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Editorial

We have the proud privilege to present the First issue of the Engineering and Technology section of the Annamalai University Journal. Our grateful thanks are due to Sri T. M. Narayanaswami Pillai, our revered Vice-Chancellor, who appreciating the special need for a Technical Journal in the development of Technological Education, has encouraged this publication.

It is needless to stress the importance of research in the field of Engineering and Technology. Research is very vital for the Industrial progress of a nation particularly for a country like India which is in the threshold of the 'take off' stage in its economic development. Industry reaps what research sows.

Our desire is to provide a Forum for the research workers and men in Industries and Projects to publish their findings and experience, and initiate discussion on these topics. 'Thinking mind is a living laboratory'. A technical journal of this nature cultivates the habit of thinking, which leads to inventive Engineering. Technical journals are few in India and fewer still are those published by Universities. So we believe that this publication will meet in some measure this long felt requirement.

We are glad that the response to our request for articles has been very encouraging especially from Engineers and Industrialists in the profession and we trust that the close liaison, thus established between industry and the University will pave the way for closer co-ordination and healthy development.

We offer our sincere thanks to Lt. Col. S. Paul, Dean, Faculty of Engineering and Technology for his initiative, sustained interest and continued help in bringing out this journal. Our profound thanks are also due to all the contributors. It is our earnest hope that contribution of research papers, reviews of technological subjects, articles of recent development in Projects and Industry and modern trends in Technological Education will be forthcoming in a large measure for the successive issues of this journal.

RM. SETHUNARAYANAN
SM. LAKSHMANAN
Editors.

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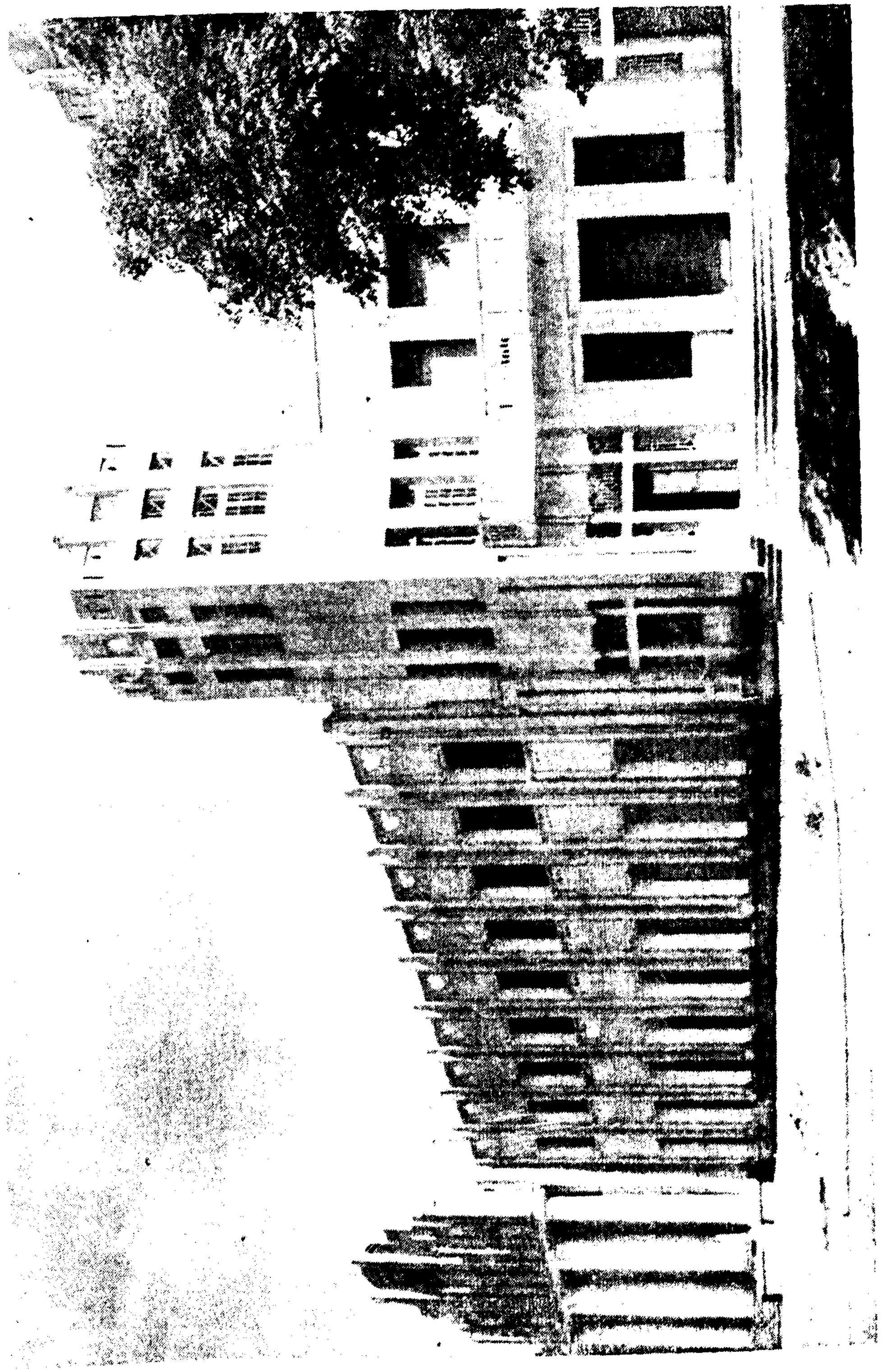


ENGINEERING AND TECHNOLOGY BUILDINGS

POWER DEVELOPMENT IN MADRAS STATE

V. P. APPADURAI, B.E., M.I.E., (IND.)
Chief Engineer for Electricity – Madras State

Introduction :

THE Madras State has no oil deposits. Until recently it was believed that it had no coal deposits either. Only a few years back lignite or brown coal was located near Neyveli in the South Arcot District about 120 miles south of Madras City. The power development during the earlier years was therefore confined to development of hydro potential of the State.

Power generation in the Madras State until about 1908 was confined mainly to a few tiny plants in tea estates run on water power and to the small hydro installation at Kateri in the Nilgiris.

The first public electric supply in the State was commenced in Madras City in 1909 by the Madras Electric Supply Corporation under licence for the establishment of a thermal station.

Real progress dates from 1925 when the Government of Madras initiated the policy of active development of the hydro electric power resources by the State.

In furtherance of this policy, the first hydro electric scheme viz., the Pykara Scheme was taken up in 1929 and the station commissioned in 1932. The Mettur station came into operation in 1937 and the Papanasam power house in April 1944. The first thermal station to be erected by the Department was commissioned early in 1951 at Madurai.

During the first five year plan a new power house at Moyar was commissioned and extensions to the existing stations at Pykara, Papanasam, Madurai and Madras were added. In 1958 the Madras III stage extensions comprising a 30,000 K. W. set and the Periyar power station were commissioned.

The Grid comprises five hydro electric power houses :

Pykara	...	70,000 K. W.	installed capacity
Moyar	...	36,000 K. W.	,,
Mettur	...	40,000 K. W.	,,
Papanasam	...	28,000 K. W.	,,
Periyar	...	105,000 K. W.	,,
and two thermal power houses			
Madras	...	98,000 K. W.	,,
Madurai	...	14,000 K. W.	,,
		391,500 K. W.	,,

11,791 miles of high tension transmission lines of voltages varying from 11,000 to 1,10,000,

16,334 miles of low tension distribution lines and

61 E. H. T. and 71 H. T. substations and 8,833 distribution stations.

The Grid is serving electricity to over 6 lakhs of consumers, about 80% of them served directly by the Board and the rest served through five Municipal Licensees and 8 private Company Licensees.

The peak demand met totalled 3,23,000 K. W. The entire power output of 1,500 million units in the State is by the Electricity Board of which 70 per cent is from water power and the balance from coal.

The total capital investment on plant in operation is about Rs. 95 crores. The annual revenue during the year 1958–59 was Rs. 12·14 crores.

Progress :

Generation : The Madras Plant Extensions which envisaged the erection of a 30,000 K. W. set with two numbers 150,000 lbs./hr. boilers were commissioned in April 1958.

All the works of the Periyar hydro electric scheme were completed bringing in an additional installed capacity of 105,000 K. W. in three units. The first unit was commissioned in October 1958, the second in February this year and the third in May 1959.

The addition of 100,000 K. W. for the year 1958–59 is an all time record for a single year registering an increase of 40%. For the Kundah hydro electric scheme, the biggest so far undertaken in the State, civil works are in full swing in all the dam sites, tunnels and power station sites. The erection of first unit in Plant No. 1 is under way and is expected to go into operation by October this year. The initial phase comprising the first two stages will be completed within the plan period and will add 180,000 K. W. of installed generating capacity to the Grid.

Second plan :

The power schemes of the Madras State included in the Second Five Year Plan envisage more than doubling the installed capacity, length of lines and the number of towns and villages electrified. The table gives the targets for the Second Plan under generation, transmission and distribution for the Madras State ; for purposes of comparison the All India targets are also given.

TABLE I

Particulars	All India target		Percentage increase	Madras target		Percentage increase
	1955–56	1960–61		1955–56	1960–61	
Generation :—						
Installed generating capacity in 1000 K.W. ...	3400	6800	100	256	571	123
Units generated in millions. ...	11000	22000	100	1055	2100	100
Transmission :—						
H. T. lines – 11 Kv. and above. ...	35000	70000	100	7343	15500	112
Distribution :—						
No. of villages and towns electrified. ...	7400	15000	145	3543	10000	182
Per capita consumption in units. ...	25	50	100	25	60	140

Transmission :

Including the transmission lines proposed under the Kundah and Periyar hydro electric schemes; an additional 8,200 miles of E. H. T. and H. T. lines and 12,000 miles of L. T. lines will be erected during the Plan period. Of these, 4,800 miles of E. H. T. and H. T. lines and 8,200 miles of L. T. lines have already been erected during the first three years of the Plan period. A major stride in respect of transmission during the Second Plan period will be the erection of the first 230 kv. line in the State from Kundah to Madras which will convey power generated at Kundah to Madras a distance of about 300 miles.

During the period the following major transmission lines were erected :—

1. Periyar-Theni-Madurai 110 kv. line.
2. Theni-Sembatti-Trichy 110 kv. line.
3. Madras-Villupuram 110 kv. line.
4. Neyveli-Villupuram 110 kv. line.
5. Salem-Attur 110 kv. line.

6. Kayathar-Arumughaneri 110 kv. line.
7. Sembatti-Karur 66 kv. line.

A number of other lines are under construction.

Rural electrification :

Madras continues to maintain its lead in the matter of rural electrification with over 8,000 towns, villages and hamlets electrified by March 1959. During the second plan period, it is proposed to extend electricity to 5,000 additional villages. Of these over 4,000 villages have already been electrified during the first three years. About 32,440 pumpsets were working on electricity at the end of the first plan period. Today over 80,000 pumpsets are deriving the benefits of electricity.

Future schemes :

The demand for power in the State is widespread and insistent. Several new industries are being planned all over the State and power for them is to be provided from the Grid.

To meet this ever-increasing demand, new power resources have to be tapped.

The investigations of the Mettur Tunnel Scheme have been completed. The Projects Advisory Committee of the Government of India have inspected the scheme and the scheme is now to be forwarded to the Planning Commission for approval and inclusion in the Second Plan, if possible. It is hoped that a beginning will be made and the preliminary works will be commenced even during the second plan period. The scheme is to utilise the irrigation discharge at Mettur for power development. The station will have initially an installed capacity of 100,000 K. W. in two units and 200,000 K. W. in its ultimate stage. The power will be seasonal and can be had for a period of seven months.

Field investigations of the Kundah ultimate phase are under progress. It is proposed to develop the potential of the Kundah river in two more power stations in addition to the two stations now under construction envisaging an installed capacity of 230,000 K. W.

Proposals are also afoot for adding a fourth unit at Periyar power station and a pumping scheme which would increase the firm power output of Periyar to 70,000 K. W. even during the dry season.

The recent conclusion of an agreement between the Kerala and Madras States regarding the Parambikulam Scheme has opened up further possibilities in the power development of the Madras State. It is estimated that about

1,00,000 K. W. of power will be available from this scheme. Preliminary investigations for the power side have been commenced.

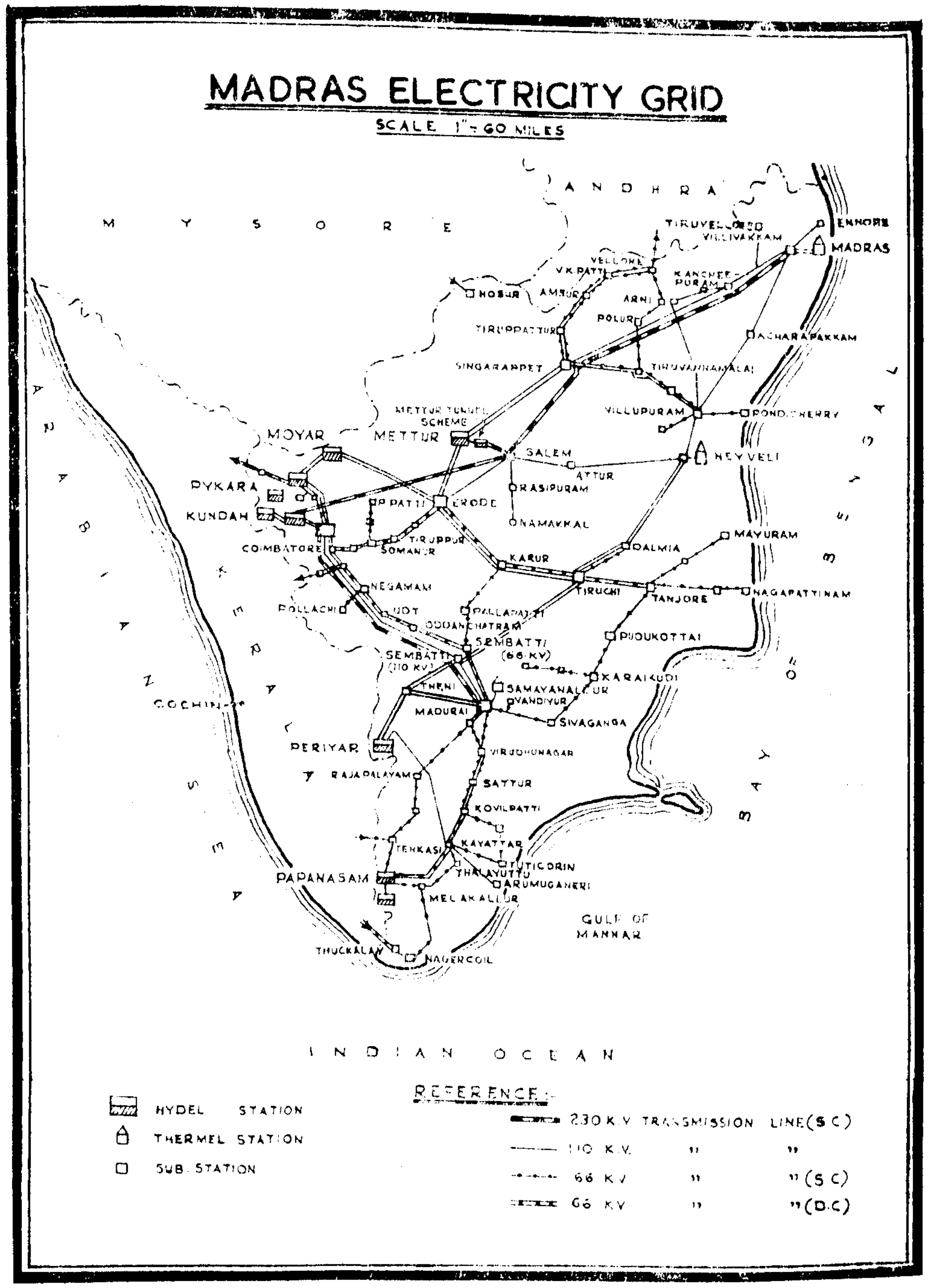
It is programmed to add an installed capacity of 665,000 K. W. in the Third Plan Period with the above scheme and with a thermal station of 200,000 K. W.

It is expected that about 200,000 K. W. of power will be made available to the Madras Grid from the proposed Neyveli Thermal Station by December 1961.

Plan of Atomic Energy Commission :

The Atomic Energy Commission has planned to establish three nuclear power plants in India before the end of the Third Five Year Plan. The first plant is expected to be set up near Ahmedabad in Bombay State at a cost of Rs. 45 crores and it is expected to go into operation by the end of 1965. This plant will produce 250,000 K. W. The Atomic Energy Commission has also recommended to the Planning Commission the setting up of power plants in Madras and Rajasthan in the third plan itself. Since Madras has enough resources of nuclear materials, we can legitimately expect the setting up of a nuclear power plant in our State. Further, the enormous demand for electricity in this State also warrants the establishment of an atomic power station.

With these schemes, we hope to march ahead in the field of social economic development of our State by the spread of electricity, especially to the rural areas and raise the standard of living of the common man and bring brightness and happiness to every home.



STABILISED SOIL ROAD WORKS IN MADRAS STATE

S. C. NAYAK, M.I.E. (IND.)
Chief Engineer (Highways)

Introduction :

THE problem of economically constructing a hard and compact surface for traffic in black cotton soils and sandy tracts, using the locally available materials was baffling the road engineers for the last few decades. Instinctively they resorted to some rule of thumb methods of stabilisation in those early days. If the terrain of the country through which the rural road or cart track traversed happened to be a predominantly sandy area, then adhesive clay or clayey gravel was carted from neighbouring fields and mixed intimately with the natural sandy soil to make a hard surface. On the other hand, if the road ran through black cotton or clayey fields, materials like sand or gritty gravel were carted from available spots or quarries nearby and were admixed with the black cotton soil to give an unyielding surface. But, the science behind it was little known at that time. It was only very recently, say about 30 years ago, that the science of soil mechanics came to be developed giving a basis for scientific stabilisation of roads using the local soils.

2. Definition and Types :

The term "soil stabilisation" means the improvement of the bearing power of the soil by means of compaction with or without added material so as to obtain a balanced medium with sufficient cohesion and internal friction. Soil stabilisation affords the means of improving and simplifying the whole technique of road making in a scientific manner. With full appreciation and utilisation of the techniques of soil stabilisation the great bulk of road work could be made even better and more enduring at low cost.

There are three well known types of soil stabilisation work and they are :-

(*a*) Mechanical stabilisation effected by the interlocking of properly blended local materials of suitable grades.

(*b*) Stabilisation with the addition of cement, bitumen, lime and other chemicals.

(c) Stabilisation by heat treatment.

Of these methods, types (a) and (b) are most useful for the purposes of highway engineering. To appreciate the technique of soil stabilisation, knowledge of soil science is essential and the basic principles of soil mechanics are briefly indicated below.

3. **Soil Mechanics**:

The properties of soil can be broadly divided into:

1. Index properties,
2. Hydraulic properties, and
3. Structural properties.

Index properties reflect the general character of a soil and help to discriminate between the different kinds of soils. The permeability, capillary action and drainage characteristics are indicated by the Hydraulic properties, whereas structural properties include compressibility, shear strength, stress strain relationship, bearing power, etc.

The size of soil particles range from even less than ·001 mm to several mm's. The process of separating soil aggregates into fractions, each consisting of

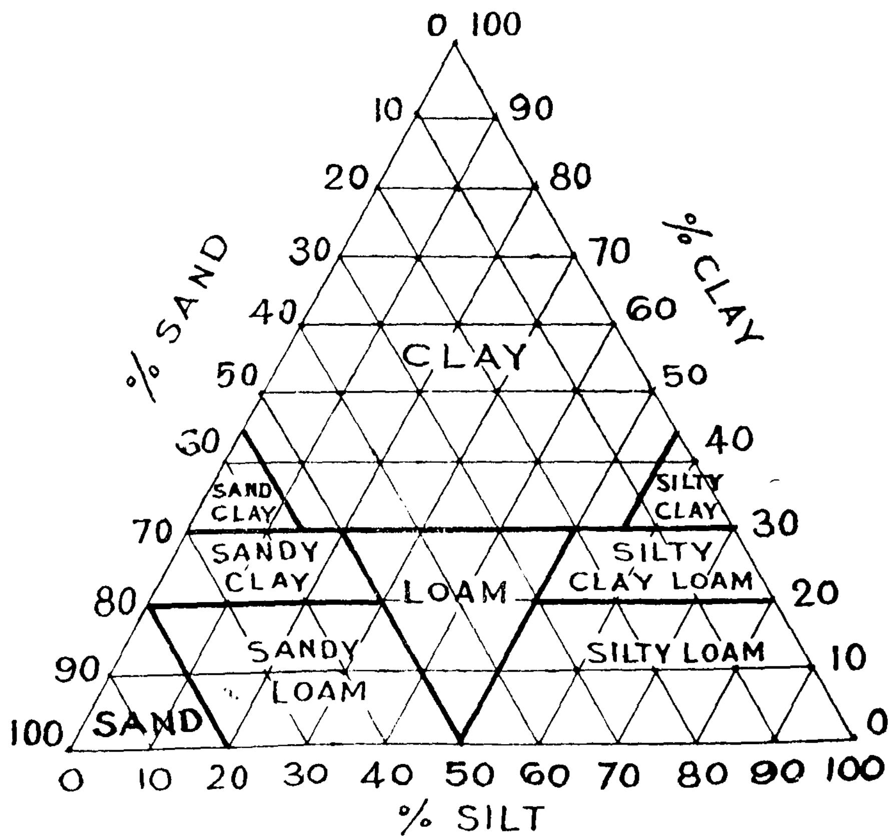


FIG. 1.

grains within a different size range, is known as "mechanical analysis". Clay is a mixture of grain sizes ranging from 1 mm. to 0·006 mm. in diameter and a very small percentage of colloidal particles. Fig. 1 is a triangular chart showing

the proportion of sand, silt, and clay for different types such as sandy loam, loam, silty clay etc. This is termed as *Textural Classification*.

The hydraulic properties of soils are revealed by porosity, moisture content and bulk density. If the water content of a clay slurry is gradually reduced, the clay passes from a liquid state through a plastic state to the final solid state. These are indicated in the graph at Fig. 2. The various limits of moisture

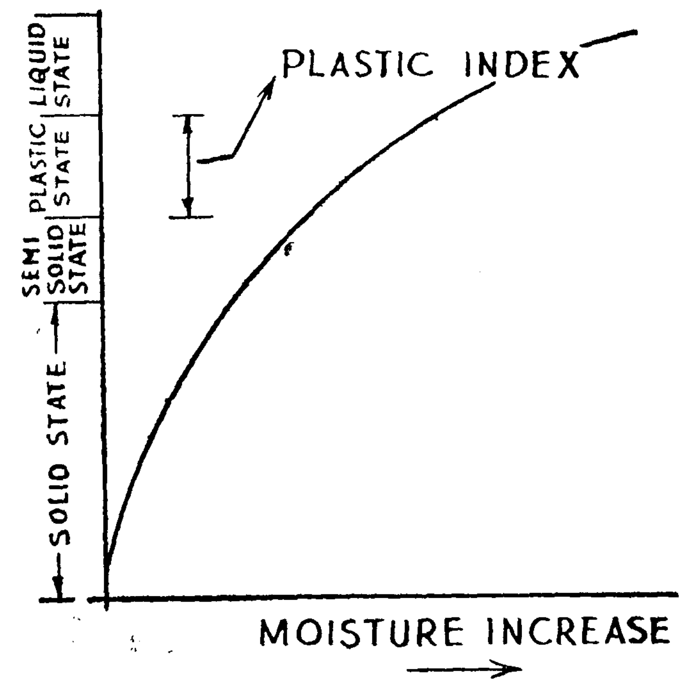


FIG. 2.

content at which the change of state occurs are the liquid limit, plastic limits and the shrinkage limit. The "plasticity index" is defined as the numerical difference between the liquid limit and the plastic limit. This is a measure of the cohesive property of the soil. This plays a very important role in the stabilisation of soils.

Soil compaction is the process by which the soil particles are forced to get packed together. This is brought about, through the help of moisture which plays an important part during the process. The degree of compaction is generally expressed in terms of density attained as a result of the compaction and expressed as the weight of dry soil per cft. Hence, to design the mixes for soil stabilisation, it is necessary that the relationship between moisture content and the density of the soil is known. When a soil is compacted with different amounts of moisture, using the same Compactive effort, the density increases with the moisture upto a certain limit and thereafter decreases. Fig. 3 shows a typical moisture density curve. The percentages of moisture in a soil, at which the

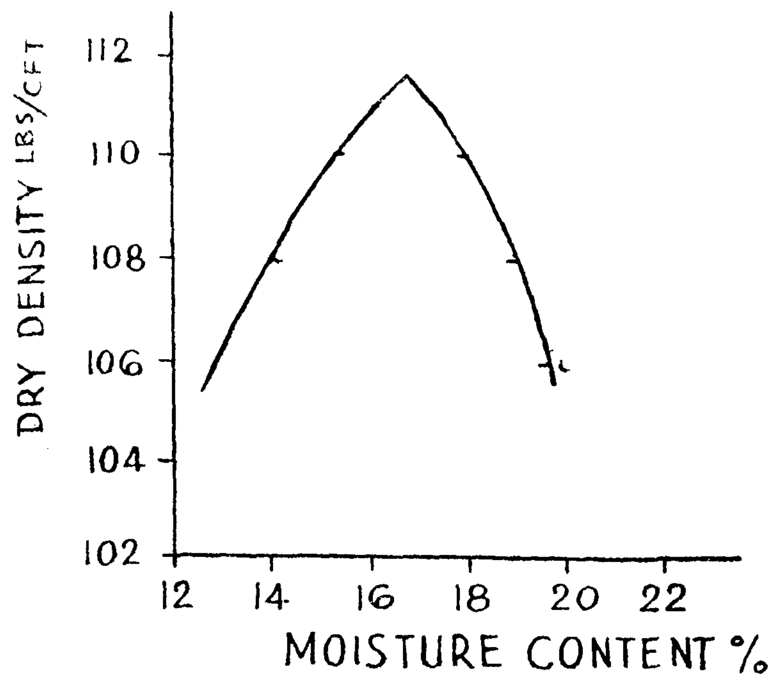


FIG. 3

greatest density is obtained under a particular compactive effort, is known as the *Optimum Moisture Content*.

