E_f , fission will usually occur. The detailed comparison of the calculated probabilities of different U, Pa and Th nuclei lead to good agreement with experimental results. The results obtained so far are based purely upon classical mechanics consideration which is in agreement with the fact that the zero point energy of the nucleus is found to be about 1/15th of the energy of fission E_f . The statistical distribution in size of the fragments of fission depends on the complicated dynamics of the dividing nucleus. The theory is not developed enough to give this distribution, but does indicate that there is a wide range of possible fragments even for energies slightly greater than the critical energy.

Turning to the quantum mechanical aspect of the problem, we have to consider the possibility of the "tunnel effect" which will make it possible for the nucleus to divide even in its ground state by passage through a portion of configuration space where classically the kinetic energy is negative. Bohr and Wheeler have calculated the fission probability λ_f on certain simplifying assumptions which include that the expression $(V-E)$ in the Gamow function is of the order of E_f , i.e., 6 MeV. The mean life is found to be of the order of 10^{22} years. This calculated value is however only approximate.

The nature of the fission products induced by neutron bombardment has been investigated by either chemical or physical methods. In the former method small amounts of chemical elements are introduced as carriers and are then separated by the known analytical methods. The radioactivity of the products are studied with the help of G-M counters. This method gives only the chemical nature (dependent on nuclear charge Z) and not the mass A of the fission products; the latter must also be radio-active to be detectable. By this method, 80 different kinds of atoms belonging to 23 different elements have been detected.⁴ The physical method depends upon the simultaneous determination of the ionisation produced by the two fission products. From the conservation of momentum between the fission products it follows that the kinetic energy of each is inversely proportional to its mass. This method gives the mass and not the nuclear charge of the fission products and can be used to detect both stable and unstable fission products. Jentschke and Prankl⁵ have identified the following nuclear fragments produced by predominantly thermal neutrons:

Heavy—Pr, Nd, element 61, Sm, Eu, Gd in the order of decreasing abundance.

Light—Ru, Rh, Pd etc.

Spontaneous Fission Products.—Libby⁶ searched for radioactive iodine in a sample of pure uranium nitrate solution kept undisturbed for five years; he came to the conclusion that the spontaneous fission, if any, must have a half-life period of over 10^{14} years. Experimental evidence for the spontaneous fission of uranium nucleus was first reported by Petrzhak and Flerov⁷. They used as an ionisation chamber, a 15 plate condenser coated with thin layers of U_3O_8 and connected it to a high gain amplifier of extremely high resolution. They found evidence of such fission occurring at a frequency of about six per hour. By means of subsidiary experiments they concluded that the pulses could only be due to spontaneous fission, as their number was too large to be accounted for as being due to atmospheric neutrons. The half life of the U nucleus was calculated to be of the order of 10^{16} years.

One of us by using an essentially similar arrangement, the details of which will be published in the *Transactions of the Bose Research Institute*, has substantially verified the above findings viz. that spontaneous fission of U nucleus occur, which are not due to atmospheric neutrons and the average half life is $\sim 3 \times 10^{16}$ years. The ionisation pulses are counted either by a suitably biased thyatron relay connected with a telephone counter or are recorded photographically on a slowly moving cine-film by a loop oscillograph. An arrangement is being set up for the direct measurement of the energy of the fission products.

If the above conclusion is correct, then in very old minerals rich in uranium, chemical analysis should indicate the presence of stable fission products. Recently, a small quantity of a highly concentrated uranium mineral containing material of orange colour (density 5.64, hardness 3) from some unknown locality in Rajputana came to our hands. It was found to be three times as radioactive as standard U_3O_8 , and appears to be a variety of Gummite. The mineral was subjected to usual group separation and the groups to careful spectrographic analysis. The following table gives a partial analysis of the mineral:

UO_3 75%	H_2O 7.25%	PbO 8.26%	SiO_2 &c. 2.23%	ThO_2 0.66%
Rare Earths 0.38%	CaO 1.67%	Na_2O 0.70%	K_2O 1.08%	Gases 0.20%
	Fe_2O_3 0.20%		Al_2O_3 0.20%	

The lead ratio is 0.1225. The corrected age appears to be about 847 million years. The radium content, calculated from uranium content is about 206 mgms. per ton.

