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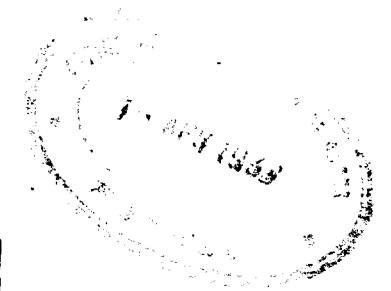
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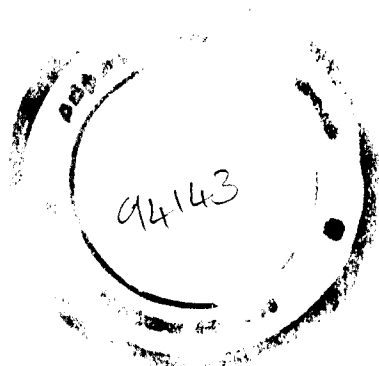


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URINARY CALCULUS
A
PROBLEM IN PHYSIOLOGICAL CHEMISTRY¹

BY

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(Nutritional Research Laboratories, Indian Research Fund
Association, Coonoor)

(Continued from page 137, vol. vii, No. 2)

PART III

EXPERIMENTAL PRODUCTION OF STONES

While the above inquiry was proceeding, Col. McCarrison investigated the possibility of producing stones in albino rats under rigidly controlled conditions through faulty diets in common use among the people of India. A number of stones were thus produced; twenty-one of them were analysed. They were all bladder-stones; they varied in weight from 3.4 to 66.6 mgs. Their chemical composition shows the following noteworthy points (Newcomb and Ranganathan, 1930, *Ind. Jour. Med. Res.*, xvii, p. 1055).

(a) All the stones are essentially of magnesium ammonium phosphate with small quantities of other substances of which carbonate is the chief.

(b) They all contain little or no calcium.

(c) None of the stones contain uric acid or urates.²

¹ Prize-thesis for the Maharajah of Travancore-Curzon Prize, 1932.

² The significance of this will be dealt at length at a later stage (*Vide* p. 65).

McCarrison observed that the chief deficiencies of the above calculus-producing diets were a deficiency of suitable proteins of good biological value and a deficiency of vitamin A-bearing ingredients. Later experiments showed that a sufficiency of proteins of high biological value neither prevented nor diminished appreciably its incidence. Thus he eliminated the protein factor in the causation of stone.¹

Experimental Production of Different Types of Stones

Having succeeded in producing stones consisting essentially of magnesium ammonium phosphate, the next point investigated by Col. McCarrison was to find out if the composition of the stones could be altered by purely dietetic means. He, therefore, added slaked lime to his experimental diets, which were deficient among other things in vitamin A, with the result that the incidence of calculus and its sequelae was greatly increased. A number of stones were thus produced on calcium-rich vitamin A-deficient diets. Seventy-eight of them were subjected to complete chemical analysis; this series also included six stones produced on diets to which lime was not added.

The physical characters of the stones produced on calcium-rich diets differed markedly from those previously reported: they were as a rule white or greyish-white in colour, and usually multiple; their appearance was chalky, and often the concretions consisted of fine, rounded chalky grains showing no tendency to adherence into a single mass. In weight, they varied from less than 2 to as much as 800 milligrammes. Of the 78 stones, 60 were bladder stones; 15 were kidney stones; 2 were ureter stones; and 1 was a chalky gravel removed from the prepuce. For purposes of analysis, they were divided into two main groups: those weighing less than 5 mgs. and those weighing more. Owing to the small amount of material, analysis of those in the first group was only possible by qualitative methods;

¹ McCarrison, R. (1930): *Ind. Jour. Med. Res.*, xvii, p. 1103.

while those in the second group admitted of analysis by quantitative micro-chemical methods (Ranganathan: *Ind. Jour. Med. Res.*, 1930, xviii, p. 599).

The results of the analysis of stones weighing 5 mgs. or less are set out in Table VII and of stones weighing over 5 mgs. in Table VIII.

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TABLE VII

Showing the chemical composition of 25 rat stones that weighed 5 milligrams or less.

[Directions: + (?) = Doubtful or faint trace; + = Present; + + = Fair amounts; + + + = Plenty; 0 = Nil.]

Stone Number	Carbonate	Phosphate	Calcium	Magnesium	Murexide Test	Diet	Location of stone
24	+ + +	+ (?)	+ + +	0	0	A	Bladder
25	+ +	+ +	- 0 (?)	+ +	0	D	Bladder
29	+	+ (?)	+ + +	0	0	C	Bladder
32	+ + +	0	+ + +	0	0	B	Kidney
38	+ + +	+	+ + +	0	0	B	Kidney
39	+	+ (?)	+ +	0	0	H	Bladder
40	+	0	+ + +	0	0	A	Bladder
44	+ + +	+ (?)	+ + +	0	0	C	Bladder
47	+ + +	0	+ + +	0	0	B	Bladder
49	+ (?)	+ (?)	+ + +	0	0	C	Kidney
57	+ (?)	+ + +	0	+ +	0	D	Bladder
60	+ + +	+	+ + +	0	0	A	Bladder
62	+ + +	+ (?)	+ +	0	0	C	Kidney
64	+ + +	+	+ +	0	0	E	Kidney
65	+ (?)	+ +	+ (?)	+	0	F	Bladder
68	+ + +	+ (?)	+ + +	0	0	E	Kidney
69	+	+ +	+ (?)	+ +	0	G	Bladder
70	+ + +	+ (?)	+ + +	0	0	C	Bladder
73	+ + +	+ (?)	+ + +	0	0	E	Bladder
74	+ + +	0	+ + +	0	0	E	Kidney
80	+ + +	+	+ + +	0	0	C	Kidney
81	+	0	+ + +	0	0	C	Kidney
85	+	0	+ + +	0	0	E	Kidney
105	+	0	+ + +	0	0	J	Bladder
107	0	+ + +	0	+ + +	0	L	Bladder

TABLE VIII

Showing the composition of 53 rat stones weighing 5 mgs. or more.