4. Design of mix for Soil Stabilisation :

The soil mixes have to be designed with regard to gradation, consistency, maximum density and maximum bearing power. To arrive at the economical mixture, the locally available materials should be used to the best advantage and the combination should be so processed that maximum density and maximum bearing power are obtained. The usual Plasticity Index of the mix should not be greater than 6. In places where the subgrade soil is well drained and where the intensity of rainfall is low, the maximum value of plasticity index of the soil mixture permissible can be raised. In certain arid regions in our country, materials with plasticity indices going even upto 10 have been used for the base

course. The gradation of the mix desired is also predetermined. The mix should not contain more than 15% and less than 7% passing No. 200 sieve in the case of gravel-sand mixes, and not more than 25% and not less than 8% passing No. 200 sieve in the case of sandy-clay mixes.

5. Thickness of stabilized soil layers :

In most cases, the thickness of stabilized soil courses in a road is designed primarily on the basis of past experience gathered from behaviour of existing roads. The thickness of the foundation layers adopted for secondary roads with light traffic varies from 6" to 12". Tests conducted at the Calcutta test tracks reveal that a seven inch thick sand-clay layer can successfully replace two layers of flat brick soiling. Scientific methods of designing the thickness of pavements using California Bearing Ratio test values for bearing power, however is possible and is slowly coming into vogue. Space does not permit here to explain the above method of designing the thickness. In areas where the subgrade soil consists of clay, a blanket layer of sand of about 4" to 6" thickness is provided to facilitate drainage and to reduce the load on the subgrade. This layer also arrests the creep of the subgrade clay into the stabilized base course.

6. The Madras Practice :

Details of design, and construction methods of some of the soil stabilised road works executed in Madras State are discussed below :

Till very recently there has not been any systematic Research in Madras. Yet, the road system-best in Madras State as also other parts of India and even the whole of the East-was built up and maintained during the past two decades based on trial sections. Full scale field experimental stretches were laid as early as 1935 to study the performance of various types of surfacings and methods of construction. One travelling along the roads round about Madras will see the tell-tale boards of those experimental stretches kept under observation. But the various experiments undertaken here and there in various parts of Madras State related more about the surfacings than to the subgrade or the soil below. In the year 1948, a beginning was made by the establishment of a research section in the Highways department by opening a soil research Laboratory in charge of an Assistant Engineer. With this as nucleus, a full scale research station has been instituted at Guindy with buildings and machinery worth about 20 lakhs of rupees.

The following are the major road works of soil stabilisation in Madras State which were taken up for full scale experimentations :—

(1) Ramnad Mandapam Road Mile 0/0 — 21/4
(2) Chidambaram Bhuvanagiri Road 1/0 — 3/0

(3) Tuticorin Tiruchendur Road M. 1/6 — 13/4
(4) Kovalam Mahabalipuram Road 0/0 — 12/0
(5) Thiruvottiyur Ponneri Panjetti Road M. 3/5 — 8/5
(6) Rettambedu Village Road 1/0 — 3/0.
(7) Tiruvanmiyur Muthukadu Road 0/5 — 12/0.

Table No. 1 shows the nature and type of soil stabilised road works mentioned above. The method of actual execution is slightly different from the three types of soil stabilization mentioned in para 3 above even though the basic principles of compaction, density and moisture control etc. are essentially the same as is common for all the three types.

Apart from the above works, soil stabilized base courses have been proposed in a few more works to be undertaken in the near future, in Madras State. One of such works is "Upgrading Veeranam Tank Bund road" (about 9 miles) in length in South Arcot District. The existing soil of this road is predominantly of clayey nature and hence the conventional method of road construction may not be economical in such regions. Hence it has been suggested to provide a sand blanket course, followed by a stabilized soil base, making use of gravel, lime and sand combination, and a wearing course of granite metalling on top with an intermediate layer of laterite metal. The Sub base has been roposed tentatively to consist of two layers of 9" and 3" respectively, the former with gravel + 3% lime and the latter with gravel + 25% coarse fraction + 5% sand + 1% lime. The design details are being worked out and the work will be commenced shortly. Being very near to Annamalainagar, it may be of some interest to the Engineering students of the University to pay a visit to this work when it is in progress.

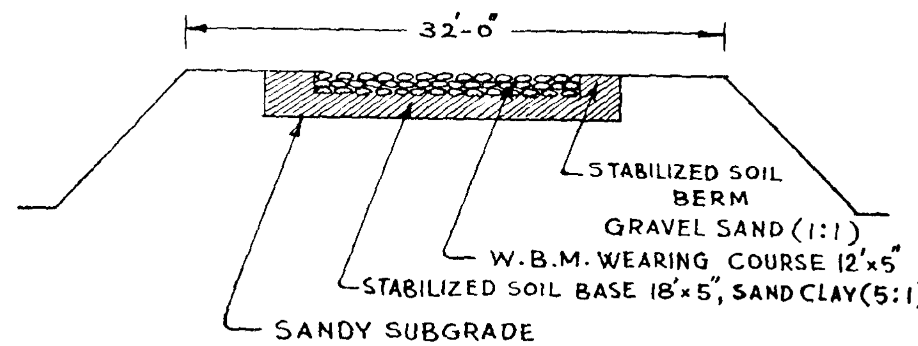
Soil stabilization works can be executed either with the utilisation of manual labour or adopting mechanized methods of road construction. Still, the use of mechanical equipments is preferable in soil stabilization works, because a thorough field control is possible with their use. The construction of stabilized soil bases and subgrades are briefly described below in accordance with the sequence of operations.

(a) **Mechanical Stabilization :**

The materials required such as sand, clay, gravel etc., are to be collected first to the required quantities making due allowance for bulking etc. and stacked in the form of windrows. The clods if any in the stacks are to be thoroughly broken and pulverized in order to facilitate thorough mixing of the soils. Before laying the base course, the subgrade should be strengthened if necessary by

loosening the same to 3 or 4" depth and compacting at optimum moisture content with the addition of about 10 to 15% of sand or clay as the case may be. The strengthened subgrade should be brought to proper camber and grade. In regions of highly expansive clays like black cotton soils, it is necessary to interpose a blanket layer of 4" to 6" of non cohesive materials like sand or mooram over the prepared subgrade before laying the base course.

The materials in the windrows are then to be dry mixed uniformly with mammootties and restacked roughly in the form of windrows and bays formed at suitable intervals for adding water. A measured quantity of water about 1 and 2% more than the Optimum moisture content to allow for evaporation and construction losses is to be added and allowed to soak through overnight. The next day, the wet soil is to be thoroughly mixed and spread in a uniform layer of not more than 6" to the required camber over the subgrade which is previously sectioned and prepared to receive the soil mixture. Next, the compaction is to be done at Optimum Moisture Content with the use of sheep foot rollers, pneumatic tyred rollers and smooth wheeled power rollers, preferably of the tandom type. At intervals during compaction, the bearing value, dry density, and moisture content are to be frequently checked with the use of Cone Penetrometer and sand bottle apparatus etc., at least at four places in a furlong. The values obtained should satisfy the design requirements. The surface is next to be allowed to dry for 2 or 3 days during which period iron tyred traffic should not be allowed. The base courses for the road in respect of the stabilization



TYPICAL CROSS SECTION OF
TUTICORIN – TIRUCHENDUR ROAD

FIG. No. 4

works in Tiruvottiyur Ponneri Punjetti Road, Chidambaram Sirkali Road, Tuticorin Tiruchendur Road and Kovalam Mahabalipuram road were constructed following the above process. A typical cross section of some of the above roads is shown in Fig. 4.

The essential machanical equipments required for this type of stabilization are pulvimixer, sheepsfoot roller, pneumatic tyred roller, disc harrows, etc. The mixing, pulverizing and blending of sand and clay are carried out with the use of pulvimixer, a costly but very useful equipment which is to be imported from foreign countries.

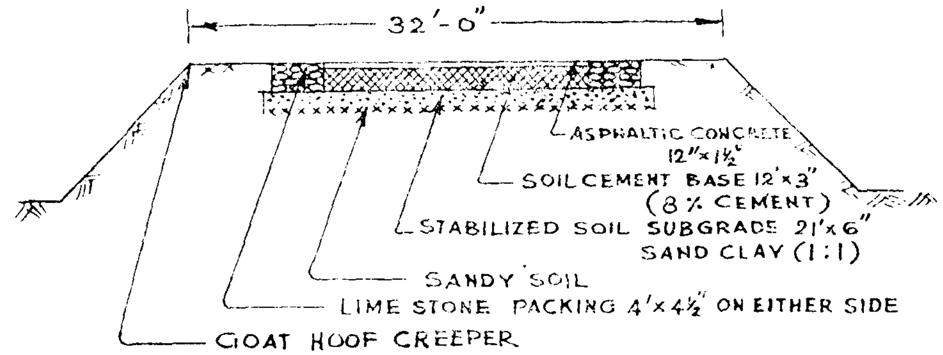
The Madras Highways Department is in possession of a Sieman's pulvimixer. It is a Diesel operated high powered (100 H.P.) pneumatic tyred tractor, with a rotary unit, that can pulverize and mix soils. The rotary unit consists of a Roter with detachable blades, or " tynes " as they are usually called, of various types so as to obtain best results for different operations. There is also a water pump attachment, with a device to control the amount of water supply. This plant can be utilised for various operations involved in soil stabilization works. The depth of penetration of the tynes can also be suitably adjusted and controlled. A high powered and versatile plant, such as this pulvimixer, is essentially intended to reduce the employment of manual labour to a minimum. The use of pulvimixer has the advantage of speed and efficiency. However, the maximum benefit from the pulvimixer can be derived only if suitable auxiliary plants such as tractors, tanks, pneumatic and sheepsfoot rollers etc. are also used in conjunction.

The sheepsfoot roller, pneumatic tyred rollers, etc. used for compacting the surfaces are manufactured in the local Departmental Workshop itself located at Guindy, at a cost comparatively lower than that obtaining in the market. If soil stabilization is to be taken up for a large mileage of low cost roads for connecting the villages, there is the need to use these mechanised equipments extensively.

(*b*) **Stabilization with the addition of cement, lime bitumen and other chemicals:**

The method to be adopted for soil cement construction is almost the same as for sand clay stabilization except that the proper amount of cement is to be added to the pulverized soil or soil mixtures and the wet mixing and compaction are to be completed within four hours of the addition of cement. The soil cement surface is to be moist cured for atleast seven days before exposure to weather

and traffic. Ramnad-Mandapam Road and Chidambaram-Bhuvanagiri Roads were constructed by this method. A typical cross section is given in FIG. 5.



TYPICAL CROSS-SECTION OF
RAMNAD – MANDAPAM ROAD
FIG. No. 5

Stabilization with bitumen is normally used for base course. The binder bitumen is added to the soil mixture stacked on the berms. The two are then intimately mixed and allowed to weather for about a week before spreading on the compacted base. The soilbitumen mix is then compacted with rollers. It is preferable to compact with Pneumatic tyred rollers in the case of soil bitumen mixture to obtain better adhesion with the layer underneath and to ensure that the mixture does not creep unduly as would happen in the front of the smooth wheeled roller. Bitumen and soil could be mixed in mechanical mixers also before spreading on the base. Such base courses are generally covered with a bituminous surface dressing.

In this connection, the possibility of utilising the huge quantities of 50,000 tons of lignite Tar that is estimated to be available per year when the briquetting and carbonisation plant proposed for installation at the Neiveli Lignite mines begins to work in full swing, for road construction works, is a problem that has to be given the deepest consideration. It has been stated that preliminary studies undertaken in this regard have not given very encouraging results so far. Though the exact nature of their studies is not known, it is considered that they may be pertaining only to the possible use of this tar for "conventional road surfacing" and not to " soil stabilization for low cost roads.', Studies have to be initiated on the possibilities of obtaining mixtures of soil tar or sand tar as in bituminous soil stabilisation or of impregnating tar on earth roads to provide an initial dustless surfacing which may later be converted into a base course to be covered by other improved types of surfacings. Lignite tar, being a by-product of the Lignite industry may not be costly and being a material available within the State, the cost of transportation will also be limited. Soil materials like laterite soils and sandy soils which occur extensively in the State may easily lend themselves to stabilization with tar. The Madras Highways Research Station proposes to take up the studies in this regard at the earliest opportunity as and when the lignite tar is made available. The subject deserves interest from the research Scholars of the Annamalai University as well.

Chemical stabilization with addition of materials other than cement has not been tried in Madras State and whatever little work has been done elsewhere in India on this line is restricted to the use of some of the chemicals available locally at reasonable cost, namely Calcium Chloride, lime, etc. Hence it is not proposed here to deal with them at any length. However it is to be noted that the use of lime has been very successfully tried both in the laboratory and in the field for improving the texture of clayey soil.

(*c*) **Stabilization by heat treatment** :

By heat treatment the plasticity of clayey soils can be considerably reduced. The soil becomes non-plastic after being heated to about 500°C. From the experiments so far conducted on the effect of heat treatment, it has been shown that there is considerable change in properties like permeability, porosity, plasticity, shearing strength, etc. The burnt aggregates obtained from the heat treatment of clayey soils, may be used along with the natural soil to improve its overall strength.

The impact values of the burnt aggregates is much more when compared to the values of well burnt bricks. It is therefore advantageous to use the black cotton soil clods after heat treatment in place of brick bats or any other soft aggregates in road construction. However, this type of soil stabilization has also not yet been tried in Madras State so far.

A slightly different method in the process of mechanical stabilization has been evolved in the construction of soil stabilised roads, at the Central Road Research Institute, New Delhi, which is popularly known as "Mehra's method of soil stabilization". This method also contemplates the strengthening of the existing subgrade by pulverization and rolling and laying a base course consisting of sand clay mix to a suitable proportion in the usual manner. But the difference lies only in the construction of the top layer which constitutes the wearing course, with a soil-soft aggregate mix in the proportion of 2 : 1 (the soil is a mixer of clay and sand in a suitable proportion) well laid and compacted. Stone grafting at the rate of 7 cft. of soft aggregates per 100 s. ft. of the surface, is also provided over the wearing course. If required chipping carpet 3/4" thick could also be provided on top.

This method, with slight modifications, is proposed to be undertaken as an experimental measure with grants given by the Council of Scientific and Industrial Research in two stretches in Madras State, one running in the sandy tracts of Ramnad District using coral stone available in the several off shore islands of Ramnad District, as a *grafting material*, and another in black cotton soil of Coimbatore District. The cost of this type of construction is found to be cheaper when compared to the conventional methods of soil stabilization.

7. Conclusion :

From the experience so far gained in the construction of soil stabilized roads in this State, it has been found that the advantages in adopting soil stabilization for road construction as against the conventional methods are :—

1. It can be constructed with the locally available materials, so that it helps to build up National economy.

2. Initial cost of construction is low.

3. Being designed on a scientific basis is capable of withstanding the effects of traffic, weather, water table, etc. and consequently maintenance cost is also low.

However there are certain handicaps which limit the adoption of soil stabilization on a large scale.

1. Heavy and costly machinery have to be imported for speed of execution, efficiency, precise quality control and economy.

2. Trained workmen are necessary to carry out the work.

3. It does not permit stage construction.

4. Field laboratories are essential as the work has to be executed under controlled conditions.

The first two objections are common to all types of works where quality and speed are to be combined. The difficulties will also be overcome in due course as we gain more experience in the construction of stabilized soil roads.

For the knotty problem of maintenance of large mileages of rural roads obtaining in Madras State, especially in the deltaic and coastal regions soil stabilization promises to provide a good solution.

TABLE : I **The nature and type of soil stabilized and road works taken up in Madras State.**

Serial No.	Name of work	Nature of sub grade soil	Nature of foundation course and wearing surface				Approximate cost per mile using		Equipments available for the use on the work	Remarks
			Sub-Base	Base	Wearing surface	Berms	Stone soiling	Stabilized soil		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	(a) Tiruvottiyur Ponneri-Poonjetti Road Mile 5/0 to 8/5 (Major District Road near Madras)	Sand	—	20'x6" sand clay (1:1) 20'x6" Mooram sand clay	3½" Water Bound Macadam		18,000	8,000	Motor grader, tractor sheepsfoot roller, Lorry disc harrows, level drag, Smooth wheeled power roller	Clay was pulverized by power roller and seived through 1/8" mesh screen
	(b) Tiruvottiyur Ponneri Poonjetty Road 3/0 to 5/0	Medium Plastic clay	22'x1" sand	(4:10:1) 20'x6" Mooram sand (2:5)	do	—	—	—	—	—
			22'x3" sand	20'x6" Mooram sand (2:5)	—	—	18,000	12,600	Same as per 1 (a) except sheepsfoot roller	—
2	Chidambaram Sirkali Road 29/2 to 30/7	Sand	—	18'x5" roadside soil clay (3:1)	3" Water Bound Macadam	—	—	—	do	Clay was pulverized by power roller and seived on ½" screen
		Medium clay	—	18'x5" sand clay (2:1)	do	—	—	—	do	—
3	Tuticorin Tiruchendur Road M 1/6 to 13/4	Sand	—	18'x5" sand clay (5:1)	3" Water Bound Macadam	2½'x3½" Gravel sand (1:1)	14,000	7,500 (Base)	do	—
		Clay	20'x4" Sand	18'x5" sand clay (5:1)	do	do	14,000	2,500 (berms)	do	Clay powder was collected by scraping a clay ground with a grader and seiving the material through 1/8" mesh screen

The nature and type of soil stabilized and road works taken up in Madras State *(Contd.)*

Serial No.	Name of work	Nature of sub grade soil	Nature of foundation course and wearing surface				Approximate cost per mile using		Equipments available for the use on the work	Remarks.
			Sub-Base	Base	Wearing surface	Berms	Stone soiling	Stabilized soil		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
4	Ramnad Mandapam Road 0/0 to 21/4	Sand	21'x6" sand clay (1:1)	12'x3" soil cement 8% cement	1½" Asplastic concrete	—	25,000	14,000 (Base & subbase)	Pulverizer water pumps and equipments listed in Project 1.	Pulverizing & mixing operations were done with pulvimixer. When pulvimixer was sick, manual operations were resorted to.
5	Kovalam Mahabalipuram Road 0/0 to 12/0	Sand	—	18'x6" sand clay (1:1)	Water bound macadam	—	—	29,700	Same as for Project 1.	—
6	Tiruvanmiyur Muthukadu Road 0/5 to 12/0	Sand	—	11'x4" sand gravel (½:1) and (1:1) 11'x4" sand gravel and lime (1:1 +2% lime)	10'x4" gravel + 50% coarse fraction	4'x3" gravel	—	14,700	Pulvimixer used	—
7	Rettmbedu village Road 1/0 to 3/0	Sand	—	16'x6" sand clay (5:1)	Black Top 3/4" Chipping Carpet		—	20,350	Disc harrows drawn by tractor	—

FIRST STEP IN RESEARCH

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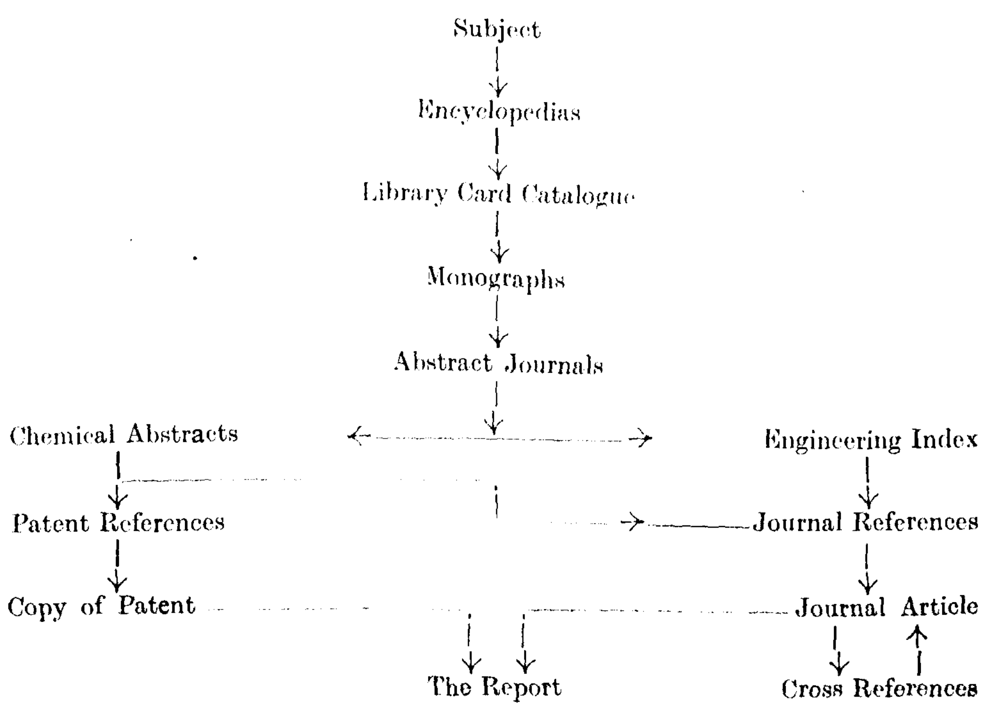
BEFORE one plans his research programme, it is imperative that he should carry out a literature survey and acquaint himself with the contributions made on the subject by others interested in the same or allied problems. A comprehensive survey of the work done so far in the particular field will enable him to avoid repetition except for verification purposes, to chalk out a line of work so that he might add or increase the knowledge on the subject and to correlate his own findings in a new and improved manner. Therefore a research worker has to be necessarily familiar with the literature and hence the procedure to be followed in searching the literature.

Let us for example take a chemical engineer interested in research work or engaged in preparing a report or dissertation or Home Paper. For him the literature of Chemistry and Chemical Engineering is a vast store house of many useful information and data. The sequence of steps for ransacking the literature is indicated in the following flowsheet.



A broad survey of a subject can be had from encyclopedias or general reference books. The most important of them for consultation are

1. The Encyclopedia of Chemical Technology (1947–56) edited by Kirk and Othmer.
2. Thorpe's Dictionary of Applied Chemistry 4th Edition (1937–56.)
3. Ullmann's Encyklopadie der technischen chemie 2nd & 3rd edition.
4. Mellor's Comprehensive Treatise on Inorganic & theoretical chemistry.
5. Friend's Text book of Inorganic chemistry.
6. Jacobson's Encyclopedia of chemical reactions.
7. Beilstein's Handbuch der Organichen chemie.
8. Elsevieros Encyclopedie of organic chemistry.
9. Weissberger's Technique of organic chemistry.
10. Eucker & Jacob's Der Chemie Ingenieur.
11. Cremer & Davies : Chemical Engineering Practice.

The above reference books will furnish a great deal of general information on properties of materials, chemical reactions, process technology, materials and design methods for various industries.

Then a research student consults books and monographs on special topics which offer a definite source of detailed information. In these cases, the date of publication should be noted. During the time interval needed for writing and printing the books, many important information might have been published by workers on the subject in various periodicals. Therefore, even the books published recently will not contain all the latest information which can be had from the journals. Search for information in various journals will appear to be a tedious and time consuming process. To minimize the trouble, the abstract journals may be consulted.

An abstract is a precis of the original article. It will enable the reader to find out which ones may contain data pertinent to the problem being investigated. At the present day, the Chemical Abstracts and the Zentralblatt are the two important abstract journals which make a survey of all chemical and chemical technology publications and patents in various countries. These two journals are valuable guides to sources of information. The Chemical Abstracts are published twice a month on the tenth and twentieth by the Americal Chemical Society at Easton, Pa. The financial burden and the work involved are very great since about 3000 journals and twenty other abstract journals are searched for and checked. They contain author index in each issue. Annually author, subject, formula and patent number indexes are published. The cumulative author and subject indexes are published decennially from 1917.

The Chemisches Zentralblatt is published weekly by the Verlag Chemie for the Deutsche Chemische Gesellschaft, Berlin. Annually author, subject, organic formula, patent indexes are published.

The British Chemical Abstracts was published from 1926 till recently. In view of the high cost, this publication has been suspended. When even an advanced country like Britain cannot afford to do this work, Tamilnad – nay the whole of India-cannot undertake such an immense task. Therefore it should be emphasized that whatever may be the medium of instruction in colleges and universities, adequate knowledge of English is essential for advanced scientific research workers.

Another useful source is the Engineering Index (1884...) which includes abstracts of articles on pure and applied chemistry, and also articles on equipment, design and construction not covered by Chemical Abstracts.

There are also a number of annual surveys and reports, such as 1. Reports on the Progress of Applied Chemistry 2. Progress of Pure Chemistry, 3. Annual review of Physical Chemistry, 4. Advances in Catalysis, 5. Advances in Chemical Engineering, 6. Annual Reviews in Industrial and Engineering Chemistry, 7. Chemical Reviews. The technical secrets and methods used by German industry are available in the reports of various American and British agencies such as the office of the technical services (O. T. S.), Field Information Agency Technical (F. I. A. T.), British Intelligence Objectives Sub-committee (B. I. O. S.) These reports included German patents and patent applications.

Patents give a lot of information not found elsewhere. A patent confers on the inventor the legal right to prevent others from using his invention without payment of adequate compensation to him. Every country publishes the list of patents issued every month or week. Some countries like U. S. A. publish also an annual index containing patentees and titles of the patents issued. The Chemical Abstracts give a brief Summary of the patents issued in industrially advanced countries.

It has been mentioned earlier that journal references are obtained from the Chemical Abstracts. Now one proceeds to consult the concerned journals. Some important industrial journals are listed below :

United States of America.

1. Chemical Engineering Progress - prior to 1947 known as the Transactions of the American Institute of Chemical Engineers.
2. A. I. Ch. E. Journal publishing basic research papers.

3. Chemical Engineering Symposium Series.
4. Industrial and Engineering Chemistry.
5. Chemical Engineering-prior to 1947 known as Chemical and Metallurical Engineering.

Canada : Canadian Journal of Chemical Engineering.

United Kingdom

1. Transactions of the Institution of Chemical Engineers (London.)
2. Chemical Engineering Science.
3. Industrial Chemist.
4. Chemical Trade Journal and Chemical Engineer.
5. Journal of the Institute of Fuel (London.)
6. Fuel (London.)
7. British Chemical Engineering (1956)

France : Chimie et Industrie.

Germany.

1. Chemie-Ingenieur-Technik.
2. Chemische Industrie - English Edition available.
3. Breñnstoff-Chemie.

Austria : Chemisches Forschung institute der Wirtschaft Osterreiches Mitteilungen.

Italy : Rassenga Chimica, Rome.