Spectrographic analysis revealed the presence of Ge, Sb, Bi, Sr, Ag, Yt, Yb, Gd, La. Absorption spectra measurements (using the micro-technique of Hopkins), showed the presence of Nd and Pr. Ce was detected by spot-test. It is believed that some of the above elements are fission products.

A comparative chart of elements, formed by fission of uranium nucleus and identified by different methods is given here :

A. Induced fission :

(1) Chemical examination : Radioactive isotopes of

^{34}Se , ^{35}Br , ^{36}Kr , ^{37}Rb , ^{38}Sr , ^{39}Yt , ^{40}Zr , ^{42}Mo , ^{47}Ag ,
 ^{50}Sn , ^{51}Sb , ^{52}Te , ^{57}I , ^{54}Xe , ^{55}Cs , ^{56}Ba , ^{57}La .

(2) Physical measurements :

Lighter fragments with masses from 74 to 109, including

^{34}Se , ^{44}Rn , ^{45}Bb , ^{46}Pd

Heavier fragments with masses from 107 to 162, including ^{59}Pr , ^{60}Nd , element 61, ^{63}Eu , ^{64}Gd .

B. Spontaneous fission :

(3) Chemical examination :

^{32}Ge , ^{38}Sr , ^{39}Yt , ^{50}Sn , ^{51}Sb , ^{57}La , ^{58}Ce ,
 ^{59}Pr , ^{60}Nd , ^{64}Gd , ^{70}Yb .

It is well-known that radioactive minerals are seldom free from rare earths. It is also known that older uranium minerals are richer in rare earths than the young ones, though there is no apparent proportionality between the rare earth and lead content. It is suggested that the growth of some of them is due to the accumulation of fission fragments. The above statement can hardly however, be made very rigorously. For, very complete analyses of uraninites have been made by Hillebrand, Marsh, Hauser and others. Their results show that the abundance of the individual rare earth elements varies widely in minerals of different localities and sometimes occur in large amounts indicating that they form the original constituents of the mineral.

Our expectation that stable fission products should occur in old uraninite minerals can be tested quantitatively in the following way. The amounts of some of the so-called fission products in several such minerals are to be determined chemically. If it is found that in some of the minerals, two or more of the so-called fission elements occur in approximately equivalent weights, then the occurrence can be taken as an indication that they are produced by fission of the uranium nucleus of the same mean life. For such determinations large quantities of uraninite minerals are required ; these are at present not available.

The authors are deeply indebted to Dr D. M. Bose, Director, Bose Institute, for his kind interest, helpful suggestions and discussions.

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PHOSPHORESCENCE AFTER GLOW OF SOME ALKALI HALIDES

CRYSTALS of sodium chloride, potassium chloride and potassium bromide are fluorescent under X-ray irradiation. If the period of exposure be sufficiently long these crystals are also discoloured. The discoloured crystals possess extra absorption bands (F-centres). The same centres can also be produced by keeping the crystals in the vapour of the alkali metals at a high temperature. The mechanism suggested for this colouration is as follows: The ionic crystals contain usually a number of vacant lattice points (positive and negative ionic positions) and a number of interstitial atoms frozen in the lattice (in the way of Schottky and Frenkel defects). The photo-electrons released by X-rays execute a sort of Brownian motion before they get trapped in one of the vacant lattice points, formerly occupied by a negative ion. These trapped electrons can be raised to the conduction band by absorption of a suitable radiation and give rise to a new absorption band. To account for the emission we can assume that electrons are primarily raised to the conduction band and thus carried to the neighbourhood of the interstitial ions where additional level systems are present ; next transition of electrons to lower levels may occur with the possibility of emission.