Stone number	Moisture per cent.	As per cent. on moisture-free sample					Wt. of stone mg.	Murexide Test	Diet	Location of stone
		Total N.	P ₂ O ₅	CaO	MgO	CO ₂				
23	5.5	2.4	Trace	43.0	2.0	43.4	30.3	0	A	Kidney
26	27.4	0.7	0	29.0	0	0	127.6	0	A	Bladder
27	3.8	1.8	1.6	42.0	2.0	37.0	26.1	0	B	Do.
31	36.7	1.1	0	35.6	0	0	117.8	0	B	Do.
33	19.4	1.1	1.4	45.5	2.0	39.5	96.0	0	A	Do.
34	8.7	1.2	Trace	29.0	1.8	22.0	17.3	0	C	Do.
35	5.8	1.3	1.1	44.4	1.5	37.1	69.3	0	C	Glaupenis
36	6.5	3.4	1.9	33.4	3.6	41.1	12.3	0	A	Bladder
37	3.5	0.5	1.1	47.6	1.6	36.0	797.8	0	B	Do.
42	11.4	0.7	0	41.5	0	7.0	104.2	0	B	Do.
43	43.8	1.1	Trace	28.0	0	Trace	99.8	0	A	Do.
45	6.0	1.2	0.9	45.0	1.8	35.6	81.2	0	C	Do.
46	10.1	1.6	Trace	30.7	Trace	21.5	43.5	0	A	Do.
48	11.6	1.4	0	32.4	0	0	20.6	0	C	Do.
50	8.5	1.5	Trace	37.0	1.4	25.5	30.7	0	E	Do.
51	11.4	2.4	0	35.5	0	0	18.5	0	C	Do.
52	5.1	1.1	0.8	42.6	Trace	29.1	59.3	0	C	Do.
53	13.3	0.5	0.9	40.3	2.0	26.5	286.3	0	E	Do.
54	18.4	1.1	2.7	43.2	1.6	38.4	37.5	0	E	Do.
55	5.0	1.5	1.3	40.0	Trace	22.2	43.9	0	C	Do.
56	19.0	0.9	0.7	29.9	0	8.6	245.4	0	B	Do.
59	35.5	0.7	0.3	29.1	Trace	5.1	370.0	0	A	Do.
61	8.8	2.3	1.0	38.1	0	22.2	13.7	0	C	Do.
63	11.6	1.2	0.3	45.7	0	5.4	59.2	0	C	Do.
66	19.9	1.5	0.7	32.6	3.5	12.3	200.9	0	E	Do.
67	7.9	3.6	1.8	32.4	2.5	28.8	21.6	0	E	Kidney
71	9.2	0.8	Trace	41.5	0	10.6	84.2	0	C	Bladder
72	8.7	3.2	0.9	44.5	0	Trace	20.6	0	C	Kidney
75	3.7	0.6	1.3	41.2	1.0	37.5	32.5	0	A	Bladder
76	7.8	1.8	1.2	38.0	1.6	33.7	51.3	0	B	Do.
77	8.6	0.5	0.5	43.7	1.4	41.8	288.6	0	B	Do.
78	14.3	0.9	0.5	47.3	1.0	21.5	72.9	0	C	Do.
79	5.7	3.5	1.3	39.7	3.0	39.7	15.9	0	C	Ureters
82	29.7	0.7	0.5	27.8	0	Trace	112.7	0	H	Bladder
83	18.4	0.6	0.4	29.5	0	Trace	123.0	0	I	Do.
84	9.4	1.6	0.3	40.8	0	7.5	73.0	0	A	Do.
86	18.0	1.5	0.9	43.7	1.2	36.2	122.4	0	E	Kidney
87	22.1	0.9	0.5	41.6	2.2	19.9	83.6	0	E	Bladder
88	7.4	3.5	1.8	34.6	3.2	23.3	18.0	0	C	Kidney
89	11.0	2.9	1.5	34.0	1.8	28.6	14.6	0	C	Bladder
91	49.3	1.1	0.3	29.4	0	Trace	550.7	0	A	Do.
92	4.6	1.7	1.9	41.1	1.5	39.4	17.5	0	A	Do.
93	19.7	0.7	0.7	53.5	Trace	34.9	36.7	0	A	Do.
94	3.5	0.4	1.6	43.2	2.1	39.0	51.7	0	E	Do.
95	41.3	1.5	0.7	26.7	0	Trace	237.2	0	B	Do.
96	2.7	1.1	1.4	27.6	0	9.6	59.5	0	B	Do.
98	12.0	2.1	11.6	37.0	2.1	Trace	13.4	0	E	Do.
99	3.8	1.0	2.3	44.7	3.2	42.3	13.1	0	E	Do.
101	2.6	0.2	1.2	48.0	1.6	39.9	163.5	0	B	Do.
103	9.3	1.9	2.2	35	1.2	39.0	11.9	0	J	Do.
104	4.8	2.5	1.9	41.6	2.8	+	6.3	0	A	Ureters
106	3.9	0.5	1.7	44.5	2.2	43.8	70.2	0	J	Bladder
108	39.1	5.0	36.8	4.36	24.4	Trace ¹	11.0	0	L	Do.