Russia : Journal of Applied Chemistry of the U. S. S. R.
English translation available.)
Journal of General Chemistry.

Scandinavian Countries : ACTA Chemica Scandinavica.

India

1. Transactions of the Indian Institute of Chemical Engineers.
2. The Indian Chemical Engineer.
3. Journal of the Indian Chemical Society
4. do do Industrial & News Edition.

5. Journal of the Bureau of Scienctific & Industrial Research
6. Current Science
7. Science & Culture
8. Indian Chemical Age.

Japan: Chemical Society of Japan.

Besides the journals mentioned above there are a number of journals devoted to individual industries. For detailed information regarding literature sources, how to find and use them, the following books will be very helpful.

1. Advances in Chemistry Series - No. 4 & 10 bearing the title
   (*a*) Searching the Chemical Literature (*b*) Literature resources for the Chemical Process Industries.
2. Mellon - Chemical Publications.

The design of a chemical plant must not only be technically sound but also economically feasible. Similarly the products manufactured must be sold at competitive rates to yield profits. Therefore a chemical engineer is interested in the technical side as well as the economics of the chemical industry.

Information about the chemical trade can be had from 1. the condensed chemical dictionary (5th Ed.), 2. the Van Nostrand Chemist's Dictionary, 3. the Merck Index (6th Ed.), 4. Hayne's chemical trade names and commercial synonyms. 5. Gardner and Cook Chemical synonyms & trade names.

The economic and business aspects are available from 1. Perry's Chemical Business Hand book (1954), 2. Hand book of Industrial Engineering & Management 3. Chemical Economics Hand book published by the Stanford Research Institute 4. Chemical Week (1951), 5. Annual Buyers' Guide, 6. Chemical Processing 7. Industrial Equipment News. 8. Chemical Engineering Catalogue, 9. Chemical Material Catalogue. 10. Refinery Catalogue, 11. Paper & pulp Mill Catalogue. These sources give information about the chemicals, equipments, materials used by the chemical industry and also the manufacturers' names together with the standard sizes of the equipments.

Numerical Data are obtained from 1. International Critical Tables 2. Perry - Chemical Engineers' Hand book, 3. Hand book of Chemistry 4. Hand book of Chemistry and Physics. 5. Selected values of chemical thermodynamic properties.

The journal "Chemical Engineering" gives a pictured flow sheet every month. A collection of these flow sheets are also available.

A chemical engineer must be able to estimate the cost of a new piece of equipment or a new plant. In order to get the methods and data for estimating the cost he may refer to 1. Chemical Engineering cost estimation by Aries and Newton, Chemical Engineering Plant Design (3rd Ed., 1949) by Vilbrandt, Chemical Engineering Costs (1950) by Zimmerman and Lavine and Chemical Engineering Costs Quarterly by the same authors.

A tremendous change is taking place in chemical industry in the matter of products, processes and application of products and processes. "The only unchanging thing in chemical industry is change itself". Therefore a great emphasis is placed on research in chemical industry. Hence it is needless to say that a chemical engineer should know how to search the literature since it is the first step in research.

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A STUDY OF METHODS FOR MEASURING MECHANICAL LOSSES IN INTERNAL COMBUSTION ENGINES.

K. ACHUTHAN NAIR, B. E., A. M. I. E.

PART—I

Use of indicating Instruments.

A knowledge of the losses occurring in an engine is very important from the point of view of design, performance and research work. If the losses are correctly estimated, steps can be taken to minimise them. The direct losses to the exhaust and cooling water can be measured accurately, with comparative ease. Correct measurement of the indirect mechanical losses comprising frictional and pumping losses is more difficult, particularly in high speed engines.

Various methods are available for measuring the mechanical losses. One method is to find the difference between the power developed in the cylinders of the engine and the power actually delivered by the engine; that is, between the indicated horse power and the brake horse power. The brake horse power can be measured with any desired degree of accuracy by means of a suitable brake or dynamometer. Accurate measurement of indicated horse power, bristles with difficulties. One method of measuring indicated horse power is by means of an indicator.

Indicators are of many kinds, mechanical, optical, electric and electronic. Some are simple while others are complex. It will take too long even to give a brief description of the different types and makes of indicators.

The simplest indicator is the mechanical indicator (Fig. 1). In this instrument paper is wound on a drum and reciprocated to and fro horizontally, proportional to the movements of engine piston by means of a reducing mechanism. A pencil point moves vertically proportionately to the pressure inside the engine cylinder. When the pencil is applied to the paper, a diagram

is drawn in which cylinder pressure is plotted to cylinder volume. From this diagram the indicated horse power can be calculated.

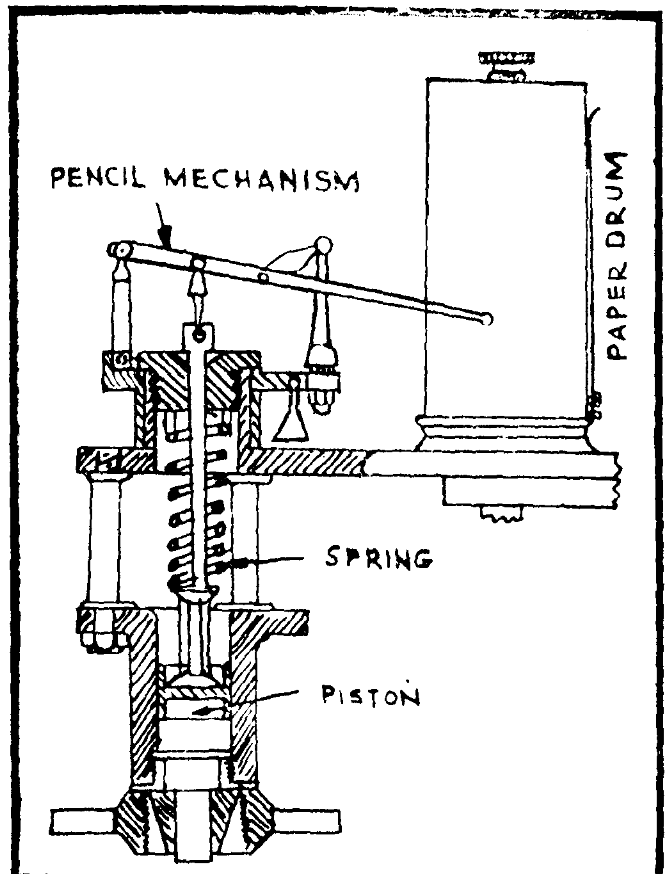


FIG. 1. MECHANICAL INDICATOR.

This instrument gives fairly good results at low engine speeds, say upto 400 r. p. m. At greater speeds the inertia of the moving parts of the mechanism causes large errors and the diagrams obtained are useless. There are also other sources of error such as friction between pencil and paper, lack of synchronisation of indicator drum and engine piston, errors in the spring scales, etc.

Inertia errors of the mechanical indicators can be minimised by reducing the size and weight of the moving parts. This will reduce the size of the diagram. In the micro-indicator this method is pushed to its logical conclusion, the diagrams obtained being so small that they have to be read by magnifying several times. This method has the disadvantage that errors due to slackness of pencil mechanism increase proportionally as diagram size is reduced.

The usual types of coil springs in the indicator cause large errors at high speeds because they have comparatively small frequency of natural vibrations and may cause resonance. That is, the whole pencil mechanism of the indicator may vibrate independently of the actual pulsations of pressure. This is avoided in some types of indicators by special design of the spring so that it has a high frequency of natural vibration. The spring takes the form of a cantilever (Fig. 2) one end of which is securely fixed to the frame of the instrument and the other end is connected to the piston of the indicator. Instruments of this type are the "Mahaik" and "Bacharach".

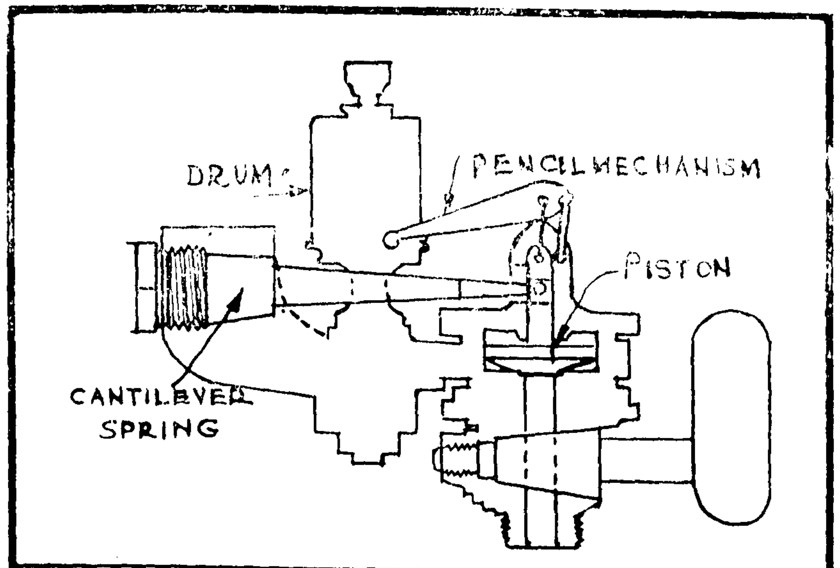


FIG. 2. HIGH SPEED MECHANICAL INDICATOR

In some types of indicators, the paper on which the diagram is to be drawn is rotated at constant speed by means of a clock work, the vertical movement of the pencil being obtained by the usual mechanism. The diagram thus obtained gives pressures to a time base. From this diagram the usual pressure volume diagram can be obtained by knowing the ratio of connecting rod to crank length. This method has the advantage that there is no need for a reducing mechanism, and hence the inertia error due to it, is minimised. But it has all the other disadvantages of the mechanical indicator.

In optical indicators the pencil point is replaced by a ray of light thus eliminating the inertia errors due to the pencil mechanism. In some instruments (Hopkinson: Burstall) a small mirror is given two rocking motions, one proportional to movements of the engine piston and the proportional to the

pressure. These motions are only of the order of fractions of an inch, thus reducing inertia effects. In some other instruments (Midgely; Watson) one mirror is given a miniature rocking motion proportional to the pressure. The light from a suitable source is reflected from this mirror on to another mirror which is given another miniature rocking motion proportional to engine piston movements. The ray of light is thrown on a suitable screen and may be photographed. (Fig. 3)

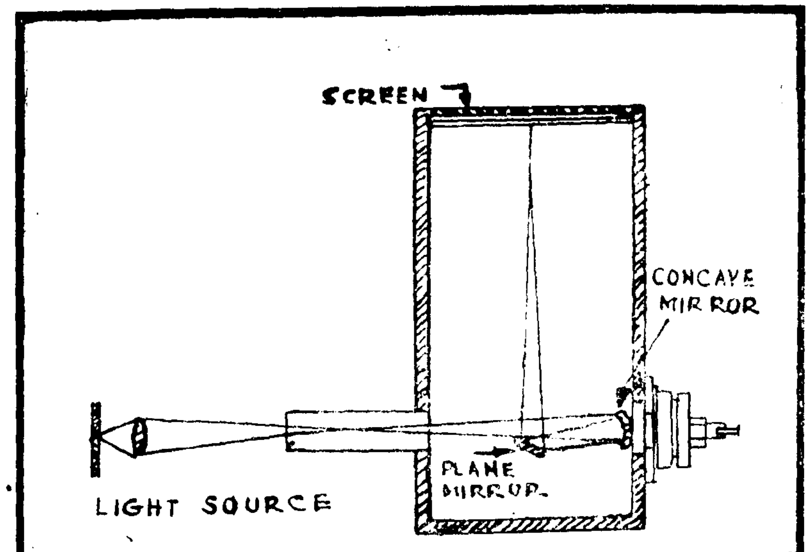


FIG. 3. OPTICAL SYSTEM OF WATSON INDICATOR

Instead of the conventional piston and spring for rocking the mirror proportional to piston movements, a plane or corrugated diaphram may be used. This will serve both as spring and piston. The corrugated diaphragm is preferred as it will give a straight line relationship, unlike a plane diaphragm. In some instruments the mirror is rotated in phase with the engine to give diagrams to a time base.

Optical instruments require careful adjustment and are not rugged enough for ordinary laboratory use but may be all right for special research work.

Another class of indicators are the balanced pressure type of indicators (Farnboro: Bureau of Standards). In these instruments a disc valve held in a suitable housing is acted upon one side by the cylinder pressure and on the other side by compressed air of known pressure. Whenever the cylinder pressure exceeds the known air pressure during the course of a cycle, the disc valve lifts. In one type (Farnboro) this lifting of the valve interrupts the current in the primary of an induction coil whose secondary causes a spark to pass through a paper which is wound on a drum rotated synchronously with the engine. By varying the air pressure, a series of pricks are obtained on the paper. By joining these pricks together a smooth curve is obtained which is the diagram of pressure plotted to a crank angle base from which the usual pressure volume curve may be derived.

In another type of indicator, (Bureau of Standards) the lifting of the disc valve is made to operate head-phones whose clicks are timed in relation to crank angle by means of an electric timer. Thus the pressures of different points of the cycle are known and can be plotted to give the pressure-crank angle or pressure volume diagrams.

This class of indicators are sturdy and can be used for rotative speeds upto 2500 R. P. M. The diagrams obtained are the average of a number of diagrams and hence the running conditions of the engine should be steady for a certain number of cycles while a diagram is being taken. Some error is caused by the fact that the effective area on both sides of the disc valve may not be quite the same. Further the disc valve requires careful maintenance as it functions also as a switch. Carbon deposit on it will interfere with the electrical circuit and cause scattering of the points on the diagram. Though the disc valve has little inertia it cannot respond satisfactorily to high frequency oscillations of pressure under knocking cumbustion.

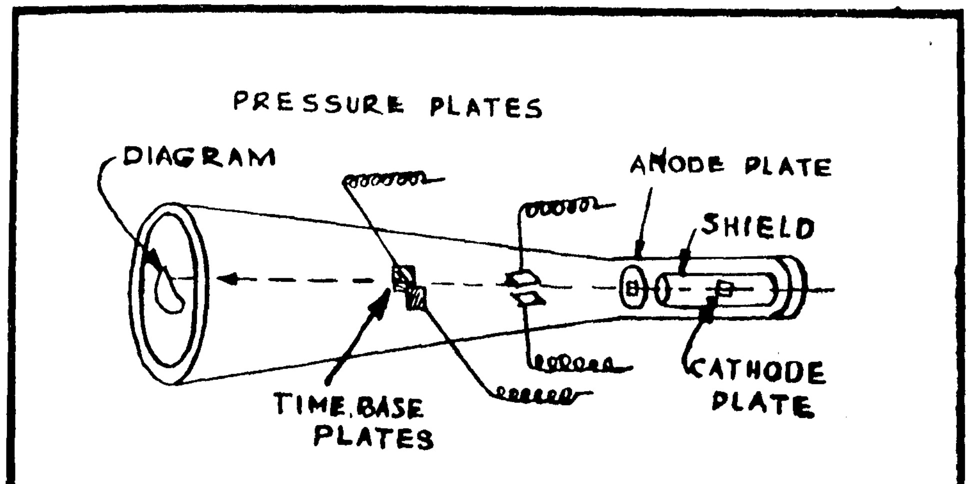


FIG. 4. PRINCIPLE OF CATHODE RAY INDICATOR

For the highest engine speeds the Cathode Ray indicator is used. (Fig. 4) This uses a cathode ray tube similar to that used in television. This ray consists of a stream of electrons and gives rise to a green spot of light when it

strikes the tube end surface which is coated with a special fluorescent material such as Zinc silicate or Calcium tungstate. The ray passes between two pairs of plates which are mutually perpendicular to one another. The time base plates are fed with voltage which varies with engine crank position, thus causing the spot to move and trace out a horizontal straight line proportional to crank angle. The other pair of plates is given a voltage which varies according to cylinder pressure and this causes the spot to move vertically proportional to pressure. The spot thus traces out a pressure crank angle diagram which may be photographed.

In this instrument inertia effects are reduced to a minimum and hence it is suitable for the highest engine speeds. But the instrument involves electrical principles of a complicated nature and its operation, maintenance and adjustment require the services of an electronics expert. Qualitative observations are readily made but quantitative observations require very careful calibration of the instrument.

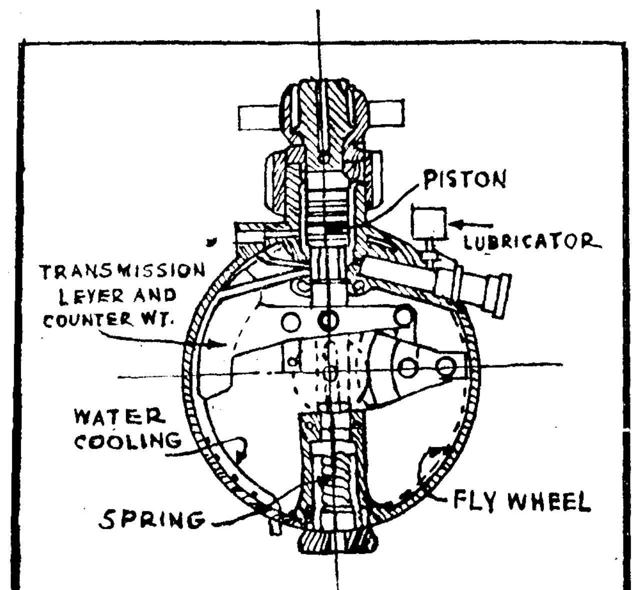


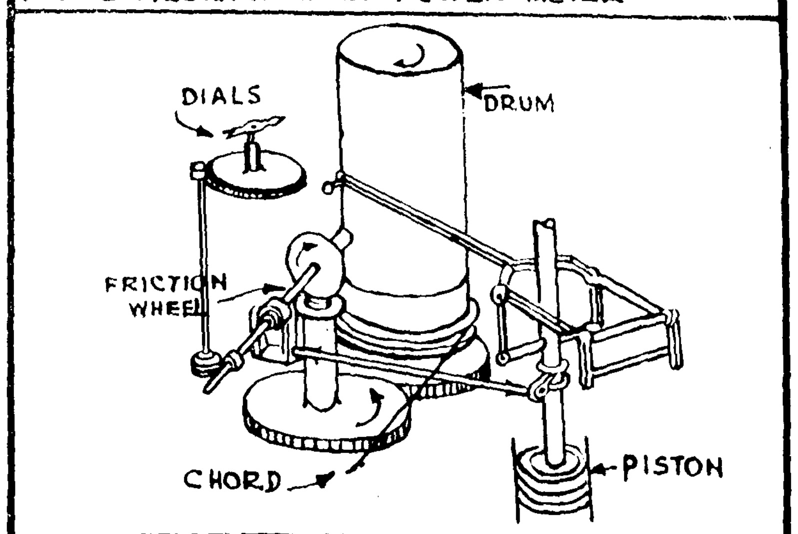
FIG: 5. MEAN PRESSURE INDICATOR.

Instruments have been devised combining the principles of the balanced pressure type indicators and the cathode ray indicators. Needless to say, these are of a complicated nature and are suitable for special research work only.

In one type of instrument (Geiger), the mean pressure inside the engine cylinder is directly read off on a dial (Fig. 5) The gas pressure acts on a piston, the movements of which are transmitted to a small flywheel inside the instrument. The mass of the flywheel absorbs the fluctuations of pressure so that the piston adjusts itself to the mean pressure which is counter balanced by a spring of suitable stiffness. The meanpressure thus obtained is to a base of time and is converted to mean effective pressure on a volume bases by means of a constant which will depend on various factors such as the type of engine, connecting rod to crank length, etc. The instrument is more suitable for comparing power developed in individual cylinders of an engine than for absolute measurement.

Any study of indicating instruments will be incomplete unless it deals with what are called Power Meters. These register the power developed inside the cylinder, on a dial or counter, more or less like a Kilowatt meter registering electrical power. Several designs are in the market (Such as, Gumbell ; Mahaik, etc.). All these work on the same principle. The power developed is proportional to the product of the mean effective pressure and piston travel. In this instrument this product is determined by inter-action *through friction* of 2 discs. (Fig. 6) one a pressure disc and another a travel disc. The travel disc has an oscillating motion which bears some fixed ratio to piston travel whereas the pressure disc positions itself according to the cylinder pressure.

FIG : 6. MECHANISM OF POWER METER



This insrument requires complicated mechanical arrangements but is more suitable for use in power plants than for laboratory use.

It is hoped that the above brief study of instruments will enable a proper choice of instruments to be made for any given purpose whether it be for routine indicators or for elaborate laboratory research work.

OTHER METHODS OF MEASURING MECHANICAL LOSSES IN ENGINES

Part II

Finding the mechanical losses by getting the difference of i. h. p. and b. h. p. involves finding the relatively small difference between relatively larger quantities and hence there is greater possibilities of error than if the losses are *measured directly*. Thus let us say that the correct i. h. p. of a certain engine is 100 and b. h. p. is 80. If i. h. p. measurement involves an error of plus 10% than the losses would be measured as 110 minus 80, or 30 instead of the correct value of 20. The error is thus 50%. If the losses are directly measured with an error of 10% the estimated i. h. p. comes out as $80 + \frac{20 \times 110}{100} = 102$. i. e., the error is only 2%. This simple example shows that a small error in i. h. p. measurement is much more serious than a comparatively large error in direct measurement of losses. Direct measurement of losses is therefore advantageous.

The most common method of measuring losses directly is the Motoring Method. This is possible when the engine is coupled with an electric dynamometer. First the engine is run at the desired speed and load. The connections of the dynamometer are quickly reversed so that it works as a motor. The fuel supply to the engine is then cut off and it is motored at the same speed. The power required for motoring the engine is taken as the losses of the engine. By doing, the motoring test quickly after the load test, the temperature of the lubricating oil and jacket water will be unchanged. When the engine is firing normally the combustion gases are pushed out by their own pressure. When the engine is not firing, work has to be done in pushing the gases out. Further, more work will be done in drawing the air into the cylinder when motoring. Hence the pumping losses are greater during the motoring test than when engine is firing normally. As against this the piston friction losses will be less during motoring test because the pressure in the cylinder will be less. Hence the two factors compensate one another so that the motoring losses are taken as the true losses.

Whether this is strictly true or not, the motoring test has enabled various investigators (Litchy & Carson ; Morris Engines Ltd.,) to analyse and find relative magnitudes of the losses in the several components of an engine such as valve gear, piston rings, oil pump, etc. The method was to do repeated motoring tests with various parts removed one by one. The analysis revealed for example that generally speaking the maximum friction loss in an engine is produced by piston rings and that too by the compression rings. The motoring test is thus a valuable aid in research and development.

Another method of finding the losses is the Morse test. This is applicable only to a multi-cylinder engine. In this method the fuel supply to each cylinder is maintained constant and the b. h. p. of the engine determined. One cylinder is then put out of action and the reduced b. h. p. determined at the same speed. The measured reduction in b. h. p., is the i. h. p. of the cylinder that is put out of action. The test is repeated by putting out the remaining cylinders one by one. By adding the i.h. p. of all the cylinders the total i. h. p. is obtained and deducting the full b. h. p. the total losses are obtained. In effect one cylinder at a time is motored by the remaining cylinders. This test is therefore based on the same considerations as the motoring tests by electric dynamometer, and is subject to the same errors. The advantage of the method is that no special equipment is required other than some type of brake. The test gives i. h. p. of individual cylinders which is not possible by any test other than indicator test The test presents difficulties on engines fitted with speed governors and some special techniques are necessary for getting correct results. Further the test cannot be applied to single cylinder engines.

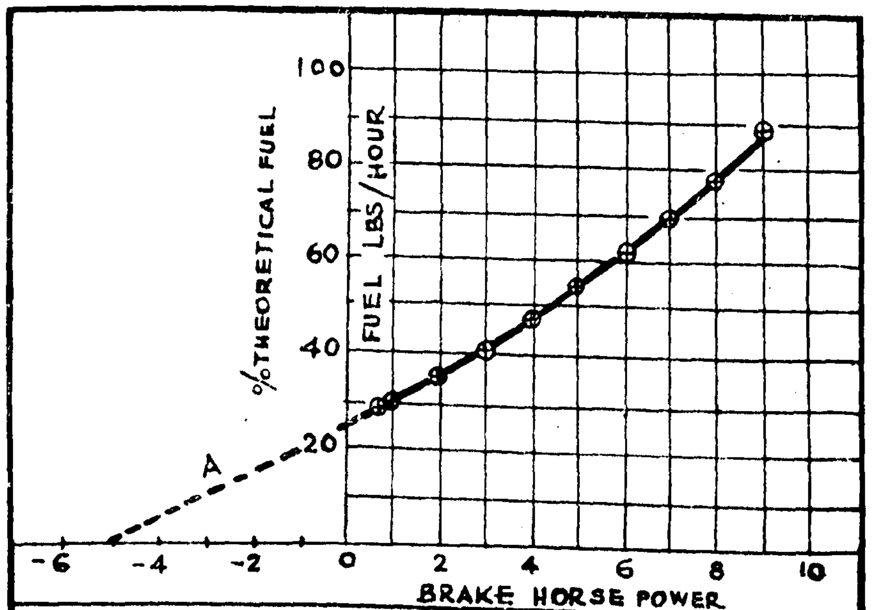


FIG. 7. FUEL CONSUMPTION OF 9 HP. DIESEL AT 1000 R.P.M.

In another method a series of fuel consumption readings are taken at the desired speed but at different loads and the readings carried right down to no load. If an electric dynamometer is used it can be used to feed back power to the mains so that readings of fuel at less than no load (Point A on FIG. 7) can

be obtained. The readings obtained are then plotted showing fuel consumed per cycle or per hour to a base of b. h. p. The curve is then extra-polated to zero fuel. The resulting negative power then denotes the horsepower required to overcome mechanical losses at no load.

In this test the engine continues to fire for the complete set of readings. There are thus no factors altering the pumping losses and piston friction losses as in the motoring test. The test therefore gives the mechanical losses at least as accurately as any of the other tests. The test has been employed to great advantage by many investigators (Davies ; Dicksee) In most cases the test gives values of mechanical losses slightly less than by the motoring test but it is really difficult to say which is more accurate. The test has the great advantage that only the simplest fuel consumption and b. h. p. measuring equipments are sufficient ; though as explained before, some refinement is possible if an electric dynamometer is available.