The electrons raised to the conduction band in their passage to the radiating centre may get trapped in trapping centres. In ionic crystals the following trapping centres are theoretically possible :—

1. Vacant lattice points (generally negative ionic positions), 2. Tamm's surface levels, 3. Landau's trapping centres. The centres of the type (1) give rise to the F and F' centres ; for the existence of (2) and (3) decisive experimental evidence is not yet available.

It has been observed that the after glow period for crystals of these compounds can be increased to

a great extent by pressure treatment of the samples. For a single crystal of sodium chloride or potassium chloride prepared in the usual way the after glow dies out within half a minute whereas pressed blocks of the same substance could be prepared which retain its after glow for more than 30 minutes (examined visually in a dark room). The colouration produced in these pressed samples also proceeds much more quickly than in single crystals and the intensity of colouration produced is also greater. Besides these, for potassium chloride, it has been further observed that the stability of colouration is dependent on the time of exposure, for example, in the case of 15 minutes' X-ray exposure the colouration produced vanishes within two hours while that produced by exposure of one hour or more appears unchanged even after the lapse of days together.

Now that the samples were prepared by sudden application of pressure we can reasonably expect that the mode of preparation will cause an increased number of interstitial atoms together with a similar increase in the number of vacant positions since sudden application of pressure causes local heating followed by immediate cooling. As the Schottky defect increases the volume of the crystal, this method is not expected to increase the number of Schottky defect. This will account for quicker colouring of the crystals as also the increased intensity of colouration. The duration of after glow is mainly due to the existence of metastable trapping centres whence the electrons can be again sent to the conduction level (and thence to the radiation centre) by the thermal energy of the lattice. The increase in the number of F centres can account for an equal increase in the number of such metastable state (F' centres), but whether these are sufficient for explaining the 60—100 times increase in the duration of after glow is a matter for further investigation and seems unconvincing at present. Another possibility is the increase in the Tamm's surface levels. The method of preparation obviously increases the lattice defects viz., surface cracks etc. which will cause fresh trapping centres. This alone or together with the former possibility may account for the present observation. The existence of Tamm's levels was also suggested from the experiments of Antonow—Romanowsky¹ who found that for zinc sulphide-phosphorus (under ultraviolet radiation) 'α' the decay constant, decreases with a decrease in the particle size.

The after glow is found to die out asymptotically and the duration period is temperature dependent. The decay curve and the exact nature of temperature dependence of 'α' is receiving proper attention ; the results will be published in due course.

My thanks are due to Prof. B. B. Ray, D.Sc.

for the helpful discussions and for granting facilities for work in his laboratory.

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¹ Antonow-Romanowsky, *Phys. Zeits. d. Sowjetunion*, 7, 366, 1935.

E.M.F. DUE TO DIFFERENCE IN TEMPERATURE BETWEEN TWO ELECTRODES DIPPED INTO IONIC SOLUTIONS

NERNST gave a formula for the potential which was produced on dipping a piece of metal into an ionic solution in terms of the solution tension, osmotic pressure and temperature of the solutions. So far as we are aware there is no data for the E.M.F. which is produced when two electrodes of the same metal are dipped into a homogeneous ionic solution and one electrode is maintained at a higher temperature with respect to the other.

Two copper electrodes through which vapour from boiling liquids can be passed were electroplated with copper in the same bath and introduced from either side to a vertical glass tube containing the solution. To avoid convection difficulty the electrode introduced at the top of the glass tube was maintained at higher temperature and the other at the bottom at room temperature. The top electrode was maintained at different temperatures by passing vapour of boiling water (100°C), benzene (80.2°C), acetone (56.5°C), the other electrode being throughout maintained at 33°C,—the room temperature. The E. M. F. produced at various temperature differences were measured by means of a calibrated potentiometer.

TEMPERATURE DIFFERENCE BETWEEN THE TWO ELECTRODES
AND E. M. F. PRODUCED.