¹ Tested only qualitatively as there was not enough stone-material for quantitative work.

It will be seen from Tables VII and VIII that the six stones (stone Nos. 25, 57, 65, 69, 107 and 108) differed from the rest in being very rich in P₂ and Mg, comparatively rich in nitrogen and very poor in calcium and carbonates. Because of insufficiency of material, ammonia was not tested for in the above six stones; it is, however, assumed that the Mg existed as the magnesium ammonium phosphate. This assumption is warranted by the positive tests given by some of the rat stones reported previously wherein there was a sufficiency of stone material for the performance of this test.

It will also be seen from the above two tables that while there are some stones containing fairly large amounts of calcium, with approximately equivalent amounts of carbonate, there are some equally rich in calcium with little or no carbonates. Qualitative tests for the presence of sulphates, cystine, formate, acetate, butyrate, oxalate and succinate showed that the calcium is not held in combination with any of these radicals; it could not exist in combination with any organic nitrogenous compound commonly found in urine, since the stones contain nitrogen only in traces. It was, therefore, suspected that the calcium might exist as its hydroxide. Such stones (containing fair amounts of calcium with little or no carbonates) when treated with a small quantity of distilled water were alkaline to litmus and methyl red. But the addition of a drop of 0.1N sulphuric acid gave a distinctly acid reaction, which again turned alkaline after violent shaking and gentle warming. The following experiment repeated with six stones (Nos. 48, 51, 59, 66, 91 and 95) was, therefore, designed to prove that stones containing fair amounts of calcium with little or no carbonates are composed for the most part of calcium hydroxide; weighed amounts of the dry, powdered stones were treated with an excess of 0.1 N acid and boiled for over 5 minutes; when cold they were back titrated against decinormal alkali. In all the six stones the acid used up was appreciable; but the amounts used up were not strictly equivalent to the amount of calcium present in the stones. Presumably, the molecules of calcium hydroxide are coated with a thin film of some urinary colloid which renders the penetration of acid difficult, and at best, imperfect. This may possibly explain why such stone powders did not use up appreciable amounts of acid when titrated

direct. However, the same stone powders, when boiled with excess of acid, took up very appreciable amounts of it. Even then, the process of neutralisation was imperfect; for the residue left over after the endpoint was reached, when freed completely from acid by repeated washings with distilled water, and boiled as before with decinormal acid, was found to use up a portion of the acid added. Further, the stones containing large amounts of calcium, with little or no carbonates, liberated ammonia when boiled with a solution of ammonium chloride. These tests show that the calcium in such stones exists as its hydroxide.

The moisture content of the stones varied widely: from 2.1 to 49.3 per cent, the average being 14.17 per cent. Comparing the moisture content of the stones with their general composition, it is seen that the moisture content serves as an approximate guide to the composition of the stone: those with a low moisture content, below 10 per cent and especially those below 5 per cent, consist mostly of calcium carbonate; those rich in moisture, viz., above 20 per cent, consist for the most part of calcium hydroxide; and those whose moisture content lies between 10 and 20 per cent, consist mostly of mixtures of calcium carbonate and calcium hydroxide.

Composition of Stones from Various Parts of the Urinary Tract.—There were in the present series of 78 stones, 60 bladder stones, 15 kidney stones, 2 ureter stones and one chalky gravel from the prepuce. There was not in this series any particular association between the location of the stone and its composition. Data relating to it are given in Table IX, in the construction of which the principal constituent of the stones is reckoned.

TABLE IX

Location of stones	Number of stones	Number of calcium carbonate stones	Number of calcium hydroxide stones	Number of mixed stones	Number of magnesium ammonium phosphate stones	Total
Bladder	60	27	11	16	6	60
Kidney	15	10	2	3	0	15
Ureters	2	2	0	0	0	2
Prepuce	1	1	0	0	0	1
Totals	78	40	13	19	6	78

Diet and Chemical Composition.—Of the 78 stones, whose chemical composition was investigated, 72 contained large amounts of calcium with very little phosphate, while 6 contained appreciable amounts of phosphates and magnesium with little or no calcium. The whole set of stones ranges itself into two distinct groups: calcium stones, wherein the calcium exists either as the carbonate, or the hydroxide or a mixture of both, and magnesium ammonium phosphate stones. The following Tables X and XI show the diets employed in their production.

TABLE X

Showing the composition of McCarrison's experimental diets containing added lime.

A.	White bread	... 97 per cent.
	Dried yeast	... 3 " "
	Lime	... 5 grains per rat per day.
	Iodine solution (1 mg. in 1 litre)	... 5 drops per rat per day.
B.	White bread	... 97 per cent.
	Dried yeast	... 3 " "
	Lime	... 5 grains per rat per day.
C.	White bread	... 95 per cent.
	Dried yeast	... 3 " "
	Gingelli oil	... 2 " "
	Lime	... 5 grains per rat per day.
	Iodine solution	... 5 drops per rat per day.
E.	White bread	... 97 per cent.
	Dried yeast	... 3 " "
	Lime	... 5 grains per rat per day.
	Iodine solution	... 5 drops per rat per day.
	Manganese chloride	... 0.0327 mg. per rat per day
H.	White bread	... 97 per cent.
	Dried yeast	... 3 " "
	Lime	... 5 grains per rat per day.
	Distilled water containing 0.25 mg. of iodine per litre of water for drinking purposes.	
I.	White bread	... 95 per cent.
	Dried yeast	... 3 " "
	Radiostoleum in gingelli oil.	... 2 " "
	Iodine solution	... 5 drops per rat per day.
	Lime	... 5 grains per rat per day.
J.	White bread	... 97 per cent.
	Dried yeast	... 3 " "
	Iodine solution	... 5 drops per rat per day.
	Lime	... 2½ grains per rat per day.