By extra-polation of the total fuel versus b. h. p. curve we were able to get the mechanical losses of the engine at no load. A further study of this curve can give some idea of how the mechanical losses vary with the load. This variation cannot normally be studied either by the motoring or similar tests but only by means of accurate indicator diagrams. This explains why studies on variation of mechanical losses with load are few, whereas the study of variation of losses with speed are many. In fact it has been fairly established that the torque required to overcome mechanical losses increases with increase of speed. No such general conclusions are available as regards variation of losses with load. In motoring and other tests the assumption is rather naively made that the mechanical losses are constant at different loads. The experimental evidence supporting this view seems to be rather meagre. Hence a study of variation with load may be of interest.

Fig. 7. gives the total fuel consumption of a small Diesel Engine plotted to a base of b.h.p. This curve is more or less straight at the lower end and is extrapolated to give the losses at no load. But it has a gradually increasing slope with increase of b.h.p. Tests on a number of engines all gave curves of the same general shape. The engines included four stroke, 2 stroke, Diesel, petrol and varied in horse power from 6 to 40 and in speed 450 to 1800 r.p.m. Now, it can easily be proved that if the indicatd thermal efficiency and mechanical losses are both constant the curve of total fuel versus b.h.p. should be straight line. The gradually increasing slope of the curve shows that either the indicated thermal efficiency goes down or the mechanical losses go up so that it takes a greater increment of fuel for the same increment of b.h.p., as the b.h.p.

increases. It is also possible that both factors, operate together, that is reduced thermal efficiency and increased mechanical losses.

To sort out the two factors we may make use of the calculations of Goodenough and Baker (Taylor and Taylor ; I.C. Engines.) They have shown that as the fuel to air ratio increases, the indicated thermal efficiency of the actual fuel-air cycle decreases. The contributory causes to this are the losses due to greater specific heat of the products of combustion and greater losses from the cylinder to the jacket. Their calculated values of thermal efficiency for a constant pressure fuel-air cycle with a compression ratio of 17 : 1 is given in Fig. 8. Assuming that

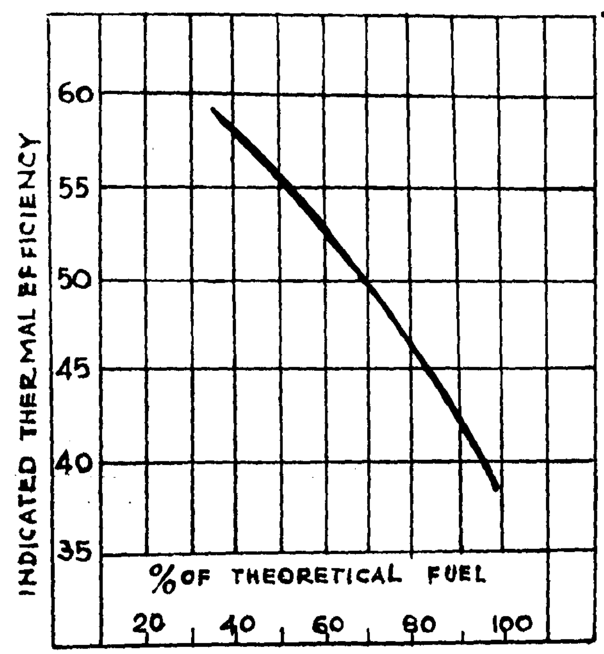


FIG: 8. EFFICIENCY OF CONSTANT PRESSURE FUEL-AIR CYCLE. COMPRESSION RATIO 17:1 (GOODENOUGH AND BAKER)

these efficiencies hold good in the present case, the i.h.p. developed, is given in col. (4) of the adjoining table. The mechanical loss is given in col. (6) of the table. The variation in losses is within a small limit. For practical purposes we may assume in the present case that the loss is constant at all loads. An explanation for this is probably that the effect of increased gas pressures at higher loads is compensated by reduced viscosity of oil caused by higher temperature. It is proposed to carry out similar studies on all the other engines tested.

In another method the retardation in engine speed is measured when slowing down owing to its own mechanical losses, after the fuel is cut off. The retardation is measured again when the engine is slowing down after an additional known resistence is imposed by means of a brake. From these observations the torque required to overcome the mechanical losses of the engine can be got by the application of simple mathematical principles. The moment of inertia of the moving parts of the engines can also be calculated and acts as check on successive experiments on the same engine.

The method can be looked upon as a motoring test in which the engine is motored by the stored up kinetic energy of its own moving parts. The method is therefore subject to the same assumptions and errors of the motoring test. The method has the advantage that it requires only the simplest of equipments. It gives fairly good results in the heavier type of engines which slow down and come to a stop in an appreciable length of time. A suggestion put forward to improve the accuracy of this method of testing is to couple up the engine to a heavy wheel preferably of known moment of inertia. This will enable the retardations to be measured more accurately.

What has been said upto now would, it is hoped, have given different possibilities of approach for the difficult problem of making a correct estimate of the mechanical losses occurring in an internal combustion engine. The best approach in any given case will naturally depend on the circumstances.

TABLE

% of Theoretical Fuel	Theoretical efficiency from Fig. 8	Fuel per hour from Fig. 7	Indicated H. P. Col. 2 × Col. 3 × 0·0727	Brake H. P. from Fig. 7	Mechanical losses Col. 4 − Col. 5
%	%	Lbs.	H. P.	H. P.	H. P.
1	2	3	4	5	6
40	58	2·01	8·5	3·0	5·5
50	56	2·51	10·2	4·4	5·8
60	53	3·02	11·6	5·8	5·8
70	49	3·52	12·5	7·2	5·3
80	46	4·02	13·3	8·3	5·0

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ULTIMATE LOAD DESIGN OF REINFORCED CONCRETE MEMBERS

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TODAY, the concept of ultimate load theories for concrete members, is advanced for enough that all progressive concrete engineers have recognised its advantages over the conventional working load-stress theory. In Russia it is mandatory that structures be designed by ultimate load theories. Brazelean and Checkoslovakian building codes have for some years, specified that ultimate load design procedure be used as an alternate method. There are indications that many countries of Western Europe and America may adopt ultimate load theories in their building codes shortly. Recent interest in ultimate load theories stems from a dissatisfaction of the conventional elastic theory as recent investigations have proved its inadequacy for reinforced concrete.

History :

Ultimate load theory is basically a return to the forgotten fundamentals. Though pronounced interest in them, dates back only to one or two decades, several design theories were put forward, by Koenen in 1886, Thullie in 1897, Ritter in 1899 and Talbot in 1904, prior to the concept of design by elastic theory, which came into vogue in the beginning of this century.

Elastic or working load stress theory :

The conventional elastic or working load stress theory is based on the design of concrete members in terms of the working or service loads and permissible stresses. The internal stresses are calculated on the assumption that stress varies in direct proportion to the load and these stresses are limited to certain maximum values. This method of design, being simple and mathematical appealed to the vanity of the user and hence found favour in preference to the old ultimate load theories. However, tests of beams to destruction, revealed the nonlenear distribution of stress with load, due to inelastic behaviour of concrete at ultimate stage. As the short-comings of the elastic theory became increasingly evident with the increase in test data, there is a tendency to revert to the original method of design by ultimate load theories.

Ultimate load theory :

Ultimate load method is in principle, the design of a structure to withstand an ultimate load which is a multiple of the service load, under conditions of maximum stresses in the material, The margin of safety of the structure is provided in the overload factor and not in the allowable stress as in elastic theory.

Disadvantages of Elastic Theory :

1. Tests on concrete members have established beyond doubt, that stresses do not vary in direct proportion to the load and particularly at the ultimate stage bear no simple relation to the working load. For example, in long columns subjected to buckling, the stress does not vary directly with the load and hence suitable adjustments are made to permissible values of stress. In prestressed concrete the rate of increase of stress with load after cracking is more rapid than before cracking. Even in simple R. C. beams subjected to flexure, the distribution of stress at collapse, approximates to a parabola, than a straight line.

2. This method as it does not take into account the plastic behaviour of concrete and steel, at ultimate stage, ignores a large element of reserve strength the member possesses for eg. in framed structure or continuous beams the collapse load is often increased due to the plasticity of concrete and ductility of reinforcement.

3. This method provides the margin of safety solely in the allowable stresses and due to reasons given above this does not represent the true factor of safety of the structure i. e. the ratio of the collapse load to working load as is usually understood by the term factor of safety. Further this does not provide a uniform factor of safety for all parts or all types of structures. For e.g. a rectangular beam and a Tee beam both designed for an allowable concrete stress of 0·45fc' will have as per elastic theory a factor of safety of 2·22. But ultimate load theory shows that the resisting capacity of concrete increases by about 3·5 times for rectangular section and only about 2·5 times for a T beam.

4. The elastic method while it provides fairly satisfactory results for simple beams and slabs does not give the same accuracy for members subjected to combined stresses or framed structures. Recent research on members subjected to combined bending and shear as well as combined bending and direct stresses, have shown that in many cases the predicted and actual capacities differ by as much as 100%.

5. In short, as this method is neither based on nor proved by experimental facts, does not give a true indication of the behaviour or strength of the member.

In contrast, the ultimate load theory is based necessarily on experimental evidence and hence enables a more consistent, satisfactory and accurate assessment of the strength of the beam. It gives a true indication of the margin of safety, and enables the design of members to conform to desired load factors or the provision of uniform safety factor throughout the structure. It is a simple, rational, logical and true to fact basis of design and is often found to result in economic use of the material.

Fundamental Steps In Ultimate Load Design :

1. Evaluation of Service loads as specified in codes of practice.
2. Choice of overload factors.
3. Evaluation of ultimate Design moments, Shear Force etc., generally by elastic theory.
4. Proportioning of Sections with the aid of ultimate load equations.
5. Performance under service loads.

Over Load Factors :

Choice of overload factors depends on a number of considerations like (1) the type of structure, the type and nature of loads, (2) the exposure conditions and (3) the quality control exercised in design and construction. Usually a factor of 1·2 is allowed for dead loads which could be estimated with reasonable accuracy. A load factor of 2 is considered sufficiently safe for live loads provided the Corresponding stress is not excessive. 1·5 is suggested for wind and snow loads. Prof. A. L. L. Baker.[3] suggests that proper load factor could be decided by assessing the relative importance or weightage of different conditions controlling, load factor and applying the formula $F = \Sigma \frac{W}{10} + 1$, as illustrated below in Table. 1.

Table 1.

		Value of W for most adverse condition.
1.	Results of failure – serious (human or economic)	4·0
2.	Workmanship	2·0
3.	Load conditions	2·0
4.	Importance of member in the structure	0·5
5.	Warning of failure	1·0
6.	Reduction of strength	0·5
	$\Sigma W =$	10·0

$$F = \Sigma \frac{W}{10} + 1 = 2\cdot 0$$

3. The maximum moments, shear force and axial force to which the structure will be subjected at ultimate stage are usually determined from the various combinations of dead and live loads, usually by the elastic theory. For multistoried framed buildings limit design is also adopted.

4. *Preportioning of Section*: The sections of various structural members are designed with the aid of ultimate load equations, which have been established from test results.

5. *Performance under service loads*: The section designed should be checked for behaviour under service loads. i.e., deflections, width of cracks, and creep etc.

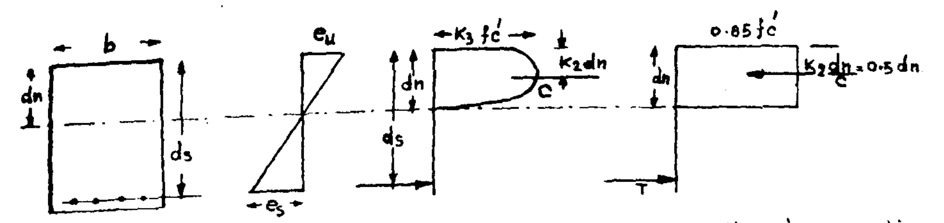
Ultimate Load Equations:

1. Ultimate strength theories for beams failing in flexure are well established on a firm foundation of experimental evidence, covering all the known variables. Many theories have been presented by different authors, but the basis of all theories is similar, namely, plane sections are assumed to remain plane even after bending and the assistance of concrete in tension is neglected and a certain stress distribution known as 'stress block' is assumed for Concrete in Compression. By summating the area of 'stress block', the total compression is obtained. This procedure is directly applicable to over reinforced beams while for under reinforced beams, the yielding of tension reinforcement causes the neutral axis to rise until the area of concrete resisting compression will be so small that the beam will ultimately fail in compression and the depth of neutral axis to the depth of steel is expressed in terms of yield stress, the ratio of tension reinforcement and the crushing strength of concrete. The resisting moment is expressed in terms of crushing strength of concrete and dimensions of stress block. Various theories suggested by the different authors differ mainly in the shape of the stress block and the values assumed for the parameters, namely the position of the centre of compression and the average compressive stress but are generally found to estimate the load fairly accurately. Of all the theories, the one due to C. S. Wlitney is simple and reasonably accurate for design office practice.

Notation:

As — area of tension reinforcement.
b — width of rectangular section.
dn — depth of neutral axis from compression edge.
ds — depth of tension reinforcement from compression edge.
Fc' — compressive strength of 6" × 12" cylinder.
Fs — stress in tension reinforcement.

Fy — yield point or maximum stress in tension reinforcement.
K1 — Ratio of the average compressive stress to maximum compressive stress in concrete.
K2 — Ratio of the deph of centre of compression from compression edge to the depth of Neutral axis.
K3 — Ratio of the maximum compressive stress to cylinder strength.
Mu — Ultimate moment of Resistance.
P — $\frac{As}{bd_s}$
T — Total Tension
C — Total Compression
e_u — Ultimate concrete strain in flexure
e_s — Ultimate Steel Strain in Flexure



General Form. C.S. Whitney's assumptions.

Equating Total compression = Total Tension.

$$b \times d_n \times K_1 K_3 Fc' = As \times Fs. \quad (1)$$

For compression failure, $M_u = As\, Fs\, (d_s - K_2 d_n)$

$$= bd_n Fc' \times K_1 K_3 (d_s - K_2 d_n) \quad (2)$$

For tension failure $M_u = A_s \times F_y (d_s - K_2 d_n)$ (3).

From equation 1 & 2, $d_n = \frac{Fs}{Fc'} \frac{pds}{k_1 K_3}$

Substituting this in eqn. 3, $M_u = Fy\, pbd^2 \left(1 - \frac{K2\, Fy\, p}{Fc\, k_1\, K_3}\right)$

$$\frac{M_u}{K_1 K_3 bd^2 Fc'} = \frac{Fyp}{k_1 K_1 Fc'}\left(1 - K_2 \frac{Fy \times p}{Fc' k_1 K_3}\right)$$

$$= \frac{dn}{ds}\left(1 - K_2\, dn/ds\right)$$

Great variations may occur with regard to the behaviour of concrete dependent on the quality of mix, and the type of aggregates used. This influences, the depth, shape and average stress of 'Stress block' in concrete at Collapse. However, safe values have been suggested for the various coefficients in the above formula, based on test results. C. S. Whitney has assumed a simple rectangular stress distribution with values of $K2 = 0{\cdot}5$, $K3 = 0{\cdot}85$ Fc′ and $K_1 = 1$. Substituting the above values in the general equations presented, for compression failure in a balanced section, we get,

$$M_u = 1/3\ bd_s^2\ Fc'$$

$$A_s = 0{\cdot}456\ \frac{Fc'\ bds}{Fy'}$$

For failure due to yielding steel,

$$M_u = As\ Fy\ \left(ds - \frac{A_s\ Fy}{2b \times 0{\cdot}85Fc'}\right)$$

$$\frac{dn}{ds} = 1 - \sqrt{1 - \frac{2{\cdot}35\ M_u}{Fc'\ bd_s^2}}$$

These equations can be easily adopted in design.

Model Calculations :

Design of a simple slab for a Span of 10 Ft. and live load of 100 lbs. per sq. ft.

1. *By conventional method* :

Live load	=	100 lbs per sq. ft
5″ Slab	=	62·5 ,, ,,
Total		162·5 ,, ,,

$$M = \frac{Wl^2}{8} = 2031 \text{ Ft. lbs.}$$

Permissible Stresses :— $Fc = 750$ p.s.i. $F_s = 18000$ p.s.i. $m = 15$.

For balanced Section $d_s = \sqrt{\frac{2031}{126}} = 4{\cdot}02''$

with cover of 1″, D = 5″

$$A_s = \frac{2031 \times 12}{18000 \times 0{\cdot}87 \times 4} = 0{\cdot}38 \text{ sq. in.}$$

2. By ultimate load theory :

Live load	= 2·25 × 100 =	225 lbs./sq. ft.
Dead load 3¼″ Slab	= 1·2 × 41 =	50 ,, ,,
	Total	275 ,, ,,

a. For compression failure — in balanced section

$$M = \frac{1}{3}\ Fc'\ bd^2 = 3437{\cdot}5 \text{ ft lbs.}$$

Ultimate stresses – concrete = 2000 lbs/Sq. in. Steel = 36000 lbs/sq. in.

$d = 2{\cdot}28''$.

with cover 1″, D = 3·25″,

$$As = \frac{0{\cdot}456\ Fc'\ bd}{Fy} = \frac{0{\cdot}456 \times 2000 \times 12 \times 2{\cdot}3}{36000}$$

$= 0{\cdot}69$ sq. in.

b. As under reinforced beam with thickness of 5 inches.

Live load	= 2·25 × 100 =	225 lbs./sq. ft.
Dead load 5″ Slab	= 1·2 × 62·5 =	75 ,, ,,
	Total	300 ,, ,,

$ds = 5 - 1 = 4''$

$M_u = 45000$ in lbs.

$$\frac{dn}{ds} = 1 - \sqrt{1 - \frac{2{\cdot}35 \times 45000}{2000 \times 12 \times 4^2}}$$

$= 0{\cdot}15$.

$$As = \frac{45000}{36000 \times 0{\cdot}925 \times 4} = 0{\cdot}338 \text{ sq. in.}$$

Ultimate load equations have been readily adopted for the design of concentrically loaded, tied up and spiral columns in almost all building codes, since the experimental results proved beyond doubt that the transformed area equation based on straight line theory, did not a give a proper estimate of the behaviour and the strength of columns.

However, adequate ultimate load equations have not been developed so far, for members subjected to combinations of flexure and shear, or Flexure, compression and shear, or members subjected to dynamic loadings. Many empirical equations have been presented, but they satisfy only to members tested under similar conditions. In such cases where no reliable ultimate load equations are yet developed, the mode of design has to be based on elastic theory.

Application to Prestressed Concrete Design :

The advantage of the ultimate load methods in conventional R. C. design apply equally well to the field of prestressed concrete design. As in reinforced concrete, ultimate strength of prestressed concrete beams failing in flexure have been fully investigated and satisfactory expressions presented by many authors like Baker, Mattock, Billet etc. The ultimate strength of beams under combined bending and shear are under extensive study in the Research laboratories all over the Western countries. The author has investigated the behaviour of I beams in combined bending and shear. It appears, the main cause of failure is diagonal crushing due to strut action between load and reaction points, initiated by diagonal cracking, unless the beam has collapsed simultaneously with the formation of the diagonal crack. On the basis of strut action, simple equations have been developed (Ref. 2.) to estimate the ultimate shear resistance of such beams, and a statistical analysis of about 75 beams tested by various persons in different countries indicates that the equations suggested by the author enable a safe and reasonably accurate estimate of the ultimate strength. Still, its suitability for all conditions of loading and all types of beams have to be confirmed, before adopting it in the design codes.

Conclusion :

Ultimate design cannot be the cure of all evils as many problems are still being solved by elastic analysis. But with the adoption of proper load factors, its application yields a more logical, rational and balanced design, resulting in safer structure without extra cost. Our natural resources are not inexhaustible. We can no longer say, " In case of doubt, throw in some more material ". The philosophy of design by ultimate load theories, " aids in limiting this area of

uncertainity ". So, no wonder, the concrete engineers, have begun to discard the straight line method of design in spite of its mathematical background and take to the ultimate load method based on facts and not on assumptions.

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INSTRUMENTATION IN SCIENCE AND INDUSTRY

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PART—1

EVER since the dawn of Science, the scientific instrument has developed side by side with it. All devices, other than those endowed by Nature, which enable man to achieve a certain purpose, can, in the most general sense, be called an instrument. The yard stick which is used for measurement of distances or lengths is an instrument. The measuring vessel used for the transactions in solids and liquids is an instrument. The levers for lifting and displacing heavy bodies and the pulleys for drawing water from wells, the simple watch used practically by every alternate man, the domestic washing machine, the stove used for cooking and innumerable other devices were, at one time or other developed as instruments. In all forms of transport, instruments play a very important part. The automobile has an instrument panel which draws the attention of the driver, next in importance to only the track which he is to cover. The pilot of an aeroplane has nothing but instruments in front of him to indicate its position and speed in three dimensional space, its inclination, and the situations as to fuel and oil.

Thus the term instrument, at present, used in its broadest sense, includes all indicating and recording devices, measuring implements of all kinds, and all assemblies of components which control, either automatically, semiautomatically or manually, a wide variety of industrial and technical operations and processes. Although some instruments have been known for hundreds of years, it is only three or four decades since the "Science of Instrumentation" emerged in its own right. During this period, this Science has developed so rapidly and in such a wide variety, that it has become an independant aspect of engineering. Though originally, it was closely associated with metrology, it uses knowledge from many fields of Physics such as electricity and electronics, optics and acoustics, general mechanics being common to all, in addition to the highly specialised principles of instrument design.

"Man" as Carlyle put it, "is a tool-using animal Nowhere do you find without tools; without tools, he is nothing; with tools, he is all". The instrument has thus become indispensable in all aspects of human activity so much so

that development of instrumentation has become synonimous with advances in civilization. The variety of instruments in general use can be classified as under:

(a) Laboratory Instruments for teaching, development and research;

(b) Industrial Instruments for process and quality control;

(c) Devices for automatic mass production and safety and standardisation.

Understanding of science starts with use of laboratory instruments. The physical principles of statics and hydrostatics, dynamics, and hydrodynamics, of heat and thermdoynamics, of optics and acoustics, and of magnetism and electricity and electromagnetism are all learnt by laboratory experiments with instruments of a wide variety. Advanced researches are carried out with highly developed instruments both old and new. Time and labour saving devices are invented to record scientific phenomena which would have otherwise taken prolonged work requiring constant attention. Far-reaching developments in engineering, civil, mechanical and electrical are achieved by the use of scientific instruments. What were, at one time simple instruments are developed into prodigious machines to accomplish things on a larger scale. An example is the modern high-power turbo-generator whose fore-runner was the simple laboratory dynamo. Modern surgery owes its developments to advances in instrumentation. For both diagnosis and for treatment, scientific instruments are extensively used by the medical profession. Endoscopy is the latest instrumental technique for the study of the internal condition of the human system, without cutting open any part of the system. The microscope in its varied forms has revealed, to the investigating Doctor, things that made his probe into the causes of diseases much easier. Development of the electron microscope has enabled discovery of submicroscopic bacteria and viruses which has added to medical advances of a far-reaching character. Biological sciences owe their developments to instrumental devices.

In fact there is no aspect of scientific and industrial activity which does not use, in one form or other, the scientific instrument.

Modern industry is dependent entirely on instrumentation. In chemical engineering, controls play a very important role. Temperature regulation in chemical processes is achieved entirely by thermostatic regulators. Humidity control in factories is accomplished by automation utilised in air conditioning. Speed regulation is spinning mills is realised by instruments. Strength of fibres, twist in yarn, length of threads produced and their fineness are all measured by instruments. Modern oil refineries are all developed by fully automatic instruments. By such automation, not only is the skilled and semiskilled personnel required considerably reduced, but all risks to persons and property practically eliminated. But for automatic instrumentation, latest developments in science and technology would have been impossible.

The most recent and the most important development of the atomic reactor would not have been achieved without corresponding developments in control instrument engineering. The temperatures developed are so great and risks involved in the approach to the reactor, on account of its intense radioactivity, so dangerous, that all operations, without exception, are to be with distant controls. Commencing from the handling of materials and their relative disposition, to the correct placement of reactor substances, all reactions are brought about by a blind fold series of control mechanisms. From the process of counting the neutrons generated, to the control of the chain reaction that they produce, instruments form the brain behind all stages of the reaction.

If mechanisation was the aim of the nineteenth century, automation is the achievement of the first half of the twentieth century. At a time when wages of workers are incessantly on the increase, and hours of work on the decrease, curtailment in human labour has become a problem of the utmost importance. Demand for consumer goods is at the same time rapidly increasing. The only solution is maximum production with minimum of human effort, by the use of automatic machines. Automatic mass production of articles has become a necessity. Thus the modern tendency is towards the replacement of the skilled operator, by relatively unskilled labour assisted by automatic instruments. Herein lies the role of the Instrument Engineer. By the introduction of automation in industry, greater productivity and higher standards are achieved, maintaining at the same time lesser wages and hours of work.

Of all the machines in use in the modern workshop, the lathes, milling machines and shapers are the most common and numerous. The modern trend in the operation of these machines is to replace skilled by unskilled workers aided by instruments. Mass production of items like bolts and nuts, screws and nails is achieved by automation. Even grinding machines are made fully automatic. The automatic cycle in this operation consists of chuck, rough grinding, finish grinding and finally the wheel is redressed to be ready for the next cycle. Even feed of the material prior to machining is done automatically. Of late, in the

more advanced countries, new instruments and control systems have been developed for controlling cutting speeds, feeds, cutter loads and sizing of work dimensions.

Recorders and electronic controls have been devised by which repeat operations by lathes are accomplished. Initially the lathe is made to run through the various operations and a magnetic tape record is made of the same. By playing back the record and in conjunction with a series of electronic devices, the lathe repeats these operations any number of times till the record is worn out. Roughing and finishing cuts, change speed, taper turning, generation of regular or irregular shapes, loading and unloading of work are all repeated with a faithfulness that is impossible by manual labour.

Photoelectric devices are invented for operation of milling machines. A line drawing of the contour to be milled is first made and is placed on a photoelectric scanning device, in which the scanning head follows continuously and automatically along the line to be machined and electric signals are transmitted to the machine to run the corresponding motors of the feed table of the miller.

The basic principles underlying the design of instruments are mainly physical. Depending upon the application and use of the ever widening variety of these instruments, one, or several, of these principles is utilised in them. Based upon their functional characteristics, instruments can be classified broadly under four different heads.

(*a*) Indicating instruments for the description of the condition of any particular scientific phenomena for example, the Galvanometer which indicates the presence of electric current.

(*b*) Measuring instruments to specify definitely the above conditions in terms of standards of reference, for example, an ammeter or voltmeter which are calibrated modifications of the Galvanometer to measure current or voltage.