Temperature difference	67°C	47.2°C	23.5°C
E. M. F. produced for N/2 NaCl Soln. in millivolt	60.1	31.3	13.0
E. M. F. produced for N/8 Cu ₂ SO ₄ Soln. in millivolt	73.0	42.7	17.6

Experimental improvements have lately been made with electrical heating arrangement and other various experimental difficulties have also been met with. The E.M.F. produced have been observed with NaCl, CuSO₄, KCl, KBr, CuCl₂ solution and the E.M.F. is found to increase gradually if the solution is gradually diluted, the temperature differences between the two electrodes being maintained constant. The

electrodes at the lower temperature is found to be at a higher potential with respect to the hot electrode in the case of NaCl solution and reverse happens in the case of CuSO₄ solution. It has however been observed that if the two electrodes are maintained at the same temperature and the solution near the top electrode is locally diluted, the E.M.F. produced is just in the opposite direction of what is obtained by heating the upper electrode.

My thanks are due to Prof. B. B. Ray, D.Sc., Calcutta University for granting me facilities to work in his laboratory.

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THE EFFECT OF LIGHT ON THE SYNTHESIS OF ASCORBIC ACID BY GERMINATING SEEDS

It has been observed that dry seeds of soya-bean contain practically no measurable quantity of ascorbic acid, as determined by titration with the indophenol reagent. But during germination in absence of light they begin to accumulate ascorbic acid within two or three days from the start. This accumulation reaches a maximum on the 5th or 6th day of germination and thereafter begins to decline, keeping to a lower but approximately constant value. It has been found that this biosynthesis can be accelerated when the seeds after germination for one day in the dark are exposed to direct sun-light for a definite period each day. Some mean values of ascorbic acid content during germination of soya-bean are given below:—

ASCORBIC ACID CONTENT IN MG. PER CENT ON WET BASIS OF THE GERMINATING SOYA-BEAN

Germination in	Ascorbic acid on the day of germination									
	1st	2nd	3rd	4th	5th	6	7th	8th	9th	10th
Darkness	nil	1.5	10.4	14.8	17.3	17.8	14.0	12.0	7.0	7.0
Sun-light	nil	5.2	17.9	27.7	34.7	30.6	30.0	30.4	30.2	30.0

This work was carried out during December, 1943.

Our thanks are due to Prof. B. C. Guha for his kind interest in the work.

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PHOTOBIO SYNTHESIS OF ASCORBIC ACID (?) BY GERMINATING SEEDS

The formation of ascorbic acid, as determined by indophenol titration, during germination of seeds and the stimulating effect of light on this process have been reported by us¹ and also by others. It has been assumed by all these investigators that the reducing substance formed in the presence of light, as determined by the usual method of titration with 2:6-dichlorophenol indophenol, is identical with ascorbic acid. In order to test this assumption experiments have been carried out with soya-bean and *Kancha Mung* (*Phaseolus Mungo*) germinating in the dark under properly controlled conditions of temperature, moisture etc. and exposing them to sun-light and ultra-violet rays of known wave-lengths for a definite period and then testing them both titrimetrically and biologically. It has been observed that an indophenol reducing substance accumulates during germination in the dark and increases to a considerably higher value when the seedlings are exposed for a period to direct sunlight or ultra violet rays of wave-lengths between 3000-4000 Å. Some of the mean values are given below:—

INDOPHENOL REDUCING EQUIVALENT IN TERMS OF ASCORBIC ACID IN MG. % (DRY BASIS) OF GERMINATING SEEDS UNDER VARIOUS CONDITIONS

Seeds	Kept at 29-30° C. for 6 hrs. in	Exposed for 6 hrs. at 29-30° C to	
	Dark	Sunlight	Ultra-violet bet. 3000-4000 Å
Soyabean	23	40	39
Kancha Mung	55	80.5	80

Preliminary results from bio-assay with guinea-pigs seem to indicate, however, that the substance produced in the germinating seeds under stimulation of sun light or ultra-violet light, is not identical with ascorbic acid, though it gives indophenol-reducing action. The reducing substance formed during germination in the dark is, however, mostly, if not wholly, ascorbic acid as previously shown by Ghosh and Guha.²

Experiments for further confirmation are in progress.

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