TABLE XI

Showing the composition of McCarrison's experimental diets containing no added lime

D.	Oatmeal	...	...	...	53 per cent.		
	Linseed meal	...	...	...	20	"	"
	Corn flour	...	...	...	25	"	"
	Sodium chloride	...	...	...	1	"	"
	Calcium phosphate	...	...	...	1	"	"
F.	White flour	...	...	...	90	"	"
	Linseed oil	...	...	...	8	"	"
	Sodium chloride	...	...	...	1	"	"
	Calcium phosphate	...	...	...	1	"	"
G.	White flour	...	...	...	20	"	"
	Casein	...	...	...	60	"	"
	Olive oil	...	...	...	8	"	"
	Gingelli oil	...	...	...	2	"	"
	Salt mixture	...	...	...	5	"	"
	Dried yeast	...	...	...	5	"	"
K.	White flour	...	...	...	60	"	"
	Casein...	...	...	...	20	"	"
	Hydrogenated fat	...	...	...	8	"	"
	Hydrogenated fat <i>plus</i> radiostoleum	...	...	...	2	"	"
	Salt mixture	...	...	...	5	"	"
	Dried yeast	—	...	...	5	"	"
L.	Casein...	...	...	...	80	"	"
	Hydrogenated fat	...	...	...	8	"	"
	Hydrogenated fat <i>plus</i> radiostoleum	...	...	...	2	"	"
	Salt mixture	...	...	...	5	"	"
	Dried yeast	...	...	...	5	"	"

There is thus found a close association between the diet and the chemical composition of stones. This association is clearly set forth in Table XII, in the construction of which only the principal constituent of the stones is taken into consideration; Table XIII shows a similar association after incorporating the results of the 21 rat stones previously reported upon.

TABLE XII

Diet	Number of stones	Number of Calcium carbonate stones	Number of calcium hydroxide stones	Number of magnesium amm. phosphate stones	Number of mixed calcium stones	Total
A	16	9	3	0	4	16
B	13	8	2	0	3	13
C	22	9	4	0	9	22
D	2	0	0	2	0	2
E	15	8	1	0	6	15
F	1	0	0	1	0	1
G	1	0	0	1	0	1
H	2	0	1	0	1	2
I	1	0	1	0	0	1
J	3	2	0	0	1	3
K	1	0	0	1	0	1
L	1	0	0	1	0	1
Total	78	36	12	6	24	78

TABLE XIII

Diet	Number of stones	Number of calcium stones	Number of magnesium ammonium phosphate stones
Those containing added lime	72	72	0
Those containing no added lime	27	0	27
Totals	99	72	27

It is thus seen that the stones produced on diets to which extra lime was added were composed either of calcium carbonate or calcium hydroxide or a mixture of both; while the stones produced on diets to which lime was not added were composed of magnesium ammonium phosphate. It is also seen that there is no association between the diet and the particular kind of calcium stones produced, for, the same diets that produced calcium carbonate stones in some rats produced calcium

hydroxide or mixed stones in others. Possibly, the stones originate as calcium hydroxide and get deposited as such, in the absence of any available carbonate in the urine. Further, it is evident from the foregoing observations that the addition of lime to the diet profoundly alters the composition of the stone. While it is generally contended that very little calcium passes through the urinary tract, instances have occurred wherein calcium has been found in the urinary tract of rats in as large amounts as one-fiftieth of the body-weight of the animal. Particular interest therefore attaches to the chemical composition of the present series of stones, as it affords material for evaluating the influence of added lime on the composition of the rat stones. The course of ingested lime was investigated biochemically; at the same time, the metabolism of phosphorus and magnesium, the two important elements occurring in the non-calcium stones, was also studied. To this end, various deficient diets which had proved to be of high stone-producing potency were used.

Experimental.—The animals were kept in individual metabolism cages, specially designed for this purpose in these laboratories. In the present studies, special precautions were not taken to prevent fermentation of the urines and the faeces, as the investigation was limited to mineral metabolism alone.

The *basal* diet used in these experiments consisted of 97 grs. of white bread and 3 grs. of yeast, to which were added 25 grains of slaked lime and 25 drops of an iodine solution containing one mg. of iodine per litre. Each rat was given 20 grs. of this food per day, thereby having a daily supply of 5 grains of slaked lime. Several modifications of this diet were made, and the effects of the change on the mineral metabolism studied. These modifications were as follows: additions of radiostoleum (vitamins A and D), sesame oil, milk, sodium phosphate, butter, sodium phosphate and vitamin A, vitamin A alone, sodium phosphate and radiostoleum, radiostoleum alone or cod-liver oil to the basal diet. Two young albino rats in growing period were fed on each of these diets. The diets were made into a homogeneous, non-crumbling mass and pressed into small glass food-containers each holding 20 to 25 grs. of food. The animals were provided with distilled water *ad libitum*. When milk formed part of the diet, it was given in measured amounts and

that left unconsumed in the milk tube being measured the next morning.