(*c*) Recording instruments for continuous record of the varying values of the above conditions; for example recording milliammeter or recording millivoltmeter.

and (*d*) Control instruments to keep the above values at desired positions within specified limits of tolerance; for example devices for keeping supply voltage constant under varying loads.

Instrumentation started with metrology or the science of measures and weights. With increasing knowledge in physical principles and improvements in experimental techniques, the precision of measurement has increased, and standards for comparison have correspondingly changed.

The most basic of metrology is measurement of length. It started with the meter stick giving an accuracy upto a minimum of 1 mm. The invention of the vernier principle, has increased the precision in this measurement to about 0·02 mm. An improvement on this is micrometer which has further reduced the minimum in linear measurement to 0·01 mm. and combining this with the vernier has enabled another stage in this reduction to 0·001 mm. Application of optical interference to linear measurements by the Michelson Interferometer has brought about a revolution in precision of line measurement to about the mean wavelength of visible radiation or 5×10^{-5} cm. or even fractions thereof.

Side by side, finer mechanical devices have also resulted in increased precision. By coupling a number of gears and pinions linear magnifications coupled with dials and pointers enable differential linear measurements to an accuracy of 10^{-4} cm.

While optical interference has brought about increased mechanical precision, applications of simple electrical phenomena, have proved of immense use in detection and measurement of minute linear displacements. In this, the electronic amplifier plays an important role. An alternating current passing through a coil of wire changes proportionately when an iron core in it changes position thus changing the magnetic fluxlinkage through the coil. The small change in current consequent on change of position of core is amplified and calibrated in terms of linear displacements.

Another interesting application of electromechanical phenomena for measurement of minute changes in linear dimensions is the strain gauge. It consists of a grid of fine resistance wire, which, when strained suffers a change in electrical resistance. Such a grid, called the strain gauge, is included in a Wheatstone bridge circuit which is initially balanced ; when the gauge is strained when attached to a mechanical strained body, the resistance varies resulting in an unbalance in the bridge circuit. The current change arising out of this is amplified and calibrated in terms of the mechanical strain.

A similar example is the change in capacitance with change in distance between the plates of a condenser. One plate is fixed and the other attached to the body whose mechanical displacement is to be measured. The capacitance

forms one of the four arms of a capacitance bridge which is initially balanced. A slight displacement of the moveable plate of the condenser disturbs the balance resulting in change of current which is highly amplified and calibrated in terms of linear displacements.

The phenemenon of electromagnetic induction is extensively applied in electrical instruments. The two types of moving magnet and moving coil galvanometers are well known. But the moving magnet type is practically out of vogue because of the fact that the restoring force due to the earth's magnetic field is too feeble to provide the requisite sensitiveness in the instrument. In the moving coil type however, the field due to the permanent magnet is large enough for increased sensitiveness of the galvanometers. Here improved techniques in the deflecting force and refinements of the controlling elements have brought about a precision that is impossible in the first categery. For permanent magnets, new magnetic steels like Alnico and Alcomax have revolutionised the range of sensitiveness of the devices. Production of phosphor bronze and beryllium copper for controlling suspensions for the moving coils have contributed for further improvements in precision. Not only is the precision increased, but stability of the instruments is achieved because of the new materials.

In the field of temperature measurements, a wide variety of physical principles are applied in the design and development of thermometers. The mercury-in-glass thermometer is based upon the principle of thermal expansion of liquids. In spite of its convenience in routine laboratory experiments, it has very many limitations. Its range is limited. It is too delicate for rough usage. The unavoidable defects in glass which forms the material for the container makes it useless as a standard of reference. Hence other types of thermometers had to be designed for larger ranges of temperature, rougher use and also for use as standards, and in some cases for higher sensitiveness also.

Gases having a much higher thermal co-efficient of expansion prove to be far better materials for greater sensitiveness. Of these, however, only hydrogen and helium have performance characteristics which make them useful for standards of reference as for example, the standard hydrogen thermometer for calibration of other thermometers over a wide range extending from — 200° to 1000°C.

The principle of differential thermal expansion of metals is widely used in industrial thermometers which are rugged and at the same time reliable. Their range of usefulness extends from several degrees below 0° to 500°C. Thin long strips of two different metals are rolled together and riveted at the ends and formed into a spiral. One end is fixed and the other end of the spiral opens out or closes in when raised in temperature. A pointer attached to the free end moving over a dial indicates the temperature to which it is subjected.

A liquid completely enclosed in a vessel with no free space above exerts high pressure when raised in temperature. The internal pressure of the liquid is a function of the temperature. If the liquid contained in a thick walled metal bulb is connected through a metal capillary to a Bourdon spiral, the whole system being completely filled with the liquid, the Bourdon spiral opens out due to the pressure developed with increasing temperature. The mechanical strain in the spiral is magnified by a rack and pinion to which is attached a pointer moving over a dial calibrated in terms of temperature by reference to a standard thermometer. Such an instrument can be used upto the critical temperature of the liquid.

Increase of vapour pressure of a liquid with temperature is also utilised for measurements of temperature with a similar mechanical set up, the only difference being that there is thermal equilibrium between the liquid and its vapour which equilibrium changes with temperature.

The above are some of the thermo-mechanical instruments used in Science and Industry. Equally interesting and useful are some of the thermo-electric phenomena. When a pair of thermo-junctions is maintained at a difference of temperature an E.M.F. is produced which is a function of the temperature difference. Different thermocouples made out of pairs of metals or alloys have different characteristics in respect of sensitiveness, stability, reliability, and range of usefulness. Pairs of materials in common use are :

Thermocouple	Sensitivity per °C m. microvolts.	Range in °C
Cu — constantan	52	— 200 to 400
Fe — constantan	58	— 200 to 1000
Chromel - Alumel	40	— 200 to 1400
Pt - Pt. Rh.	10	0 to 1700

Thermo - electric thermometers have the widest range of application in temperature measurement.

The other important electric effect is variation of resistance of wires with temperature. In practice it is used only for standardisation work with the platinum resistance thermometer.

For still higher temperatures, there are two types of pyrometers based upon physical principles of high temperature radiation. One type, called the total radiation pyrometer, works on the Stefans law of radiation and the other called the optical or disappearing filament pyrometer adopts the Planck's law of spectral distribution of intensity of radiation from a hot body. Thus several thermic principles are applied in a wide variety of thermometers for use in scientific investigations and industrial processes.

Principles of optics have even a wider application in instrumentation. The basic phenomenon of all optical instruments is that of image formation by reflection or refraction. Angular magnification is the primary principle in the functioning of telescopes which are used for study and measurements of both terrestrial and celestial objects. The smaller among them are of the refracting type, while the larger are mostly of the reflecting category. The laboratory reading telescopes, the surveying levels and theodolites, the terrestrial and astronomical telescopes, spectroscopes and spectrometers, sextants, periscopes and a host of other kinds of optical equipment have the telescope as the main component in conjunction with mechanical devices to suit the work for which they are designed.

The other extreme is the microscope for linear magnification of objects which are too small to be seen with the naked eye. Routine microscopes are mostly of the refracting type, but the latest in the field are reflecting microscopes which are easier to manufacture, without sacrifice of efficiency or power. Application of the principle of phase-contrast has considerably improved the visibility in image formation by microscopes.

Microscopes of varying degrees of magnification and numerical aperture as used for 1) precision linear measurements as in vernier microscopes and micrometer microscopes ; these are of low magnification varying from 120 to 40.

(2) biological, clinical, pathological and bacteriological purposes ; these are of high magnification varying from 400 to 1500 including oil immersion work with staining.

(3) petrological work including polarising accessories ; also used for micro-crystallography.

(4) metallurgical applications ; these are for study of opaque objects

and (5) phase contrast work for transparent objects.

More complicated optical instruments are spectrographs, spectrophotometers, the latter two being of both the non-recording and recording types. While spectrographs are modifications of spectroscopes for photographic purposes, microphotometers and spectrophotometers include, in addition to precision mechanical components, electrical accessories like thermocouples and photo-electric cells for detection and measurement of small intensities of radiation. In some spectrophotometers there are polarising optical components also like Nicols and double image prism. As an example will be described one advanced type of spectrophotometer which comprises a complicated system of optical and electrical assemblies.

Applications of these spectrophotometers are many and varied. Primarily they are intended for spectro - mechanical analysis. There are complicated automatic instruments of this category for infra-red, visible and ultraviolet radiation. The substance that is to be analysed is to be fed at one end of the instrument to an electric are which is permanently aligned in the spectrophoto meter which is run by meters and the analysis is given within a short time indicating the percentage of the different elements in the sample, at the other end in the form of a recorded chart.

The uses of instruments in scientific studies and researches are many and varied. Instruments enable man to measure linear dimensions as small as 10^{-13} cm. which is the size of the nucleus of atoms by the study of deflections of fundamental particles in collision with these nucleii. Also distances as large as several millions of light years are measured by methods of parallax using telescopes. Speeds ranging from a few cm. per second to the speed of light which is 3×10^{10} cm. per second are also determined with an accuracy of one in a million. Weights of particles as small as the electron, proton or neutron are found with a similar degree of accuracy all by scientific instruments. Weights of stars, of enormous magnitudes, are indirectly calculated by application of physical principles in instruments. If our knowledge of science is what it is at present, it is all due to applications of instruments.

INDIAN STANDARD SAND

by

M. MIAKHAN, B. E., M. Sc., Tech. (Manch), A. M. C. T.

1. Introduction :

Standard sand can be defined as a standard fine aggregate for mortar mixed for the purpose of assessing the quality of the cementing material. It is mostly used for testing cement so as to ascertain whether it conforms to the strength requirement laid down in the relevent standard specification for cement (ordinary, rapid hardening, etc).

Formerly the British standard sand from Leighton Buzzard in England was being used in India for testing cement etc., and in 1955 it was replaced by Indian Standard sand from Ennore, near Madras city. This article describes the salient facts leading to the discovery of the Indian standard sand, the advantages and uses.

2. Specifications :

According to the British standard specifications, the standard sand should be of white variety, thoroughly washed and dried, and should pass through a B. S. test sieve No. 18 (: mesh opening 0·853 mm, or 853 microns), and not more than 10 percent by weight retained on B. S. test sieve No. 25 (: mesh opening 599 microns). The loss of weight on extraction with hot hydrochloric acid (50% concentration) of specific gravity 1·16, should not exceed 0·25 percent.

3. Requirements :

The obvious aim in replacing the British standard sand with indigenous material is to avoid the high cost as well, as to save foreign exchange. But it was equally important to maintain the quality and assure that the Indian standard sand should match with the foreign sand as closely as possible. As the Leighton Buzzard sand is light grey in colour, and almost entirely (: 99·58%) made up of quartz grains, mostly sub-angular in shape, the investigations carried out mainly aimed at the discovery of a similar type of sand in colour, texture and composition.

4. Investigations and Results :

Investigations were conducted on samples of sand collected from different parts of the country in Research Laboratories, at Madras, Khalari, Hirakud and Hyderabad. So far as the laboratory at Madras was concerned, the pit sands available at Ennore & Bapatla were examined. The sand deposit at Ennore occurs as a layer one to two feet thick, five to six feet below ground level and extends over about 1½ Sq. miles area near the Madras - Ennore Road. The colour is whiter than Leighton Buzzard sand and mineral content is about 99·3 percent quartz. Weathered white felspar is present in small proportions.

The sand from Bapatla is light brown in colour and is mostly quartz with a fair amount of weathered felspar. The sand is obtainable from the surface at Ramperu, which is not far from the sea coast. The results of tests conducted on samples of standard grade passing through B. S. No. 18 and retained on B. S. No. 25 are shown below :

Properties	Ennore Sand	Leighton Buzzard Sand	Ottawa Sand	Bapatla Sand
I. *Physical properties* :				
1. Colour	Greyish white	Light grey	Colourless	Light brown
2. Specific gravity	2·64	2·65	2·63	2·61
3. Absorption in 24 hrs.	0·80%	0·30%	—	0·70%
4. Shape of grains	Sub-angular	Sub-round	Round	Sub-angular to Sub-round
II. *Chemical properties* :				
5. Chemical Analysis SiO_2	99·30%	99·58%	97·40%	—
Al_2O_3	—	0·27%	Traces	—
Fe_2O_3	0·10%	0·03%	Traces	—
CaO	—	0·22%	Traces	—
6. Loss on extraction with HCl.	0·11%	0·13%	0·24%	0·25%
7. Loss on ignition	—	0·13%	0·20%	—
III. *Petrographic analysis* :				
8. Quartz	97·4%	Nearly 100%	Nearly 100%	8·33%
Felspar	2·5%	Traces	—	16·6%

On account of the greater yield, less impurities, and better durability, the Ennore sand was finally recommended for processing standard sand and also accepted by the Indian Standards Institution who have issued the relevent standard specification No. I. S. 650·1955.

Manufacture and supply :

The excavation, processing and supply of Indian standard sand is being exclusively done by the Concrete and Soil Research Laboratory, Madras. The standard sand is packed in metallic Containers at the store shed at Ennore, and supplied at a cost of Rs. 470/- per ton, exclusive of cost of metallic containers and Railway freight. This works out to be much cheaper than Leighton Buzzard sand which sold at Rs. 940 per ton in the year 1953, and the American standard sand which cost at 6·46 dollars per cwt in 1948.

Uses : The sand can be used as follows :

i. Testing of cement, lime and other cementing materials.

ii. Study of the comparative properties of cementing materials with and without admixtures.

iii. As an abrader for standard abrasion tests.

(i) The tests on cement, for which standard sand is required are tensile strength and compressive strength of mortar 1:3, by weight. 300 gms of cement should be thoroughly mixed with 900 gms of standard sand and water added as per formula $\frac{0 \cdot 78P}{4} + 2 \cdot 50$ percent where P is the percentage of water required for normal consistency in the standard consistency test. The usual value will be in the order of 7·5 to 8·5 percent on the cement sand mixture by weight. The mortar should be evenly distributed in the 6 standard briquette moulds kept over a non-porous plate and well beaten down by means of standard spatula, until water appears on the surface. The briquettes may be removed after 24 hours and cured in water at 80°F to 90°F. The average tensile strength of such briquettes tested at the age of 3 days and 7 days (Six numbers to be tested for each period) should be atleast 300 lbs/sq. inch and 375 lbs/sq. inch respectively for ordinary Portland cement.

For Compression tests, the following materials are required :

Cement : 185 gms.

Standard sand : 555 gms.

Water : 74 gms. (10% of dry materials)

The mortar should be placed in a 2·78 inch cube mould and compacted by vibration. The specimen is taken out after 24 hours, cured in water and tested at the age of 3 days and 7 days. The minimum strength required for ordinary Portland cement is 1600 lbs/sq. in. for 3 days and 2500 lbs/sq. in. for 7 days.

(ii) For studying the effect of adding admixtures to cement in order to improve the hardness or imperviousness or other properties, the use of a standard fine aggregate is indispensable. The standard sand is well suited for such a purpose. Cubes or briquettes cast with and without the admixture, can be tested and the comparative properties studied.

(iii) In the determination of resistance to abrasion of various materials such as building stones, concrete etc., a fixed quantity of a standard abrader is to be used. The standard sand is very useful for this purpose, on account of the hardness of the quartz particles of which it is made up.

EXCELLENT MATERIAL OF CONSTRUCTION 'PVC'

by

Shri. S. SRINIVASAN AND Shri. P. A. CHENGAPPA.

Plastics may be defined as organic materials that can be easily molded or shaped by mechanical or chemical action to give tough and noncrystalline substances that are solid at ordinary temperatures. These solids may have various substances incorporated with them to impart colour and strength.

The plastics are used very widely in Chemical Industries and in particular PVC has earned a unique place among them because of the remarkable easiness to work with that material and also a high degree of resistance to many of the industrial chemicals. The resistance of PVC to various chemicals with the limiting temperature is given in the table at the end of this article. PVC is used in Chemical Industries to handle mostly corrosive acids, alkalis and gases and there is no corrosion problem involved in PVC at all. By virtue of this it is rapidly replacing the rubberlined equipments and special alloys used in handling corrosive chemicals. Nodoubt, rubber withstands the action of acids and alkalis but the life of rubber lining in common practice is about 5—6 years after which it requires renewal. Even a pin-hole in the rubber-lining is sufficient for the chemical handled to penetrate and corrode the metal exposed to it. It is not possible to detect these pin-holes and other defects developed during operation until the metal exposed is completely eaten away. Moreover fabrication of vessels pipes etc., to be rubber lined should be of very high standard with all care taken to avoid any blow-hole or protruberance in the surface. This is a job of an expert and a very costly one too. The surface should be absolutely free from grease and rust. Utmost care should be taken for preparing a good surface before rubber-lining.

As far as the alloyes go, they are covered usually by patents and besides being very costly, there is no alloy which will withstand the actions of such a wide range of chemicals as PVC does. Above all, it is very light compared with steel and other materials, and it is easy to instal the article made of PVC.

PVC has got excellent chemical, thermic, mechanical and electrical properties, so that it proves to be of no less importance in electrical and other fields than Chemical Industry. It is a very good insulating material for cables. It is used in automotives and aeroplanes because of beauty, strength, oil and electrical resistance. It has got an unlimited scope in the field and decorative arts too, since it can be imparted almost any color combination available.

PVC cloths and yarns are also used in chemical industries to a wide extent besides luxury articles, such as Handbags, upholsteries etc. Our works uses PVC cloth in Bag Filters as filter elements for handling alkaline solutions of brine with sludges.

In the Chemical Industries, PVC is being used in the form of tubing and piping, plain or laminated piping, tanks, absorption towers etc.

The following are some of the important thermic, Chemical, mechanical and electrical characteristics of PVC from which the reader can have an idea of its application :

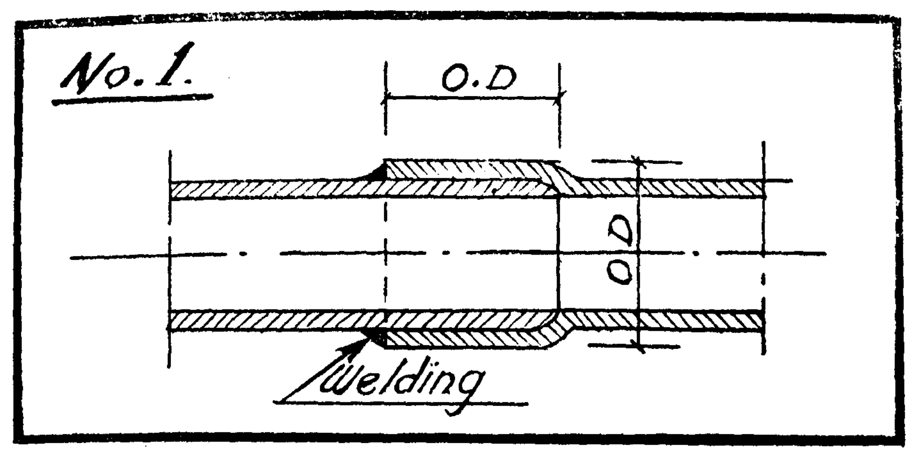
Density	1·4
Resistance to elongation	600·0 Kg/cm^2
Resistance to compression	800·0 ,,
Resistance to bending	1200·0 ,,
Resistance by shock	150·0 Kg/cm/cm^2
Hardness	1200·0 ,,
Elastic modulus	50·000 ,,
Superficial electric resistance	3 × 106 Mu
Transversal ,, ,,	106 Mu
Dielectric constant	W×/10^3 cycles/S 3·4
Breaking voltage	KV/mm 20·0
Calorific conductivity at 20°c	35 × 10^6 cal/cm/cm^2/sec/°c.
Coleft of linear expansion	0·08 mm/m/°c.
Specific heat	0·32 to 0·51
Combustibility	Incombustible but carbonises without burning.

PVC can be molded and such molded pieces are often used as insulators in electrical side. PVC pipings are manufactured by extrusion. It is of thermo-plastic nature that it becomes pliable at a temperature of about 80° C but regains its original rigidity when cooled. In the pliable state, it can be expanded or shrunk to suit our purpose and then cooled by water to retain its shape The heating is done usually with kerosene blow-lamp or oil baths. It is not. inflammable, but over-heating chars the material. The right state of pliability is felt by pressing it with hand all over the heated portion when it will yield to any shape desiredeasily.

Two pieces of PVC can be welded with special PVC welding rods. The welding is a skilled and a specialised job. The welding rod is melted and the molten PVC is filled in the gaps or grooves cut already. The rod is melted with hot air under pressure directed towards it. This is done by a welding torch. This consists of a heating coil made out of copper tubing to which compressed air is supplied from mains or compressor. The pressure required is about 3 kgms/cm^2. In the centre of the coil, there is a jet of acetylene which derives its supply from an acetylene cylinder. The jet is lighted and the acetylene flame heats the air passing through the coil and this hot air in turn melts the PVC welding rod. The article to be welded is turned when the molten PVC fills the gaps or grooves, thus ensuring good welding.

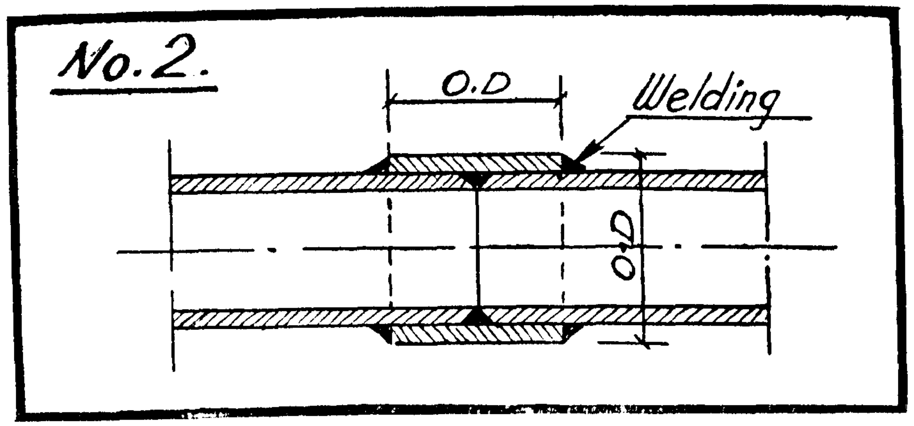
In our works, PVC has been extensively used in pipings, blowers etc., to handle HCl gas, Chlorine gas and soft water. The use of PVC in soft water line is mainly to minimise the contaminations of soft water by metal which are not desirable for smooth working of mercury cells for producing rayon grade caustic soda. Such contaminations are likely to occur when pipe lines of other materials are used.

PVC pipes of same dia can be joined to one another by three methods. The first and the simplest method is to expand one end of the pipe to the outer diameter of the other pipe and then inserting the second pipe into the first. These pipes are welded at the junction. This method is used when the pipes are of small diameters.

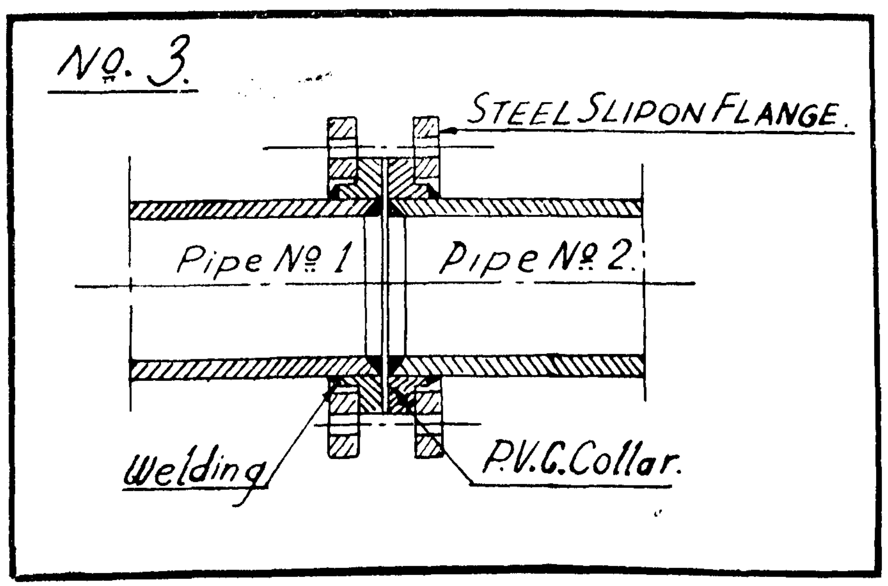


The second method is to join the pipes with PVC coupling. The coupling is just a pipe piece whose inner diameter is equal to the outer diameter of the pipes to be joined. The two pipe pieces are welded first at the junction and then the coupling is driven to the centre. Welding is again done at both the ends of coupling as shown.

The third method is by having flanged ends. Flanges can be prepared out of PVC and welded to the pipes. In this case tightening of the flanges by



bolts should be done carefully and uniformly lest the PVC flange may break. It is also usual to have iron slip on flanges too on pipes welded with PVC collars.



PVC has also got certain draw backs which are worth mentioning in this connection. It has got low mechanical strength even though several materials such as paper pulp, sawdust, glass fibre and others are added during the manufacture to increase its toughness and strength. It is brittle and should be handled with great care. It cannot be used at temperatures greater than 70°C. The co-efficient of linear expansion is very high being 0·08 mm/meter/°C. So in pipe laying, sufficient allowances have to be given for free space for PVC to expand and also expansion joints to be provided along the pipe line.

Resistance of PUC to Chemicals.

Substances handled	Resistances	Limiting Temp. 0°C
Salt solutions :		
Dilute or concentrated solutions of NaCl, Alum, Salts, and Ca, Na, K, Zu, Cu, Sn, Mg, Ni, Pb, Al, NH_4 etc.	G F	40 60
Bases :		
NaOH, KOH — Dilute	G F	40 60
NaOH, KOH — Concentrations upto 40%	G	60
Mineral Acids :		
Sulphuric Acid - very dilute	G	40
,, ,, 40 to 80%	G	60
,, ,, 80 to 90%	G	45
,, ,, 90 to 100%	G	60
Sulphurous Acid	G	40
Hydrochloric Acid - dilute	G	40
,, ,, 30%	G	60
Nitric Acid - dilute	G	40
,, ,, 30 - 50%	G	50
,, ,, 50 - 60%	G	20
Phosphoric Acid - very dilute	G	40
,, ,, 30%	G	60
,, ,, 30 - 60%	G	20
Chromic Acid - dilute	G	40
,, ,, 35 - 50%	G	50
Gases :		
Chlorine - Dry	G	20
Chlorine - Wet	F	40
Hydrogen chloride - Dry	G	60
,, ,, - Wet	G	40
Carbonic Acid - Dry	G	60
,, ,, - Wet	G	40
Ammonia - Dry	G	60
,, - Wet	G	40

Substances handled		Resistances	Limiting Temp. 0°C
SO_2	– Dry	G	60
SO_2	– Wet	G	40
SO_3	– Dry	G	60
SO_3	– Wet	G	40
Oxygen		G	60
Ozone		G	20
Hydrogen		G	60
Calcination gases		G	60
Combustion gasses		G	60
(containing CO_2, HCl, H_2SO_4 & SO_2)		G	60
Organic Acid :			
Acetic Acid	– Very dilute	G	40
,, ,,	– 25 to 85%	G	60
,, ,,	– 85 – 90%	F	40
,, ,,	– 90%	F	20
Formic Acid	– 50%	G	40
,, ,,	– Concentrated	G	20
Oxalic Acid	– Very dilute	G	40
,, ,,	– Concentrated	G	60
Lactic Acid	– Very dilute	G	40
Alcohols Aldehydes & Phenols :			
Formaldehyde – dilute		G	40
Formaldehyde – at 40%		G	60
Acetaldehyde – at 40%		G	40
Ethyl Alchohol at all concentrations		G	40
Methyl Alchohol at all concentrations		G	60
Glycerine		G	45
Phenol Acquous solution		F	45
Cresol ,, ,,		F	45

Note : G represents 'Good'
F ,, 'Fair'

The following table gives an interesting statistics about the production and demand of PVC sheets, cloth and pipings as in the year 1957, in India.

		PVC sheets	PVC cloth	PVC tubes
1	Capacity	1150 Tons	4·9 Mil. Yds.	Not available
2	Production in 1957	175 Tons	3·28 ,,	About 3 lakhs yds
3	Name of consumers	All manufacturers of purses, hand bags and other novelty goods.	Automobile & Rly. Coach Manufacturers.	
4	Estimated consumption by 1960/61	Near about capacity.	May be of the order of the capacity.	
5	Estimated rated capacity by 1960/61	Not expected to increase.	No increase is expected.	

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RECENT ADVANCES IN CONCRETE TECHNOLOGY, DESIGN AND CONSTRUCTION TECHNIQUES *

by

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PART I—MATERIALS

ALTHOUGH some form of concrete is known to have been used since the ancient Roman times— about 2000 years ago—our scientific knowledge of Portland cements, concrete technology and design, dates only from the beginning of this century. But the past decade or two have seen the development of certain marked trends in concrete design and construction. The recent developments could be classified under four major heading.

1. Materials.
2. Concrete technology.
3. Structural design.
4. Construction Techniques.

Materials :

Portland Cements

The principal material used in making concrete is Portland Cement.

While it is well-known that Portland cement was first manufactured about 135 years ago, the basic knowledge of its constituents and their properties and influence on cement characteristics is quite recent. Even today the knowledge of the chemistry of Portland cements is far from complete.

We however now know that the principal constituents of the finished cement are :—

Tri-calcium silicate	C_3S
Di-calcium silicate.	C_2S
Tri-calcium aluminate.	C_3A
Tetra-Calcium alumino-ferrite.	C_4AF
Magnesia.	MgO

and small amounts of other compounds.

* The Substance of Special lecture delivered at the Department of Engineering - Annamalai University.

When burning is incomplete or when excess of lime is present in the raw mixture, free calcium oxide (CaO) is also present. Besides, caustic alkalis Na_2O and K_2O are often present as minor constituents. The properties of these and their influence on cement characteristics are given below.

	Properties.	Effects on cement characteristics.
Tricalcium silicate. C_3S 3 CaO, SiO_3	(a) Being high in lime, it liberates larger quantities of free lime on hydration.	(a) Contributes to strength at all ages and largely so upto 28 days.
	(b) Evolves greater heat of hydration.	(b) Higher percentage gives higher early strengths.
		(c) Controls to a limited degree the setting of cement.
Di-calcium silicate. C_2S 2 CaO, SiO_2	Hydrates very slowly after 28 days. Evolves very little heat during hydration.	Contributes to strength at later ages.
Tri-calcium Aluminate. C_3A 3CaO, Al_2O_3	(a) In glassy form (quick quenched clinker) it sets very slowly, but in crystal state, it sets very fast (flash set).	(a) Contributes to strength at 1 day. (b) Larger percentage increases susceptibility, to sulphate attack, as also increases danger of shrinkage cracking due to excessive heat evolution.
	(b) Evolves larger heat during hydration.	
Tetra-calcium Alumino ferrite C_4AF. 4CaO, Al_2O_3 Fe_2O_3	(c) Helpful in reducing clinkering temperatures in conjunction with C3A which is responsible for rapid stiffness of cement pastes and deterioration through sulphate attack.	Neither contributes directly to strength nor affects setting. Substitution of $C3_A$ by C_4AF decreases heat evolution and increases resistence to sulphate attack.

The ultimate strength potentiality of a Portland cement depends upon the combined value of C_3S and C_2S. Higher the percentage of C_3S the faster is the rate of gain of strength at all ages, particularly at early ages. The quantity of lime liberated during hydration of C_3S is also greater. A larger percentage of C_2S on the other hand gives a slow and steady increase of strength at later ages.

A comparison of C_3S and C_2S contents in the compositions of old and modern cements and fineness of grinding along with the strength requirements of standard specifications over the past few decades will be found of interest.

Compound.	Old time cement.	Modern day cement.
S_1O_2	21·70	21·00
Al_2O_3	7·10	6·50
Fe_2O_3	2·50	2·50
CaO	62·20	64·00
MgO	3·80	2·50
SO_3	1·60	2·10
C_3S	32·80	48·00
C_2S	37·00	27·00
C_3A	14·20	12·00
C_4AF	7·70	8·00

It is interesting to note that the change in the composition is appreciable in respect of only two compounds C_3S and C_2S.

British Standard Specification for Portland Cement.

Date of issue of specification.	Minimum tensile strength specified 1 : 3 mortar.			
December 1904	120 lbs./sq. inch	at 7 days	80% passing	170 B. S. sieve
June 1907	150	,,	,,	,,
March 1915	200	,,	,,	,,
October 1925	200	,,	,,	,,
November 1931	375	,,	90%	,,

MgO is present in cement as an impurity and finds its way through impurities in raw materials and particularly with magnesian limestones (dolomitic). MgO, if present in crystalline form gives unsoundness to cement as the very slow process of hydration causes delayed expansion and disruption of concrete. Evil effects of MgO are however nullified, if it remains in the form of extremely fine particles (glassy) and does not have a chance to crystallise, because in this form, hydration is accelerated and no delayed expansion results.

It is clear that better basic knowledge of the mechanism of Portland cements gained so far has made possible their planned development and improvement to meet the varying and progressively more exacting needs of the architect, engineer and products manufacturer. They can now have

(1) High Early Strength or Rapid Hardening cements for precast or prestressed concrete work for rapid re-use of moulds.

These cements do not differ significantly in composition from ordinary Portland cement, but are essentially more finely ground, the surface area varying between 2500—3000 sq. cm./gm. (Wagner Turbidimeter) against 1800—2400 for ordinary cements. They have higher percentage of C_3S and C_3A, which are responsible for high early strength. They tend to evolve greater heat of hydration and have higher volume changes. Durability of these cements is lower than that of ordinary cements.

(2) Low Heat cements for low heat of hydration for mass concrete work.

In these cements, the C_3S, C_3A contents are reduced to the minimum to cut down the heat of hydration, These are therefore more slow setting than ordinary Portland cement, but have a higher resistance to chemical attack.

(3) Sulphate Resisting cements for increased resistance to attack by sulphate bearing soils or ground waters.

These are similar to low heat cement, but C_3A content is further restricted to less than 5%.

(4) High Alumina cements for very high early strength and resistance against corrosion and heat.

Being made from bauxite and lime, they have CA as their principal cementing compound as against CS compounds in the case of ordinary Portland cements. They, evolve considerable heat during early stages of hydration and are therefore particularly suitable for low temperature placing operations.

There are also other types of cement which are now manufactured, such as white or coloured cements, blast furnace cements, puzzolanic cements, masonry cements, air-entraining cements, hydrophobic cements and expanding cements.

Hardening of the cement paste.

There are two theories profounded to explain the process of hardening of cement.

Crystallisation theory

According to this, the hydrated cement compounds from a growth of interlocking crystals similar to those in the crystallisation of plaster of Paris and which account for the growth in strength.

Gel Theory :

According to this, the cement paste is considered to be a supersaturated solution of hydrated compounds, which eventually coagulate into an amorphous mass called " gel " and which on drying out shrinks and binds together with the aggregates in a fashion similar to glue.

Recent research in the subject has shown that both the theories are applicable, the alumina compounds being in line with the crystallization theory and the lime-silica compounds satisfying the ' Gel Theory '.

To sum up, developments in Portland cements have been largely directed towards improved durability and higher strengths especially at early ages. The latter have been achieved by a combination of factors including—

(*a*) An increase in C_3S content and

(*b*) An increase in fineness of grinding.

In addition to other factors difficult to evaluate, such as improvements in, and better control of manufacturing processes, have played an important part, not only in the improvement of strengths, but also in the uniformity of the product.

The cement research worker today has at his disposal tools unknown to his predecessors. Simple chemical analysis is reinforced by X-Ray analysis, microscopic examination, spectrography, flame photometry and more recently by the electron microscope and the use of radio-active tracers.

Aggregates :

The next important constituent of concrete is the aggregate and recent studies have shown the influence their character have on it. These have revealed to what extent the strength, shape, surface texture, size and grading of aggregates affect the workability, strength, density and water tightness of concrete. Such information now assists the designer to specify the type of aggregates to suit his exact requirements.

In the past, all aggregates were regarded simply as inert material, but recent laboratory work and field experience have shown that certain kinds of aggregates are reactive such as opal, chalcedony, cherts, flints, and volcanic tuffs. These are now known to contain amorphous silicious mineral constituents, which react with the alkali (Na_2O, K_2O) in the cement and cause serious internal expansion in concrete, resulting in cracking and early deterioration of concrete structures. These are called " alkali-reactive aggregates " and their use must be avoided.

The alkali-reactive aggregate came into prominence when serious deterioration of concrete in the Parker Dam (in America) occurred within five years of its completion. Once identified, this reaction served to explain many hitherto baffling cases of deterioration due to gross expansion within the concrete.

In Europe and America, light-weight aggregates such as foamed slag and expanded clays and shales have been developed for making structural light-weight concrete with 28 day compressive strength of 3500 to 4000 lbs/in. weighing about 95 to 105 lbs. per cu. ft. The use of such aggregates produces considerable saving in dead loads and consequently economy in cost particularly of multi-storied buildings.

Expanded vermiculite and expanded obsidian called " Perlite " have also been developed as light-weight aggregates for giving concrete or mortar, excellent thermal insulating properties. Sprayed-on vermiculite mortar (Pyroc) has also been used on wrapping of expanded metal for fireproofing of steel framed structures with large savings in dead weight and cost.

Admixtures :

The use of admixtures, once frowned upon by most concrete technologists has now assumed a greatly increased importance and status. Some American leaders in concrete research have even expressed the opinion that future improvements in concrete as a constructional material are likely to depend more on the use of admixtures than on any other single factor. The reason for this change in outlook is the development of new class of admixtures — and primarily the development of air-entraining agents and pozzolans.

The use of air-entraining agents — whether interground with the cement or added at the mixer — is generally rated in America as the most important advance in the science of concrete making. Their use substantially improves the workability of the plastic mix and durability of the hardened concrete.

The use of surface-active agents also improves the workability of concrete with lesser water-cement rate, and thereby increases the strength of concrete.

The use of pozzolan is actually a reversion to early Roman practice. Suitable pozzolanas used even as a replacement for part of the Portland cement improves not only durability, but other concrete qualities viz—

(1) Reduces temperature rise and thermal and drying shrinkage.
(2) Develops early strength slowly but gives high ultimate strength.
(3) Improves workability, permeability and crack resistance.
(4) Increases resistance to sulphate attack.
(5) Limits the expansive alkali—aggregate reaction.

Pozzolanas have been extensively used in different countries—' Fly ash ' in America, " Trass " in Germany, Italy and Holland, while Surkhi has been recently tried in our country. Actually, ready-made Puzzolanic cements are marketed in Germany.

There also has been development in the manufacture and use of other admixtures like integral water-proofers, quick-setting compounds retarders hardeners, foaming agents, Colouring pigments etc.

Equipment :

Some of the latest equipment that has been developed for making concrete are :—

(1) Aggregate screening and washing plants.
(2) Weigh-batching plants for providing quality-controlled concrete on large jobs.
(3) Ready mixed concrete plants including truck-mixers or truck agitators for providing quality concrete even to small concrete consumers.
(4) Wheel barrows, chutes, cranes, skips or elevator buckets for transporting concrete for short distances.
(5) Belt conveyors or Buckets carried by aerial ropeways or concrete pump units for transporting concrete over long distances.
(6) Vibrators for compacting concrete.
(7) Block and brick making machines.
(8) Membranes for curing in-situ concrete.
(9) Auto-claves for high pressure steam curing of pre-cast concrete units.

PLASTIC DESIGN OF STEEL STRUCTURES.

by

Prof. L. VENKATESAN and Sri. T. JAGDEESAN

THE plastic design of steel structures is a new method of design and is being used increasingly in designing of structures in countries like U. K. This method is more rational and also results in saving of steel of about 20%.

The Multi-storey steel frames are generally designed by orthodox conception of pin joints. But this results in very uneconomical sections. In England, during 1928 to '36, a steel Structures Research committee was formed and they went into this question and sought a better method for the design of steel framed structures. They investigated the actual stress distribution in existing multi-storey buildings and found out that the actual stress distribution had no relation at all to the stress-distribution assumed for the purpose of the Orthodox elastic design. Hence it was decided that the elastic method of design could not be used as the basis of an improved rational design method. Investigations were directed to the behaviour of a structure when it is actually over-loaded so that the elastic range is passed at critical points and the plastic range has begun. It was found, the conditions of the structure at this stage, that is the collapse stage of the structure, are simple and a practical rational method of design based on this, could be established.

Let us first review the stress-strain curve for annealed mild-steel as produced during a tension test. The stress-strain diagram is as shown in Fig. 1.

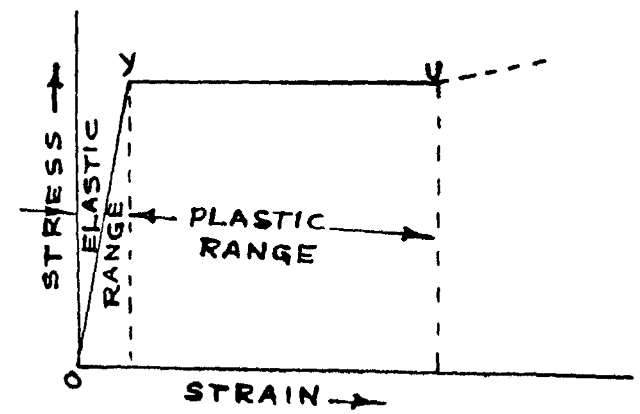


FIG. 1.

Y is the yield point. The plastic flow begins at this point and strain continues to increase upto point U without increase in stress. Beyond the point U, strain-hardening takes place. From O to Y, the material is in elastic range and from Y to U it is in the plastic range. As seen in the Fig. 1 the plastic strain is considerable in magnitude compared to the elastic strain and it is on this fact that the plastic theory is based.

Now let us examine the behaviour of a simply supported beam with a concentrated load when the load is increased gradually. At the section where there is a maximum B. M., the fibre stress across the section will be as shown in Fig. 2—i.

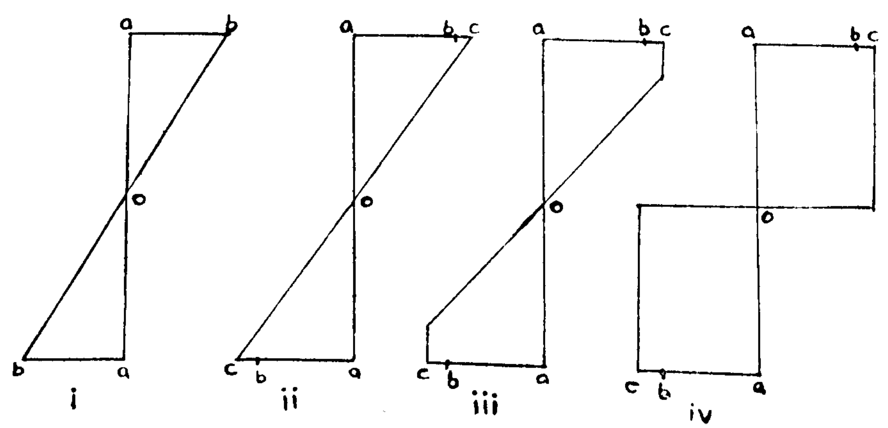


FIG. 2.

The stress distribution is linear and let this maximum fibre stress correspond to the working stress of the material, caused by a load W_w. As the load is increased at one stage the extreme fibre stress will attain the value of the yield stress (Fig 2—ii) and for any further increase in load, this fibre will yield without adding to the resistance. The inner fibres will be stressed more and they will in turn reach the plastic stage as shown in Fig. 2--iii. This goes on until all the fibres become plastic under a load called the collapse load W_c. At this stage the section is said to be fully plastic. Any further increase in the load will continuously increase the deflection and cause the collapse of the beam. The beam will behave as if it were hinged at this section which is fully plastic. Hence this section is said to have become a " plastic Hinge ". Its action is more like a 'rusty hinge'. The ratio of the collapse load to working load (W_c/W_w) is called the " load Factor ".

We can work out the load factor, for different sections, as follows : Taking the case of a rectangular section of breadth 'b' and depth 'd' and

assuming the working stress of 10 Tons/Sq" and a yield stress of 15·25 Tons/Sq", it is seen clearly from Fig. 3. that the moment of resistance under working load.

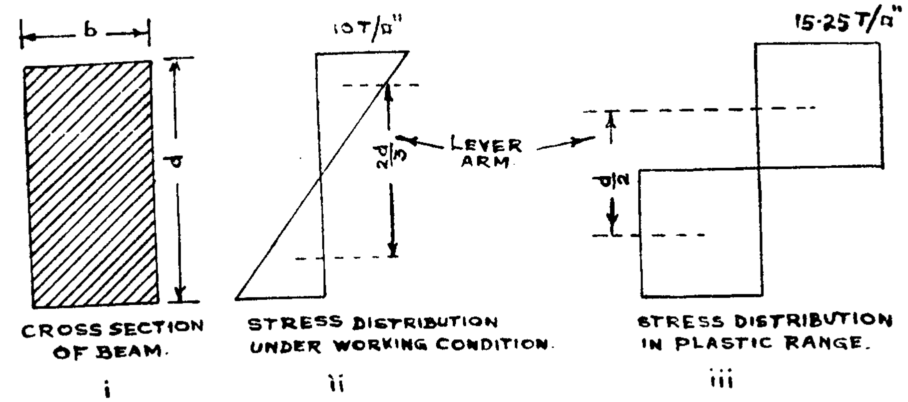


FIG. 3

$$M.R_w = 1/2 \times 10 \times d/2 \times b \times 2/3\ d$$

$$= 10 \times \frac{bd^2}{6} = f_w .\ Z.$$

Moment of resistance under collapse load (M.Rc)

$$M.R_c = 15{\cdot}25 \times d/2 \times b \times d/2 = 15{\cdot}25\ \frac{bd^2}{4}$$

$$= f_y \times \text{the first moment of area about N.A.}$$

$$\text{Hence, load factor} = \frac{\text{collapse load}}{\text{working load}} = \frac{M.Rc}{M.R_w}$$

$$= \frac{f_y}{f_w} \times \frac{\text{first moment of area about N.A.}}{\text{the modulus of section.}}$$

$$= \frac{15{\cdot}25 \times bd^2/4}{10 \times bd^2/6} = 1{\cdot}525 \times 1{\cdot}5 = 2{\cdot}2875$$

In the elastic range, the moment of resistance of any section can be represented as working stress multiplied by the Modulus of section (2). We see that similarly, in the plastic range, we can represent the moment of resistance as yield stress multiplied by the first moment of area of the section about the centre. This quantity namely the first moment of area is called the " Plastic Modulus " of the section and is represented by S. The ratio of S/Z, " Shape Factor " of the section influences the value of the " load-Factor ", as seen from the previous derivation, " Load-factor " $= \frac{\text{yield stress}}{\text{working stress}} \times$ shape-factor In the case of rectangular section, the value of shape factor $= \frac{bd^2}{4} / \frac{bd^2}{6} = 1{\cdot}5$

The value of Shape - Factor for I - sections is about 1·15. The load factor for a beam of I - section will be $\frac{15{\cdot}25}{10} \times 1{\cdot}15 = 1{\cdot}75$

The factor of safety for the beam of I – section, according to elastic design using the same stress values would have come out as 2·8, whereas actually, we see that its margin of safety against overload is much less, being only 1·75. In this case of a simple beam, the Plastic design helps us to realise the drawbacks of the orthodox elastic design and see how the plastic design is more rational. In the case of more complicated structures, the design procedure itself gets simplified and also the plastic design will result in more economical sections, as will be seen below.

In the case of fixed beam, the bending moment diagram under a uniformly distributed load will be as shown in Fig. 4 – ii. Let W_w be the working load that is the load which causes a max. fibre stress equal to working stress. Let W_c be the load at the collapse stage of the beam

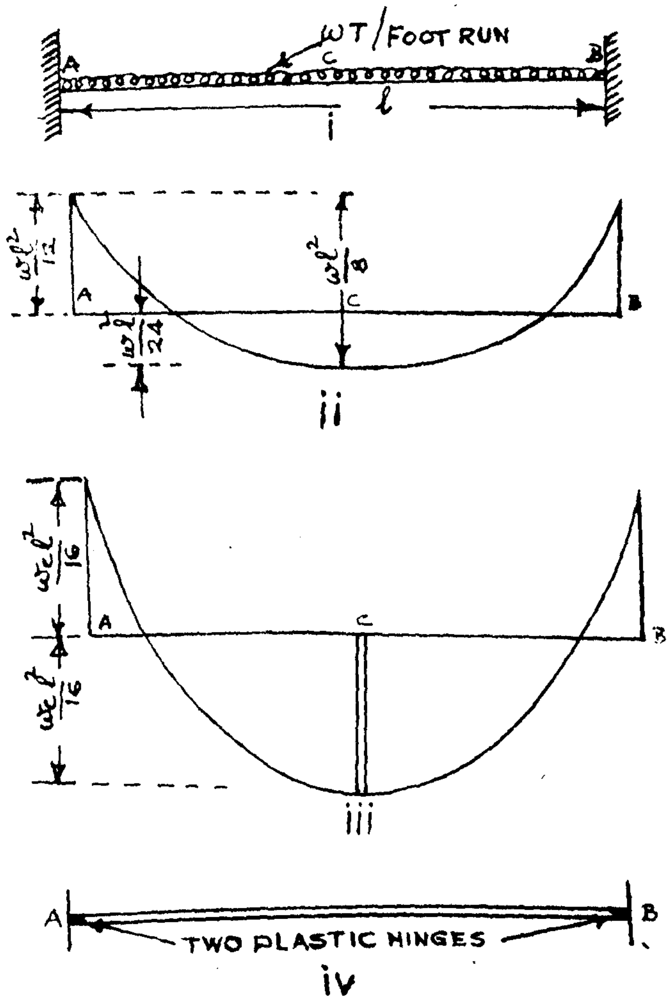


FIG. 4.

The bending moment diagram for the fixed beam consists of the free bending moment diagram of the simply supported beam over which the fixing moment diagram is superimposed. Now, as the value of load is gradually increased, the maximum bending moments also increase in value. The elastic limit will be reached first at the fixed ends. Further increase in load brings the material into plastic range and ultimately a fully – plastic section, in other words a " Plastic-hinge " is formed at each of the fixed ends. Even now, the beam has not reached the collapse stage and takes further loading. Now, the plastic - hinge moments at the fixed ends remain constant while the central moment continuosly increases and it too forms a " Plastic hinge " and its moment then equals the " Plastic hinge moment " already obtained at the fixed ends. Now the beam has reached the collapse stage. The bending moment diagram at the collapse stage can be drawn easily as it amounts to drawing the free bending moment diagram for a simply supported beam, and fixing a new base line such that the ordinates at the ends and at the centre are equal in magnitude, as seen from the figure. the value of " Plastic hinge moment " will be equal to $\frac{1}{2} \times \frac{W_c . l^2}{8} = \frac{W_c . l^2}{16}$

Taking the case of a steel beam of R. S. J. section of 30 Ft. span carrying a uniformly distributed load of $\frac{1}{2}$ ton per foot run, let us compare the sections obtained by the plastic and elastic design.

Plastic Design :

Load factor $= 1 \cdot 75$

Collapse load $= 1 \cdot 75 \times 0 \cdot 5 = 0 \cdot 875$

Let the " Plastic hinge moment " be M_p

Then, $M_p = \frac{0 \cdot 875 \times 30^2}{16} = 49 \cdot 1$ Ft. tons $= 590$ in. tons.

Let the " Plastic Modulus of section " be S

Then, $S = \frac{M_p}{\text{min. yield stress}} = \frac{590}{15 \cdot 25} = 38 \cdot 7 \text{ in.}^3$

Let the elastic " Modulus of section " be Z

Then, $Z = \frac{38 \cdot 7}{1 \cdot 15} = 33 \cdot 62$ inch^3 units.

Use $12'' \times 5'' \times 32$ lbs. R. S. J. section.

Z actually provided $= 36 \cdot 84$ inch^3 units.

Wt. of beam $= 30 \times 32 = 960$ lbs.

Elastic Design :

$$\text{Max. B. M} = \frac{wl^2}{12} \times 12 = \frac{1/2 \times 30^2 \times 12}{12}$$
$$= 450 \text{ in. tons.}$$

$$Z = \frac{450}{\text{working stress by elastic theory}}$$

$$\frac{450}{10} = 45 \text{ in.}^3 \text{ units.}$$

Use $12'' \times 6'' \times 44$ lbs. R. S. J. section.