The animals were fed at 11 a.m. daily and the following morning the food left unconsumed was picked out of the containers and weighed. The food-intake of each animal was thus arrived at, due allowance being made for loss of weight consequent on drying. This loss was slight; it ranged in the 13 diets used between 1.5 and 3.0 per cent.

The calcium, magnesium and phosphate contents of the various diets were estimated. The urines were collected daily into stoppered bottles and analyses made on representative samples of them collected during each week. In collecting the urines, urinary deposits were often noticed sticking to the stem of the funnel and to the bottom of the flask. These deposits were dissolved in 5 to 10 c.c. of strong hydrochloric acid on the last day of each weekly collection, and added to the main bulk of the urines. An additional advantage of this procedure was that it held in solution salts which would otherwise have been thrown out of solution during the storage necessary before analyses could be completed by a single worker. Before the addition of hydrochloric acid solution of the urinary deposits to the main bulk of the urines, aliquots of the representative samples were taken and utilised for chloride estimation. Total nitrogen, phosphate, calcium and magnesium were determined in the remainders. The faeces were collected at least two hours before the administration of food, care being taken to avoid their contamination by food particles. They were weighed and then dried at 100°C for over 6 hours. When completely dry, they were again weighed, powdered and representative samples taken for analysis. Phosphates, calcium and magnesium were determined in them. It is thus possible from the above analysis to form a fairly accurate estimate of the actual intake of calcium, magnesium and phosphates and of the respective amounts of them that are excreted through the urinary and intestinal tracts, and therefrom to arrive at the amounts retained in the body. Records of the intake of food, the volume of urine voided, the weight of faeces excreted and the weekly body-weights were maintained for each animal. For the sake of convenience, the experiments were divided into three series.

SERIES I

The mineral metabolism under this head was confined to the following four diets :—

Group I received a modified 'stock' diet,¹ consisting of 'atta chapatties', sprouted Bengal gram, cabbage and milk;

Group II received the basal diet, wherein 2 parts of white bread were replaced by 2 of sesame oil containing half a drop of radiostoleum (300 Blue, B.D.H.). The consumption of radiostoleum was approximately 0.06 of a drop per rat per day.

Group III received the same diet as in Group II but without the radiostoleum.

Weekly analysis of the urines and faeces were made for six weeks when the following alterations in the diets were made. The animals in Group I were given in addition slaked lime to the extent of five grains per rat per day (incorporated in 20 gms. of food) while those of the other two groups received milk in addition. This alteration in the diets was made with a view to finding out what changes, if any, were brought about in the excretion of lime by its addition to the 'stock' diet and what by making good the vitamin deficiencies of the other diets by the addition of milk. The observations of mineral metabolism under the altered conditions were carried out for a further six weeks. The results are set out in detail in the *Indian Journal of Medical Research*, 1931, vol. xix, p. 1; a summary of the results is given in Tables XIV (a), (b) and (c) and XV. The results for the faeces are reported on dry samples.

TABLE XIV (a)

	CALCIUM (CaO).					
	Intake mg.	Output			Balance or retention.	
		Urine mg.	Fæces mg.	Total mg.	Mg.	Percent- age of intake
Group I.						
Mean for the first 6 weeks.	844	45	129	174	670	79.4
Mean for the second 6 weeks.	2,133	46.5	1,192.5	1,239	894	41.9

¹ The original 'stock diet' included in addition carrots and occasionally meat.

TABLE XIV (a)—Contd.

	CALCIUM (CaO).					
	Intake mg.	Output			Balance or retention.	
		Urine mg.	Fæces mg.	Total mg.	Mg.	Percent- age of intake
Group II.						
Mean for the first 6 weeks.	1,314	320	273	593	721	54.9
Mean for the second 6 weeks.	1,616	76	690	766	850	52.6
Group III.						
Mean for the first 6 weeks.	1,152	171	324	495	657	57.0
Mean for the second 6 weeks.	1,442	86	675	761	681	47.2

TABLE XIV (b)

PHOSPHATES (P ₂ O ₅).							
Intake mg.	Output			Balance or retention		CaO retained/ P ₂ O ₅ retained	
	Urine mg.	Faeces mg.	Total mg.	Mg.	Percent- age of intake		
Group I.							
Mean for the first 6 weeks	1,029	441	225	666	363	35.3	1.85
Mean for the second 6 weeks	1,025	162	892	1,054	—29	—2.7	...
Group II.							
Mean for the first 6 weeks	411	13	109	122	289	70.3	2.49
Mean for the second 6 weeks	622	45	344	389	233	37.5	3.65

TABLE XIV (b)—Contd.

	PHOSPHATES (P_2O_5).						CaO retained/ P_2O_5 retained
	Intake mg.	Urine mg.	Output		Balance or retention		
			Fæces mg.	Total mg.	Mg.	Percentage of intake	
Group III.							
Mean for the first 6 weeks	360	12	117	129	231	64.2	2.84
Mean for the second 6 weeks	568	56	377	433	135	23.8	5.04

TABLE XIV (c)

	MAGNESIUM (MgO).					
	Intake mg.	Output			Balance or retention	
		Urine mg.	Fæces mg.	Total mg.	Mg.	Percent- age of intake
Group I.						
Mean for the first 6 weeks.	233	18	47	65	158	67.8
Mean for the second 6 weeks.	428	57	297	354	74	17.3
Group II.						
Mean for the first 6 weeks.	250	37	31	68	182	72.8
Mean for the second 6 weeks.	316	46	93	139	177	56.0
Group III.						
Mean for the first 6 weeks.	219	36	26	62	157	71.7
Mean for the second 6 weeks.	283	35	89	124	159	56.2