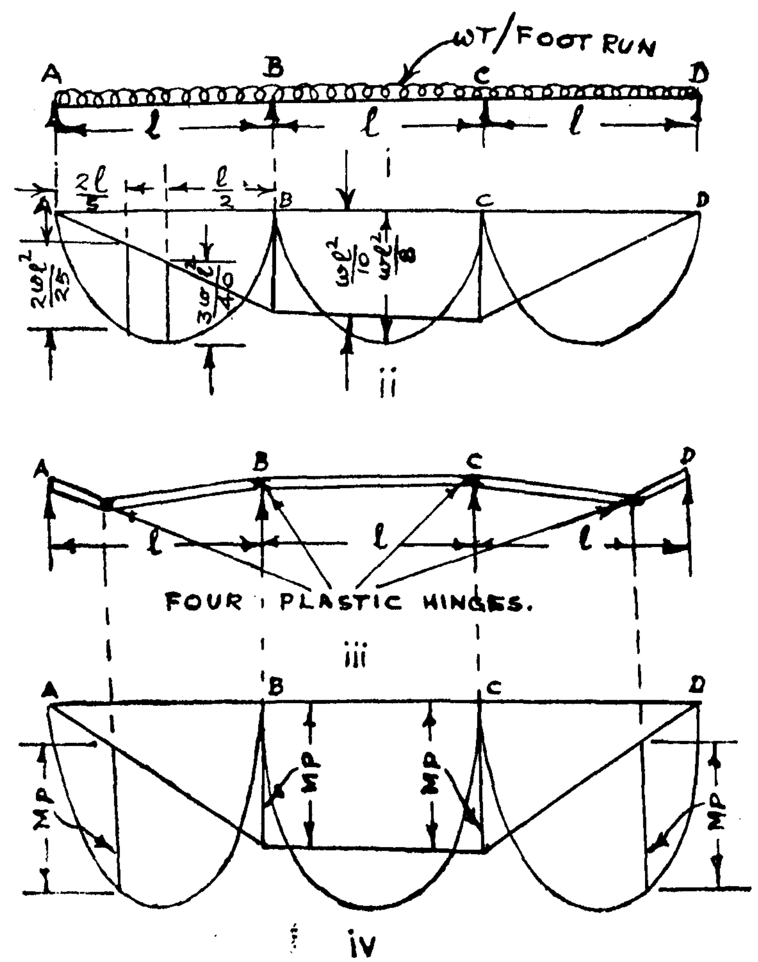
Z actually provided $= 52 \cdot 79$ in.^{3} - units.

Wt. of beam $= 44 \times 30 = 1320$ lbs.

Hence, saving in steel $= \frac{(1320-960)}{1320} \times 100 = 27 \cdot 3\%$

The saving of steel may not be as high as above in many cases but a saving of steel of about 20% can be expected generally.

The method can be developed further for continuous beams. In Fig. 5-1. is shown a continuous beam of uniform cross-section and of three equal spans.



For a uniformly distributed load, the bending moment diagram will be as shown in Fig. 5-ii. It is evident that the beam will reach the collapse stage only after the formation of the " Plastic hinges " shown in Fig. 5 - iii. The " Plastic hinge moment " is equal to M_p at each of the four " Plastic hinges ". The B. M. diagram at collapse condition shown in Fig. 5 - iv can be drawn easily.

The above examples serve to show not only the economy but also illustrate the simplicity in the method of analysis. This advantage will be more pronounced in the case of more complex redundant structures. In these cases, there is a redistribution of bending moment after the formation of each " Plastic hinge ". In other words, more parts of the structure develop their maximum bending strength. Hence the greater economy. The design of multi-storey structures is beyond the scope of this article but it may briefly be stated as follows. Every form of collapse of sub-structures is visualised and the ultimate loads in each case determined. " The ultimate load " or the " Plastic load limit " will be the load attained when a sufficient number of " Plastic hinges " have been formed, to transform either part or whole of the structure into a " mechanism ". " A mechanism " may be defined as a system of structural members which will deform indefinitely even with slight increase in load. This ultimate load divided by the load factor (usually $1 \cdot 75$) gives the working load.

No doubt, the elastic theory which is based on the " first yield " will give a safe design but we have no idea about the actual safety of the structure. On the other hand, the plastic design is based on the ultimate strength. One thing to be particularly noted is that though we visualise the formation of plastic hinges etc. for the purpose of design, still the structure should not fail by elastic instability under the working load. The occupant of the building is of course more interested in its behaviour under working loads than at collapse load. In the form of structures built so far, deflections and other conditions under working loads are satisfactory. But when plastic design is applied to a new form of structure, it is necessary to check the conditions of the structure under working loads.

In conclusion, it may be stated that the plastic design method offers a much simpler and rational method of design. Considerable economy in steel may also be expected. At the present stage the method is used for single storey frames and is expected that with further developments in its application, the method will be extended to multi-storey buildings and then it will come into general use.

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MAGNETIC AMPLIFIERS AND SATURABLE REACTORS

by

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Recently in the electrical engineering field, there is a revival of interest in the development and application of magnetic amplifiers. These amplifiers were known even at the beginning of the century and they reached the first stage of development in the year 1916, when Alexanderson triumphantly employed them in establishing a radio link between the United States and Europe. The same period had also witnessed the rapid progress in the development of vacuum tubes. The mass production of vacuum tubes and their phenomenal performance overshadowed the application of magnetic amplifiers effectively and economically Furthermore, the successful development of rotating amplifiers such as amplidyne completely suppressed the development of magnetic amplifiers. " Like the sleeping beauty in the fairy tale, the magnetic amplifier fell into dormancy. waiting to be awakened by a Prince Charming, or as it turned out, by two of them."

These two charmers appeared in the horizon in the thirties. Because of the significant advances made in the field of metallic rectifiers and in the development of magnitic core materials with improved qualities, the performance of the magnetic amplifiers were raised to astounding levels and it was possible to extend their applications to new fields also.

Though simple in the external form, the magnetic amplifier is highly complex in the internal mechanics of operation. Just as the characteristic curves of a triode tube present the first step towards understanding the action of a vacuum tube amplifier, so also the characteristic curve of a saturable reactor will provide an insight into the operation of a magnetic amplifier.

Saturable Reactor.

The saturable reactor is the basic component of all magnetic amplifiers. A simple saturable reactor is shown is Fig. 1. (*a*)

N_L is the load winding and is connected to A. C. Supply in series with the load R_L. The control winding N_c is connected to a battery through a variable resister R_c and an iron-cored choke L_c. The purpose of the choke L_c is to reduce the effect of transformer action.

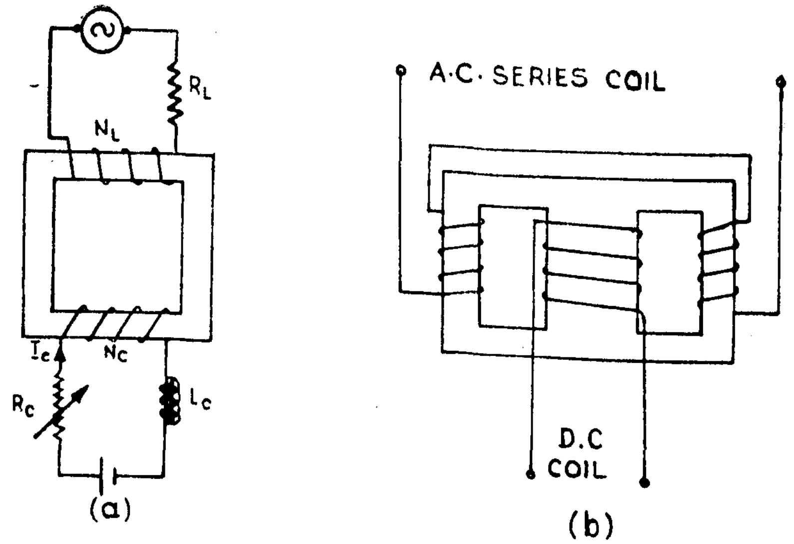

FIG. 1 (a) SINGLE CORE SATURABLE REACTOR.
(b) THREE-LEGGED CORE SATURABLE REACTOR

The saturable reactor functions as a d-c. controlled variable impedance. This impedance is a function of the control current flowing in the loop. The load current I depends on the magnitude of this series impedance and the load R_L. The effect of varying the control current I_c is illustrated in Fig. 2.

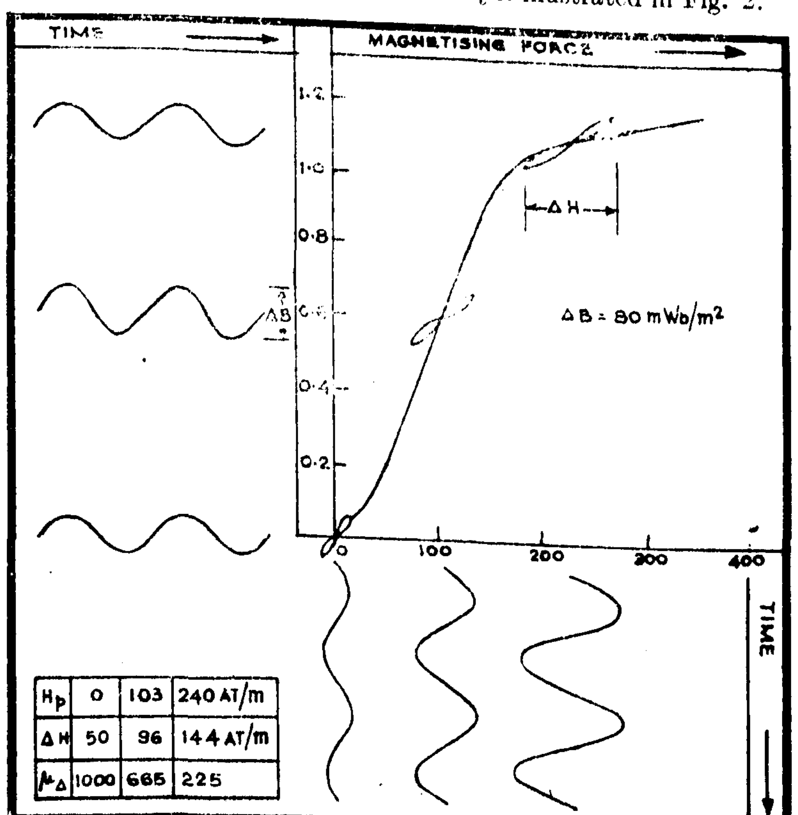

FIG. 2. HYSTERISIS LOOP SHOWING THE MINOR LOOPS AND ILLUSTRATING CHANGE OF INCREMENTAL PERMEABILITY WITH POLARIZING FIELD

When there is no current I_c flowing in the control loop, the impedance of the saturable reactor is maximum and hence the load current is a minimum. Since the impedance of the saturable reactor is inversly proportional to the amount of d. c. magnetization, the flow of control current I_c decreases the impedance. If the core is saturated, the impedance is reduced to its minimum and hence the load current will be at its maximum.

When the self-inductance is thus varied, an alternating voltage, due to transformer action, may be induced in the d. c. control loop. In many practical applications, this transformer action may be undesirable. So this effect is suppressed by placing the two coils in such a manner that their mutual inductance is zero.

To eliminate the undesirable transformer action, different methods are described by Burgess and Frankenfield. One of them is to use a three-legged core shown in Fig. 1(b) The A. C. windings on the two outer legs are connected to an alternating voltage source and the winding on the central leg is connected to the d. c. control voltage. If the a. c. windings have equal number of turns and are connected in proper polarity, the alternating magnetic field will be confined to the sides and ends of the core. Since there is no alternating flux in the centre leg of the core, no emf. is induced in the d. c. coil.

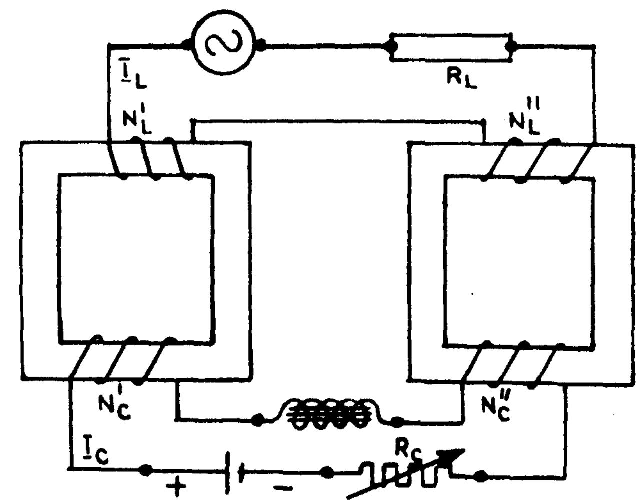

FIG. 3. TWIN-CORE SATURABLE REACTOR CIRCUIT.

Another method of eliminating the undesired effects of the transformer action is to use two separate saturable reactors with equal ratings. The d. c. control windings are connected in series aiding and the load windings in series opposing, as shown in Fig. 3. The voltages inducted in the two control windings N_c', N_c'' are equal and opposite in nature and hence no voltage will appear across the control windings. Hence, there is no necessity of providing a choke in the control winding. In practice, however, such a choke is always incorporated so as to control the even harmonic currents.

With this simple arrangement, it is possible to obtain power amplification provided the load resistance R_l is matched to the impedance value of the saturable reactor. The output power P_l is the power developed across the load R_l and is equal to $I_l^2 \times R_l$. The " input power " P_c represents the actual losses in the control circuit and is given by the equation $P_c = Ic^2\ Rc$. The ratio of the output power to the input power is the power gain and will have a value ranging from 10 to 100, depending on the design and size of the saturable reactor.

Feedback and Non-feedback Amplifiers

The magnetic amplifiers are classified into feedback and nonfeedback types. The nonfeedback type includes polarized, nonpolarized and duodirectional amplifiers. The basic saturable reactor is the non-polarized type amplifier. This type of amplifiers is unable to discriminate between the " positive " and " negative " control currents. With this type the same load current I_l is obtained with the " reversed " control current I_c. Thus, the transfer characteristic of this type will be symmetrical as shown in Fig. 4(*a*).

(*a*) Non-polarized circuit :

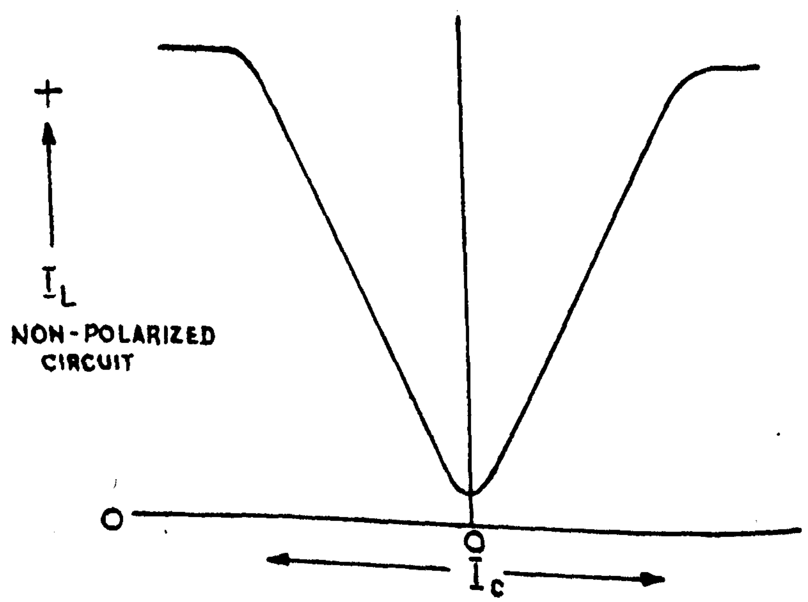

FIG. 4(a). TRANSFER CHARACTERISTICS OF MAGNETIC AMPLIFIER CIRCUITS.

(*b*) Polarized Circuit :

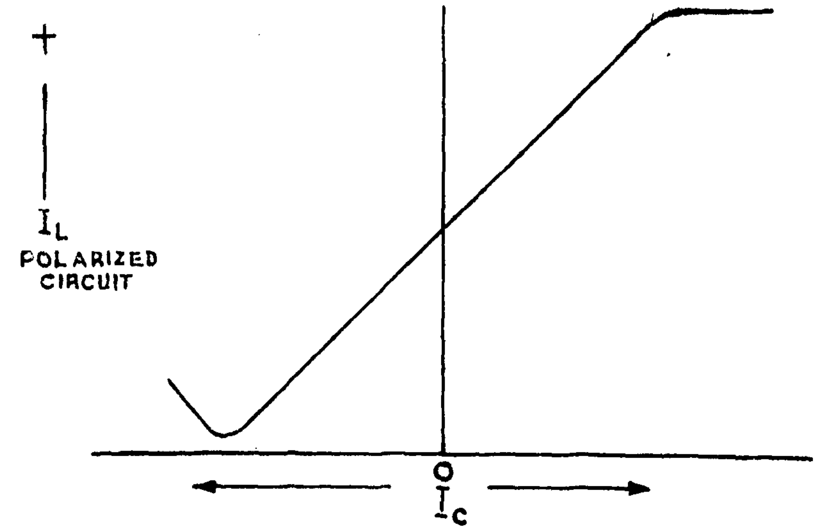

FIG. 4 (b). TRANSFER CHARACTERISTICS OF MAGNETIC AMPLIFIER CIRCUITS.

(*c*) Duodirectional Circuit :

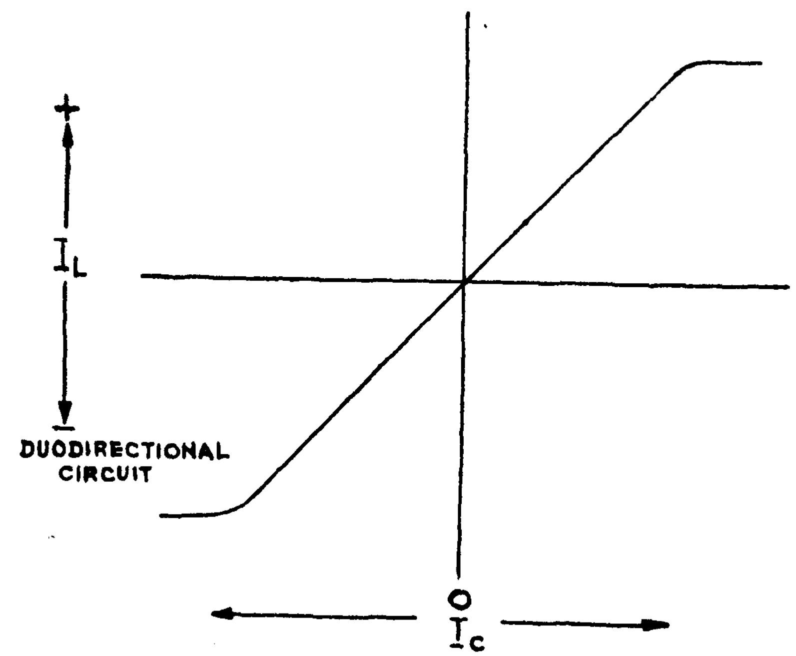

FIG. 4 (c). TRANSFER CHARACTERISTICS OF MAGNETIC AMPLIFIER CIRCUITS.

Fig : 4. Three typical transfer Characteristics of magnetic amplifier circuits.

However, for many special application, it is found necessary to provide some discrimination between " positive " and " negative " control currents. By applying an additional magnetomotive force (bias) on the cores, it is possible to obtain polarity-sensitive performance characteristic. In this case, the transfer characteristic is asymmetrical as in Fig. 4 (b). A positive control current causes an increase of load current while a negative control current causes a decrease. Evidently, the load current never changes its direction. This type represents a polarized magnetic amplifier.

A polarity-sensitive magnetic amplifier does not mean that the discrimination is obtained by the application of bias magnetization on the cores. There are other possibilities of obtaining the desired discrimination. One of them is to connect two non-polarized magnetic amplifier units operating with a switch, relay, a special rectifier or other equivalent device. In contrast to such arrangements, the term " polarized " shall define only those types of amplifiers which are polarity sensitive due to the application of bias magnetization.

In a similar way as the galvanometer in a Wheatstone Bridge does, a magnetic servo-amplifier must operate as a balance detector, according to the fundamentals of servomechanism. In this case, the load current must change its direction depending on the direction of the control current. In order to

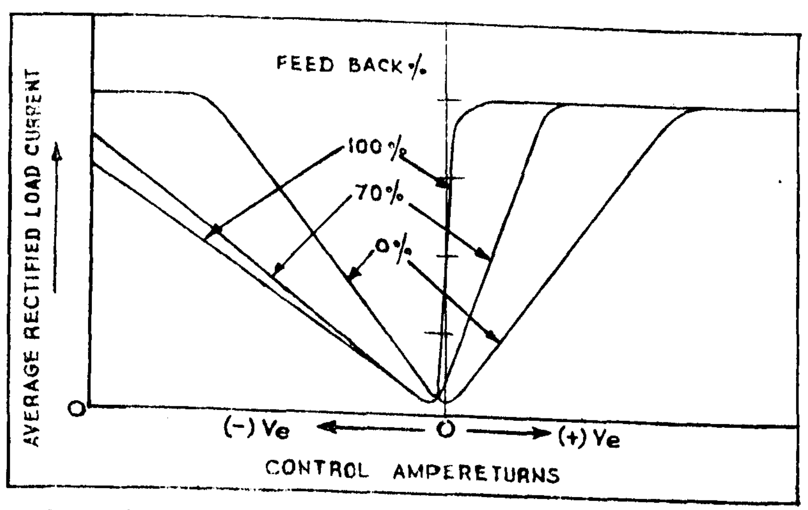

FIG. 5. THE EFFECT OF FEED BACK ON A MAGNETIC AMPLIFIER.

obtain magnetic amplifier circuits having this type of transfer characteristic (Fig. 4. C), two saturable reactors are used in a balanced arrangement, preferably in a push-pull circuit. Such an arrangement represents a "duodirectional" magnetic amplifier.

If the output current of a non-feedback amplifier is rectified and fedback through windings on the core having the same sense as the control windings, the amplifier is a feed-back type. The rectified feedback current may be arranged to provide a magnetomotive force which will assist or oppose that of the control windings, depending upon the polarity of the control signal. If the aiding control conditions are used, the feedback is positive or regenerative. However, if opposing control conditions are used, the feed-back is negative or degenerative.

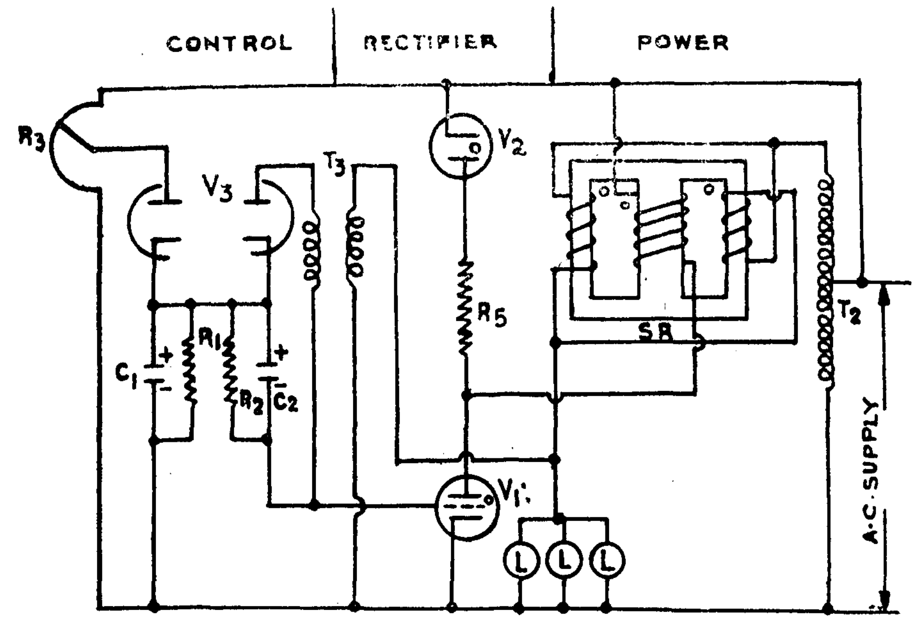

FIG 6. SATURABLE REACTOR CIRCUIT FOR THEATRE LIGHTING CONTROL.

The regenerative feedback increases the power gain considerably. The sensitivity of the amplifier is also increased. The form of the transfer characteristic is substantially, modified by this arrangement. The effect of various amount of feedback on the transfer characteristic is illustrated in Fig. 5.

Applications:

The simple saturable reactor circuit is useful for light control in theatres and large public rooms where it is pleasant to the eye that the light is put " on " and " off " slowly. Of course, it can also be used to adjust the lighting to different intensities without any moving parts or contact devices requiring supervision and maintenance. The inherent amplifying properties of the circuit make it possible to control large power outputs by means of small devices having low power consumption. Therefore, smaller control equipment may be used instead of large principal load. Also, the saturable reactor and the load can be placed where required, and the control at a more convenient place. This means that the control for many separate loads may be grouped together so as to be accessible to a single operator for rapid and convenient manipulation.

Power control :

(*a*) Theatre lighting control :

One of the oldest uses of saturable reactors is for dimming control, of lamps for theatres, illuminated fountains etc., and more recently, for the remote control of airfield lighting. The basic circuit used for theatre lighting is shown in Fig : 6. The power circuit consisting of lamps and the saturable reactor is shown at the right. A booster transformer is used to raise the linevoltage by about 10% to compensate the drop in the saturable reactor.

The d. c. control current for the saturable reactor is supplied by a rectifier circuit consisting of thyratron tube V_1, and an "inverted" rectifier V_2. The control circuit for the thyratron grid is shown at the left of Fig 6. A portion of the alternating supply voltage is rectified by a half wave rectifier in the twindiode V_3. This charges the R_1 -C_1 combination which has a large time constant. The voltage appearing across the combination makes the thyratron grid more positive, and is called "turn-on" voltage.

The other halfwave rectifier of the twindiode rectifies the a. c. voltage appearing across the secondary of the feedback transformer T_3 whose primary is connected across the load. The voltage thus appearing across the R_2-C_2 combination is in a direction opposing the turn on voltage and is called "turn-off" voltage.

It should be borne in mind that the time constant of this turn-off voltage is much shorter than that of the turn-on voltage. If the feedback is properly phased with respect to the thyratron anode voltage, the capacitor C_2 is charged on the inverse half-cycle and the discharge begins on the positive halfcycle. Thus, if the turn-off voltage, is first equal to the turn-on voltage, the thyratron grid will be at zero potential and the tube will conduct for the full cycle. This will increase the load voltage and hence the turnoff voltage, and the thyratron will fire sometime late in the next cycle. If this is too late to supply sufficient saturating current to the reactor, the feedback voltage will fall and the thyratron will fire earlier. As a result, the lamp voltage becomes regulated.

Since this circuit tends to hold constant voltage across the load, a change in the load affects only slightly the voltage on the rest. The load may be varied as much as 4 to 1 without appreciable voltage change.

The lamp voltage, in its simplest form, is controlled by potentiometer R. In practice, the lamp voltage may be controlled through a more elaborate network to permit fading present, and other effects desired by the lighting engineer.

(*b*) **Battery Charging Regulator** :

Lead-acid accumulators are widely used as standby sources of power in case of emergency. It is wellknown that the life of these accumulators depends largely on the treatment they receive. Its life may be increased considerably by maintaining them at their normal voltage and allowing them to draw a small charging current sufficient to make up the losses due to normal action.

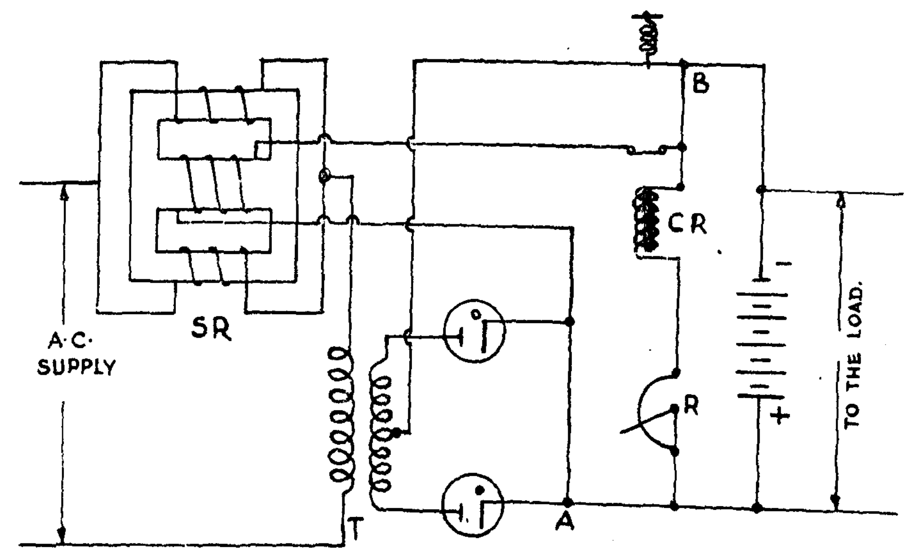

FIG.7. CIRCUIT FOR BATTERY CHARGING REGULATOR.

A basic arrangement using a saturable reactor is shown in Fig. 7. The alternating voltage across the primary of the transformer T is controlled by a saturable reactor. The two gas-diodes rectify the a. c. voltage appearing across the secondly of the transformer T. The resulting voltage is used to charge the the storage battery. If the contact of the relay is held closed, the current through the d. c. winding will saturate the reactor and hence full a. c. voltage appears across the transformer. This allows only pulses of current to pass through the tubes and charge the battery.

Any desired battery voltage may be set by the regulator R. If the battery voltage is as high as desired, this high voltage forces enough current through the relay to open the contact. This stops the flow of current through the control winding of the saturable reactor. The voltage across the transformer decreases and very little current flows through the battery. However, as the load current slowly lowers the battery voltage, the relay closes the contact, control current flows again in the saturable reactor thus charging the battery.

To obtain a continuous control over the charging current, commercial battery chargers use a combination of gas diodes and thyratron tubes instead of the mechanical relay and contact.

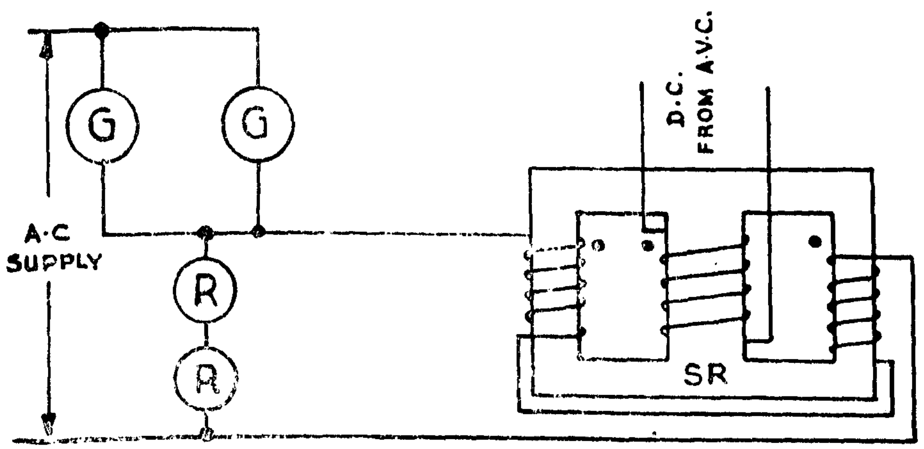

FIG.8. TUNING INDICATOR USING A SATURABLE REACTOR.

(c) Radio Turning Indicator :

One of the earliest uses of the saturable reactor was for the indication of proper tuning of radio sets. The circuit shown in Fig: 8 employs four panel lamps and a saturable reactor. The control current for the saturable reactor is obtained from the automatic volume control (A. V. C.) bias signal. When a station is properly tuned in, the A. V. C. signal is maximum and this effectively lowers the impedance of the saturable reactor so as to short-circuit the red lamps and this increases the current flowing through the two green lamps. Thus, the dial lighting changes from red to green as the station is tuned in.

Instrumentation

Direct Current Metering :

The saturable reactor is particularly suitable for use as as D. C. Transformer for the measurement of very large direct currents, usually thousands of amperes. Such devices have been described by Kramer (Fig. 9.)

The d.c. busbar carrying the large current functions as a single turn control winding of the saturable reactor. The a.c. windings are as usual connected to a suitable source in series with a bridge-rectifier. The rectified current is a measure of the current in the D.C. busbar.

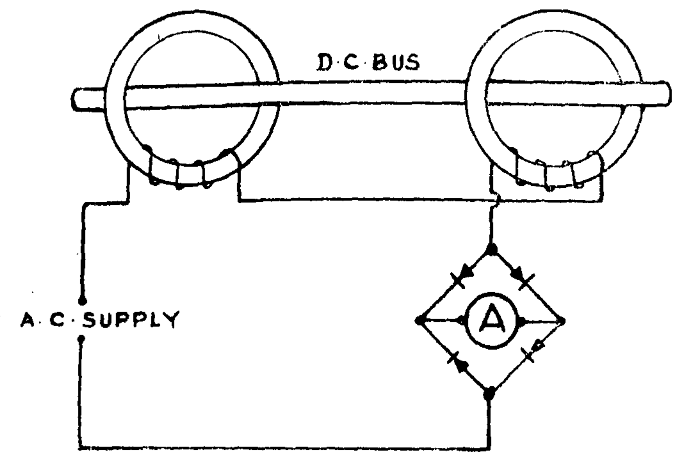

FIG.9. SATURABLE REACTOR D·C·TRANSFORMER.

This method has the following advantages :

1. The meter-shunts are eliminated, thus avoiding the losses in the shunt.
2. The meter may be housed at a convenient place since the resistance of the meter leads is far less critical than with shunt.
3. The meter is not damaged by heavy overloads.
4. The meter is completely isolated from the busbar. Hence, the meter may be earthed independently.
5. The cost of a large installation is considerably less than for shunts.

Military Applications

Before and during the World War II, in Sweden, the magnetic amplifiers were extensively applied to industrial purposes, while in Germany, there were successful attempts to design the circuits so as it might be used in military equipment, such as gun position control and stabilization, rocket steering, aircraft control and servo systems. The intrinsic reliability and robustness made them particularly suitable for these above applications, An added advantage was their ability to operate immediately without any " warming up " time.

Long life and trouble-free service of components are the vital features in the radar applications. The saturable reactor has no moving or wearing parts. Properly designed, it requires a negligible amount of maintenance and is characterised by extremely long life-expectancy. These saturable reactors are gradually replacing the electronic discharge devices in pulse generators even at the highest peak power of several megawatts.

In electronic digital computers, the magnetic amplifiers are extensively used to provide memory devices with important advantages over electronic alternative.

The magnetic amplifier may be used for a host of other applications such as the generator voltage control, Motor-speed control, and phase shift controls.

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INDUSTRIAL DEVELOPMENT OF MADRAS STATE

Extract from the Budget Speech 1960 - 61 of

Hon. C. SUBRAMANIAM,

Minister for Finance and Education, Govt. of Madras.

SIR,

I rise to present the Budget Estimates for 1960 - 61. ....

Members may note with satisfaction that the Neyveli Lignite Project is progressing as expected. The total cost of this project is Rs. 86 crores of which the anticipated outlay in the Second Plan period is Rs. 49 crores. Rs. 11 crores had been spent up to the end of March 1959 and Rs. 15·47 crores would be spent in the current year. The most important part of this integrated project is the mining of 35 lakh tons of lignite per year. The lignite will be utilized as follows: 15 lakh tons out of the 35 lakh tons will be used to produce 2·5 lakhs k.w. of electric power, 5 lakh tons will be used in a fertiliser plant to produce 1·5 lakh tons of urea and the remaining 15 lakh tons would be used for making carbonised briquettes. The fertiliser plant and the briquette plant will go into production as scheduled early in the Third Plan period. It has been proposed to step up the mining programme to 60 lakh tons of lignite in the Third Plan.

Preliminary arrangements are under way for establishing a steel plant utilising the lignite from Neyveli and iron ore from Salem. The Government of India have already constituted a Technical Committee to go into this question.

Honourable Members may also be aware of the steps being taken to take up exploration of the Cauvery Basin for oil resources. The Government of India have at our request promised to further intensify these efforts.

An agreement has been concluded with a French firm to establish a raw film factory in the Nilgiris district and the factory is expected to go into production by the end of 1962. Rupees 5 crores will be spent on this Project in the first stage and 1,300 persons will be employed.

The Government of India have decided to set up a Surgical Instruments Factory at Guindy through the National Industrial Development Corporation. This Factory which is to be established with Soviet aid, will produce 20 lakhs surgical instruments of different kinds each year and provide employment to 2,000 persons.

The three co-operative sugar factories started at Madurantakam, Udumalpet and Ambur are nearing completion and are expected to go into production in 1960—61. Arrangements are in progress for the setting up of four more sugar factories.

Many major industries are being started by the private sector in the State. The caustic soda plant in Tirunelveli district which I referred to in my last year's Budget speech, has gone into production and is functioning smoothly. Buildings for the rayon factory in the Coimbatore district are coming up and preparations are being made for the erection of the machinery. The Madras Government have taken shares worth Rs. 10 lakhs out of the total share capital of Rs. 3·5 crores. One thousand five hundred persons will be employed in this factory. The Madras Cements Limited, Rajapalayam, with an authorized capital of Rs. 1 crore is expected to go into operation in about the middle of 1960. The first stage of the factory will produce 66,000 tons per annum. Ultimately, it will produce 132,000 tons per annum and employ 700 persons.

The factory for manufacturing refractory bricks from the Salem magnesite ore started by Messrs. Burn and Company is nearing completion and may go into full production in 1961. This factory will have a capacity of 1,000 tons of refractory bricks every month.

Arrangements are in progress to establish an aluminium plant at Mettur with the collaboration of an Italian Firm.

Messrs. Ramakrishna & Sons (Private) Limited, are starting a factory at Tiruvottiyur near Madras with French collaboration, for the manufacture of heavy machinery specialising in the machines required by the cement and sugar industries. Certain types of machines are being manufactured here already and steps are now being taken to expand the production.

A factory for the fabrication of railway wagons with a capacity of 1,000 units per year has been established at Pattabhiram near Avadi with a paid up share capital of Rs. 1 crore in which the Madras Government have a token participation of Rs. 2 lakhs. Messrs. Seshasayee Brothers are establishing a paper factory at Mettur with a capacity of 50 to 60 tons of paper per day. Of the share capital of Rs. 4 crores required for this Project, the Madras Industrial Investment Corporation are making arrangements to subscribe Rs. 1 crore. The plant is being imported from America.

Messrs. T. V. Sundaram Iyengar and Sons Limited, are proposing to establish a factory for the manufacture of wheels and rims with a capacity of 15,000 wheels and rims per month, at a capital cost of Rs. 1 crore.

Efforts are also being made to set up two fertiliser plants and it is hoped that these units will be set up in the near feature.

It is no doubt true that many industrial units are being established in our State but there can be no doubt on the point that our industrial development is still far from adequate. We shall therefore have to redouble our efforts to set up many more heavy industrial units in our State. The integrated Neyveli Project and the Salem Steel Plant will be the base for this expansion.

The National Council of Applied Economic Research has undertaken a survey of the possibilities of our industrial development. They have submitted a preliminary report which is under examination. We may hope that this will be of help in formulating our industrial programme for the Third Plan.

Under the small-scale industries programme 19 model production centres, 19 common service workshops, 5 community welfare centres, 11 marketing centres, 1 Technical information centre, 1 raw material depot, and 6 production-cum-training centres had been planned. Out of the 19 model production centres proposed, 11 have already been established and are already manufacturing various useful articles. Six more centres are to be started in the near feature. Various articles such as pressure die cast parts, ferrous castings, scientific glass apparatus, splints and veneers, dies, jigs and fixtures, centrifugal machines, bolts and nuts, cycle parts, sheet metal articles, etc., are being manufactured in these centres. We have programmed to established a Structural Workshop at Mettur in 1960-61. A refractory plant would be established at Sivaganga in 1960-61. In the 6 training centres training has so far been given for 175 persons in carpentry, blacksmithy and allied crafts. Out of the 19 common service centres proposed in the Plan, 13 have been started already servicing many industrial units and 650 small-scale entrepreneurs have derived benefit so far. Three more common service centres will be set up very soon and 3 additional centres will be started in 1960—61. Three common tool shops will be started at Pettai, Tiruchirapalli and Virudhunagar in 1960—61. We have also been assisting private industrialists with loans to start small-scale industries. In the first three years of the Plan, loans amounting to Rs. 63 lakhs have been disbursed to 7,700 persons. This programme is being continued on the same scale in the current and the next year.

Two industrial Estates and 5 Industrial Colonies are now functioning. One more industrial Colony will be established before the end of this month at Thanjavur. One hundred and fifty-seven out of 158 completed units in these Industrial Estates and Colonies have already been leased out. A further 61 units are under construction. Seventy-eight units are now engaged in production in the Guindy Estate as against 52 units in January 1958. Two new Industrial colonies are programmed to be built at Salem and Katpadi. Thirteen Industrial Co-operative Societies have so far been established during the Plan period. Rs. 354 lakhs were set apart for small-scale industries as a whole during the Second Five-Year Plan. Out of this Rs. 195 lakhs were spent in the first three years. In the current year Rs. 100 lakhs will be spent and Rs. 109 lakhs have been provided for in 1960—61. Thus over the 5 years the total expenditure will be Rs. 404 lakhs. On industrial estates the actual expenditure would be Rs. 131 lakhs as against Rs. 95 lakhs provided for the Five-Year period.

THE ROLE OF THE DEPARTMENT OF INDUSTRIES AND COMMERCE
(MADRAS STATE)

T. K. PALANIAPPAN, I.A.S.,
DIRECTOR OF INDUSTRIES AND COMMERCE.

Till the beginning of 1955, the activities of the Industries Department were confined mostly to the maintenance of Commercial and other Institutions already started, sinking of bore and tube wells for agricultural industrial and drinking water supply purposes, the grant of loans under State Aid to Industries Act, Technical Education, Fisheries, Controlled Commodities and Sericulture. The development of industries was not also undertaken in any appreciable measure. The Polytechnics and the pumping and boring work were transferred to the Directorate of Technical Education and the Department of Agriculture in 1957–1958 respectively. A separate Directorate for Fisheries was formed in 1958 This Department is at present concentrating in the development of Industries-Heavy, Small Scale and Village, Handicrafts, Sericulture, Craftsmen Training and Industrial Cooperatives. The staff in the headquarters as well as in the districts has been strengthened. The Government have also given a fillip to the industrial development by constituting a State Industries Development Committee.

State Aid :

The State Aid to Industries Act as well as the rules thereunder have been suitably amended with a view to liberalise the provisions relating to the grant of loans and to minimise the delay in their grant. A sum of Rs. 125·80 lakhs has been ear-marked for this purpose under the IInd Five Year Plan.

Research :

On the Research side, the Chemical Testing and Analytical Laboratory attached to this Department is doing valuable work in analysing samples of ores, minerals, foodstuffs etc. and issuing test reports at nominal rates to private bodies and free of cost to Government Departments.

Geological Unit :

To tap the mineral resources of the State in general and to expedite the setting up of iron and steel plant and Aluminium plant in particular, a State Geological branch, under an experienced Retired Superintending Geologist has been formed. This branch is functioning. Enquiries pertaining to mineral concessions under the relevent rules and mineral resources of the State are being attended to promptly.

Heavy Industries :

NEIVELI LIGNITE, Salem Iron ore and Bauoxite will pave the way for rapid development of Industrialisation in this direction. One pig iron plant was switched into production in the private sector at Coimbatore. Four more plants are expected to be started. Thermal power plant and the fertiliser plant proposed to be started, as subsidiary to Neiveli Lignite, will go a long way to augment the power supply in the State and to agricultural production respectively. The tests of bauxite ores, in connection with the setting up of the Aluminium plant, are being expedited. Ooty has been selected as an ideal place for the establishment of a photographic raw film factory and an infant milk food factory. Efforts are afoot to establish a Rayon Pulp factory near Bhavanisagar and a paper factory at Mettur utilising the bamboo wealth of the Bhavanisagar Mettur region. A huge soda ash plant is being established in Tirunelveli district. A new cement factory at Ramanathapuram is expected to be started in the near future. 3 Co-operative Sugar factories with Government share capital are expected to go into production in the middle of 1959.

Small scale industries :

The development of Small Scale Industries is an important factor of economy for the wide distribution of both economic activities and advantages. Without draining the internal resources, it will provide more employment opportunities. With this end in view, a number of model training, servicing and production centres, technical information section, servicing corporation for supply of raw materials and industrial estates for providing factory space have been started. The Industrial Estate at Guindy constructed at a cost of Rs. 70·03 lakhs has accommodated a number of Small Scale Industries both under private and the public sector. Another estate at Virudhunagar is under construction at a cost of Rs. 28·49 lakhs. Also Industrial Colonies at Tirunelveli, Tiruchy, Madurai, Tanjore and Marthandam are being set up.

Village Industries :

Schemes for the development of Village Industries, utilising the raw materials and idle labour available in villages, are being implemented with a view to make the villages self-sufficient in regard to their daily requirements such as handpounded rice, oil, honey and pottery etc.

Handicrafts :

The development of handicrafts is also given due importance considering the traditional beauty, workmanship and fine quality and a number of schemes for the development of art-metal, bell metal, sculpture, paper toys, ceramics, fancy

leather goods, printing and dyeing, druggets and carpets, ornamental handles etc. are being implemented. Marketing of finished products is also given priority and sales depots are proposed to be opened in the Districts.

Sericulture :

Sericultural activities are being extended in Tenkasi area of Tirunelveli district and Gudiyattam taluk in North Arcot District. Hosur in Salem District is the important centre in the silk industry of the State after the transfer of Kollegal to Mysore State.

Industrial Co-operatives :

Industrial Co-operatives for small scale and Village Industries started with Government subsidy have made good progress in the field of handpounding of rice, pottery, oil industry, tannery, handicrafts and metalware. 1,400 jaggery manufacturing co-operative societies with a target of 24·71 lakhs maunds of jaggery for 1958—59 have already produced 15·42 lakhs maunds upto November, 1958.

Labour and Labour Welfare :

The Craftsmen training schemes implemented through a number of industrial training institutes located throughout the State are providing full time and part-time courses. They are already turning out a large number of technical personnel for mining these industries. The gap between the turnover and the manpower requirements will be bridged. The implementation of the schemes included in the Plan is sure to lead industrial development and there can be no doubt that Madras will before long gain an important place in the industrial map of India.

UNIVERSITY NOTES

FOUNDER'S DAY

The Thirtieth Founder's Day was celebrated on the 13th of September 1959 when Sri R. Venkataraman, Minister for Industries and Labour, Government of Madras, delivered the Commemoration Address.

THE CONVOCATION

The Twentyninth Annual Convocation of the University was held on Wednesday, the 21st of October 1959. His Excellency Shri Bishnuram Medhi, Governor of Madras and Chancellor of the University, presided. On this occasion the Honorary Degree of Doctor of Letters (D. Litt.) was conferred on Professor Humayun Kabir, Union Minister for Scientific Research and Cultural Affairs, New Delhi. Professor Humayun Kabir delivered the Address to the Graduates.

ADDITIONAL HOSTEL BUILDINGS FOR WOMEN STUDENTS

Srimathi Bishnuram Medhi declared open the newly built Hostel Buildings for Women Students on the 22nd October 1959.

DR. C. P. RAMASWAMI AIYAR LIBRARY BUILDING

On the 22nd of October 1959, His Excellency Shri Bishnuram Medhi, Chancellor, declared open the Dr. C. P. Ramaswami Aiyar Library Building which was newly constructed. Dr. Rajah Sir Muthiah Chettiar of Chettinad presided at the function.

THE TWENTY-FIFTH SESSION OF THE INDIAN ACADEMY OF SCIENCES

The twenty-fifth Annual Session of the Academy was held at Annamalainagar from the 26th to the 28th of 1959. Several distinguished scientists, Fellows of the Academy and Delegates from various parts of India attended. There were on rolls nearly eighty sessional members from the staff of this University and over 100 student members, mainly post-graduates of the University. Sir T. M. Narayanaswamy Pillai, M.A., B.L., Vice-Chancellor, was the Chairman of the Reception Committee, Dr. G. Rangaswami, Professor and Head of the Department of Agriculture and Dr. J. Jacob. Senior Research Officer, Marine Biological Station, Portonovo, Annamalai University, were the Local Secretaries.

The Session was inaugurated on the evening of the 26th of December 1959 by Dr. Rajah Sir M. A. Muthiah Chettiar of Chettinad, Kt., B.A., D. Litt., M. L. A., Founder, Pro-Chancellor of Annamalai University. In his inaugural address Dr. Muthiah Chettiar referred to the role of Science in the modern world and stressed the importance of retaining English as a medium of instruction in colleges and universities. Sri T. M. Narayanaswamy Pillai, Vice-Chancellor and Chairman of the Reception Committee, delivered the welcome address, wherein he showed how the aims and objects of this educational foundation included among others the synthesis of modern science with oriental learning. Sir C. V. Raman, Nobel Laureate, and President of the Academy delivered the presidential address. He expounded an entirely new theory explaining many of the problems of light, colour and vision.

The second day of the session opened with a symposium on "Tectonics in Relation to India" under the Chairmanship of Dr. S. Bhagavantam, Director, Indian Institute of Science, Bangalore, Dr. M. S. Krishnan, Dr. C. Mahadevan, Dr. S. Balakrishnan and Sri N. A. Vemban presented papers. A number of papers on Physical Science were presented and discussed in the afternoon. A symposium on "Chemical and Biological Control of Insect pests" under the Chairmanship of Dr. K. Ramiah, F.A.O., Expert on Rice, was held on the 29th. Drs. M. Putturudriah, K. V. Joseph, Sardar Singh and G. Rangaswami took part in the discussions. In the afternoon session, Dr. M. K. Subramanian presented a paper on "The yeast nucleus", Dr. G. Rangaswami two papers on "Microbial spoilage of Canned Food, I and II", and Dr. J. V. Bath on "the Taxonomy of *Vibrio extorouens*".

Dr. G. Rangaswami, Local Secretary, thanked Sir C. V. Raman and the officials of the Academy for accepting the invitation and holding the session at the Annamalai University and the distinguished scientists who participated in the session. He thanked the Founder Pro-Chancellor for inaugurating the session and the Vice-Chancellor, members of the Syndicate and various officials, staff and students who contributed to the success of the session.

There were two public lectures on the evenings of the 27th and the 28th. The first was on "Supersonic Flight" by Dr. P. Nilakantan and the second on "Radio Astronomy" by Dr. S. Bhagavantam.

Two excursions were arranged on the 29th, one to the Neyveli Lignite Corporation and the other to the Marine Biological Station at Portonovo.

FORTY SECOND SESSION OF THE ALL INDIA ECONOMIC CONFERENCE

The Forty-Second Session of the All-India Economic Conference was held under the auspices of the Annamalai University on 30th and 31st December 1959 and 1st January 1960. The Vice-Chancellor was the Chairman of the Reception Committee and the Professor of Economics was the Honorary Local Secretary. The Conference was attended by more than two hundred delegates and members of the Indian Economic Association. The Founder-Pro-Chancellor, Dr. Rajah Sir M. A. Muthiah Chettiar, KT., B.A., D. Litt., M.L.A. graciously inaugurated the Conference. Prof. J. J. Anjaria, Chief Economic Adviser, Ministry of Finance, Government of India presided. It is after 25 years that our University has been the venue of the Conference of the Indian Economic Association. The success of the Conference was due in no small measure to the hearty co-operation and support of the Chambers of Commerce, Co-operative Institutions, Industrial magnates, land-holders and Colleges in the Madras State. The elaborate arrangements made by our University evoked the appreciation and warm praise of all the delegates, Indian and Foreign. In proposing the vote of thanks to the University, Dr. S. K. Muranjan, Member, Tariff Commission said that the Forty Second Session of the All India Economic Conference should rank with two memorable sessions in the past 40 years. Prof. J. J. Anjaria, President, in his letter to the Vice-Chancellor expressed his appreciation as follows:—

"I cannot leave this place without writing a line to you to request you to convey the warmest thanks of all those who attended the Conference to Prof. K. S. Sonachalam and his colleagues for the tremendous personal trouble they took to make everyone of us comfortable.

I should mention in particular the excellent work done by the volunteers. They were always ready to help: they were eager, responsive and disciplined. Please convey my personal thanks to them also. These qualities the volunteers displayed will, I am sure, prove valuable assets to them in life.

I will not embarass you by thanking you, but, I realise that you are the guiding spirit behind all this."

தவணைத்தாள்.

சே எண் : ப. எண் :

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