TABLE XV

	Output of CaO in		Output of P ₂ O ₅ in		Output of MgO in	
	Urine	Fæces	Urine	Fæces	Urine	Fæces
	Percentage		Percentage		Percentage	
Group I.						
Mean for the first 6 weeks.	0.023	0.58	0.232	1.18	0.011	0.21
Mean for the second 6 weeks.	0.022	4.44	0.076	3.67	0.027	1.23
Group II.						
Mean for the first 6 weeks.	0.291	4.29	0.012	1.69	0.035	0.36
Mean for the second 6 weeks.	0.055	7.91	0.025	4.03	0.029	1.10
Group III.						
Mean for the first 6 weeks.	0.131	6.20	0.010	2.24	0.027	0.038
Mean for the second 6 weeks.	0.061	8.25	0.039	4.65	0.024	1.07

The results of metabolic studies show that there was very little excretion of calcium through the urinary tract of rats when they were fed on the 'stock' diet. Even when the calcium content of the diet was greatly increased by the addition of lime, the excretion of calcium in the urine was not appreciably affected. These results are in conformity with those of Stewart and Percival,¹ Telfer,² and Bauer, Albright and Aub.³ But the addition of lime to diets of which the chief deficiencies were fat-soluble vitamins and phosphates, led to a great excretion of calcium through the urinary tract. The excretion of calcium through the bowels was also great. When the above deficiencies were partly corrected by the addition of milk, the urinary

¹ Stewart and Percival (1928): *Physiol. Rev.*, viii, p. 283.

² Telfer (1922): *Quart. Jour. Med.*, xvi, p. 45.

³ Bauer, Albright and Aub (1930): *Abst. J.A.M.A.* (1930), xciv, p. 1022.

calcium decreased while the faecal calcium correspondingly increased. It was suspected that the apparent discrepancies in the estimation of urinary calcium of animals in Group III, just before the addition of milk, were possibly due to the development of stone in one of the animals, which exhibited clinical symptoms of this malady—protrusion of the penis, a common symptom of stone—and loss of weight; this it was thought would lead to a storage of mineral salts. This suspicion was later confirmed at the post-mortem when stones were found both in the kidney and bladder; these weighed 19.2 and 95.0 mgs. respectively. Their compositions were as follows:—

—	Mois.	N.	P ₂ O ₅	CaO	MgO	CO
Kidney	5.1	1.6	0.9	44.2	Trace	40.8
Bladder	3.6	1.3	1.4	43.0	1.5	36.5

The figures represent results on moisture-free samples.

The amount of calcium excreted through the bowels in animals fed on the stock diet exhibited a fairly close relation to the amount of phosphates in the faeces. On this diet, the two ingredients, CaO and P₂O₅, seemed to exist approximately in the ratio obtaining in calcium phosphate. This relation of CaO to P₂O₅ was not so well observed in rats fed on the deficient diets, especially in the pre-milk period; showing thereby that a considerable part of the calcium was excreted in some form other than calcium phosphate, possibly as sulphate. Qualitative tests showed that the faeces of the deficiently-fed animals contained more sulphates than those of animals on the stock diet.

As regards phosphates, there was, comparatively speaking, a far greater excretion of phosphates in the urine on stock diet than on the deficient diets. When lime was added to the stock diet, the urinary phosphates rapidly decreased, while the faecal phosphates correspondingly increased. In the deficiently-fed rats, there was very little excretion of phosphates in the urine; but with the addition of milk, urinary phosphates increased gradually.

A study of the excretions of CaO and P₂O₅ in rats fed on the three diets shows that the urinary excretion of phosphates seems to be governed by the intake of CaO and P₂O₅. If the diet be well balanced as regards its calcium and phosphorus,

there should theoretically be only very little excretion of calcium in the urine. But in the deficiently-fed animals, where there was a preponderating excess of calcium over phosphates, very little of the phosphate was left, after combination with calcium in the bowels, to be excreted in the urine. Again, the greater urinary excretion of phosphates in stock animals was due only to the relative amounts of calcium and phosphates in the stock diet and not to the content of fat-soluble vitamins in the diet; this was well shown by the behaviour of rats (Group II) receiving radiostoleum.¹ It was also shown by the rats on stock diet in the post-lime period where a great imbalance between calcium and phosphorus was brought about by the addition of large amounts of lime to the diet.

SERIES II

The study of mineral metabolism under this head was confined to the following four diets:—

Group I received the basal diet of white bread, yeast, lime and iodine without further addition;

Group II received the basal diet *plus* milk *ad libitum*;

Group III received the basal diet *plus* sodium phosphate in amounts approximately equivalent to the amount of calcium in the diet so as to facilitate the formation of calcium phosphate;

Group IV received the basal diet *plus* butter to the extent of 20 per cent of the diet.

It was suspected as a result of the metabolic studies recorded under Series I, that if the diet rich in calcium were also to contain an abundance of phosphates, in quantities sufficient to form calcium phosphate, then very little of the calcium ingested would pass through the kidneys, while most of it would pass through the bowels. Further, it had been noticed in the first series that the addition of milk to calcium-rich diets was able to divert the course of a major portion of the calcium from the urine to the faeces. In order to determine whether this was achieved solely by the fat-soluble vitamins of the milk, or by its phosphate content alone, or by the conjoint effects of both, the above four diets were employed.

¹ It is possible, however, that the amount of fat-soluble vitamins added to the deficient diet in the form of radio-stoleum may have been insufficient for the metabolic needs of the animals. But as will be seen later in Series III, the same observations were noticed even when the radiostoleum content of the diet was increased sixteen-fold.

As in the first series, weekly analysis of the urines and the faeces were made to find out the excretions of CaO, MgO and P_2O_5 . These observations were extended to nine weeks. The diets were also analysed for their CaO, MgO and P_2O_5 contents to evaluate the intake of the three mineral salts. A summary of the results as total excreted is reported in Table XVI (a), (b) and (c), while Table XVII gives the same as percentages of the urines or the faeces. The results for the faeces are reported as before on moisture-free samples.

Slight changes were effected in the amount of butter added to the diet. Up to the end of the sixth week, the animals were receiving butter to the extent of 20 per cent of their diet. In the seventh week, the percentage was reduced by one-half, viz., to 10 per cent, during the eighth week to 5 per cent, and during the last week butter was totally cut out from the diet. It was seen that the urinary excretion of CaO which was as high as 112 mgs. in the seventh week, rapidly fell to 42 mgs. in the eighth week, and to 29 mgs. in the ninth week. Synchronous with this decrease in the urinary output of CaO, the animals grew better during the last three weeks, they had better appetite and consequently, there was a greater intake of CaO.

At the end of the experiment the animals were killed and subjected to complete post-mortem examination. Vesical calculi were found in one of the animals on the basal diet; the weight of the dry stones was 31.3 mgs. On analysis they were found to contain: moisture 11.5, nitrogen 2.2, P_2O_5 1.36, CaO 34.2, MgO nil, and CO_2 trace; the figures represent results as percentages on moisture-free sample.

TABLE XVI (a)

	CALCIUM (CaO).					
	Intake mg.	Output			Balance or retention	
		Urine mg.	Faeces mg.	Total mg.	Mg.	Percent- age of intake
Group I.						
Mean of nine weekly determi- nations.	1,145	96	272	368	777	67.9

TABLE XVI (a)—Contd.

	CALCIUM (CaO).					
	Intake mg.	Output			Balance or retention	
		Urine mg.	Faeces mg.	Total mg.	Mg.	Percent- age of intake
Group II.						
Mean of nine weekly determi- nations.	1,929	122	670	792	1,137	58.9
Group III.						
Mean of nine weekly determi- nations.	1,844	90	952	1,042	802	43.5
Group IV.						
Mean of nine weekly determi- nations.	1,042	57	267	324	718	68.9

TABLE XVI (b)

	PHOSPHATES (P ₂ O ₅).						
	Intake mg.	Output			Balance or retention		CaO retention/ P ₂ O ₅ retention
		Urine mg.	Fæces mg.	Total mg.	Mg.	Percent- age of intake	
Group I.							
Mean of nine weekly determinations	334	12	84	96	238	71.3	3.26
Group II.							
Mean of nine weekly determinations	729	28	221	249	480	65.8	2.37
Group III.							
Mean of nine weekly determinations	1,316	86	340	426	890	67.6	0.90
Group IV.							
Mean of nine weekly determinations	305	13	78	91	214	70.2	3.36

TABLE XVI (c)

	MAGNESIA (MgO).					
	Intake Mg.	Output			Balance or retention	
		Urine Mg.	Fæces Mg.	Total Mg.	Mg.	Percentage of intake.
Group I.						
Mean of nine weekly determinations.	201	30	42	72	129	64.2
Group II.						
Mean of nine weekly determinations.	355	75	94	169	186	52.4
Group III.						
Mean of nine weekly determinations.	324	20	129	149	175	54.0
Group IV.						
Mean of nine weekly determinations.	182	23	57	80	102	56.0

TABLE XVII

	Output of CaO in		Output of P ₂ O ₅ in		Output of MgO in	
	Urine	Fæces	Urine	Fæces	Urine	Fæces
	Percentage		Percentage		Percentage	
Group I.						
Mean of nine weekly determinations.	0.153	8.51	0.018	2.69	0.053	1.33
Group II.						
Mean of nine weekly determinations.	0.076	7.42	0.017	2.52	0.046	1.12
Group III.						
Mean of nine weekly determinations.	0.067	12.74	0.051	4.65	0.021	1.72
Group IV.						
Mean of nine weekly determinations.	0.088	5.25	0.017	1.60	0.034	1.12

SERIES III

The mineral metabolism in this series was restricted to the following six diets :—

Group I received the basal diet *plus* sodium phosphates in amounts equivalent to the calcium content of the diet to form calcium phosphate;

Group II received the basal diet *plus* sodium phosphate as in Group I *plus* vitamin A concentrate (vitamin A Oil, Special, 150 Blue; without added vitamin D, British Drug Houses, Limited) in the proportion of one drop per rat per day;

Group III received the basal diet *plus* vitamin A concentrate as in Group II;

Group IV received the basal diet *plus* sodium phosphate as in Group I *plus* Radiostoleum (300 Blue, B.D.H.) in the proportion of one drop per rat per day;

Group V received the basal diet *plus* radiostoleum as in Group IV;

Group VI received the basal diet *plus* sodium phosphate as in Group I *plus* cod-liver oil to the extent of 2 per cent of the diet.

A relatively high excretion of Ca and a low urinary excretion of phosphates having been observed in Group II (receiving basal diet *plus* radiostoleum) of the first series of experiments, it was suspected that this might have been due to the insufficient provision of fat-soluble vitamins. Hence in the present series, the amount of vitamin preparations, either as vitamin A concentrate or as radiostoleum, was increased sixteen-fold. With a view to finding out the influence, if any, of vitamin D on this mineral metabolic study, diets containing vitamin A alone, and others containing vitamins A and D were used. A diet with cod-liver oil (Group VI) was included to evaluate the efficiency of the proprietary vitamin preparations of the British Drug Houses in terms of cod-liver oil.

It may be mentioned here that the appetite of the animals receiving sodium phosphate in their diets, viz., those in Groups I, II, IV and VI, was so great that the 20 grs. of food usually given was not sufficient. Therefore the amount of food given was increased to 25 grs. per rat, but still containing only the five grains of lime and five drops of the iodine solution.

As before, weekly analysis of the urines and the faeces were made to find out the respective excretions of CaO, MgO and P_2O_5 . These observations were extended to six weeks. The diets, too were analysed for their CaO, MgO and P_2O_5 contents. A summary of the results obtained, expressed in milligrammes as total excreted is set out in Table XVIII (a), (b) and (c) and the same calculated as percentages of either the urines or the faeces, are set out in Table XIX. The results for the faeces are reported on moisture-free samples.

TABLE XVIII (a)

	CALCIUM (CaO.)					
	Intake mg.	Output			Balance or retention	
		Urine mg.	Fæces mg.	Total mg.	mg.	Percentage of intake.
Group I. Basal diet <i>plus</i> sodium phosphate.						
Mean of six weekly determinations.	2,300	141	1,412	1,553	747	32.5
Group II. Basal diet <i>plus</i> sodium phosphate <i>plus</i> vitamin A concentrate.						
Mean of six weekly determinations.	2,448	159	1,458	1,617	831	33.9
Group III. Basal diet <i>plus</i> vitamin A concentrate.						
Mean of six weekly determinations.	1,074	231	531	762	312	29.1
Group IV. Basal diet <i>plus</i> sodium phosphate <i>plus</i> radiostoleum.						
Mean of six weekly determinations.	2,305	153	1,352	1,505	800	34.7
Group V. Basal diet <i>plus</i> radiostoleum.						
Mean of six weekly determinations.	1,136	137	460	597	539	47.3
Group VI. Basal diet <i>plus</i> sodium phosphate <i>plus</i> cod-liver oil.						
Mean of six weekly determinations.	2,391	51	1,426	1,477	914	38.2

TABLE XVIII (b)

	PHOSPHATES (P ₂ O ₅).						CaO retained/ P ₂ O ₅ retained
	Intake mg.	Output			Balance or retention		
		Urine mg.	Faeces mg.	Total mg.	Mg.	Percent- age of intake	
Group I.							
Mean of six weekly determinations.	1,604	94	688	782	822	51·3	0·91
Group II.							
Mean of six weekly determinations.	1,707	139	709	848	859	50·3	0·97
Group III.							
Mean of six weekly determinations.	265	31	209	240	25	9·4	12·48
Group IV.							
Mean of six weekly determinations.	1,607	151	642	793	814	50·7	0·98
Group V.							
Mean of six weekly determinations.	281	16	156	172	109	38·8	4·94
Group VI.							
Mean of six weekly determinations.	1,666	65	731	796	870	52·2	1·05

TABLE XVIII (c)

	MAGNESIA (MgO).					
	Intake mg.	O u t p u t			Balance or retention	
		Urine mg.	Fæces mg.	Total mg.	Mg.	Percentage of intake
Group I.						
Mean of six weekly determinations.	280	37	156	193	87	31.1

TABLE XVIII (c) (contd.)

	MAGNESIA (MgO).					
	Intake mg.	Output			Balance or retention	
		Urine mg.	Fæces mg.	Total mg.	Mg	Percentage of intake
Group II.						
Mean of six weekly determinations.	298	23	170	193	105	35.2
Group III.						
Mean of six weekly determinations.	122	41	69	110	12	9.8
Group IV.						
Mean of six weekly determinations.	281	27	152	179	102	36.3
Group V.						
Mean of six weekly determinations.	128	15	70	85	43	33.6
Group VI.						
Mean of six weekly determinations.	291	21	155	176	115	39.5

TABLE XIX

	Output of CaO in		Output of P ₂ O ₅ in		Output of MgO in	
	Urine	Fæces	Urine	Fæces	Urine	Fæces
	Percentage	Percentage	Percentage	Percentage	Percentage	Percentage
Group I.						
Mean of six weekly determinations.	0.058	14.18	0.042	6.89	0.016	1.57
Group II.						
Mean of six weekly determinations.	0.081	14.00	0.072	6.91	0.012	1.62

TABLE XIX (contd.)

	Output of CaO in		Output of P ₂ O ₅ in		Output of MgO in	
	Urine	Fæces	Urine	Fæces	Urine	Fæces
	Percentage		Percentage		Percentage	
Group III.						
Mean of six weekly determinations.	0.124	11.98	0.017	4.65	0.023	1.55
Group IV.						
Mean of six weekly determinations.	0.068	14.27	0.067	6.73	0.012	1.60
Group V.						
Mean of six weekly determinations.	0.218	12.47	0.027	4.62	0.025	1.45
Group VI.						
Mean of six weekly determinations.	0.036	14.01	0.047	7.13	0.015	1.52

Limitations of space preclude a detailed interpretation of the results. But the one noteworthy point that arrests the attention is the significant difference between the groups I, II, IV and VI on the one hand, and groups III and V on the other. In the former, as a rule, there was comparatively far less excretion of CaO in the urine than in the latter two groups. A study of Table XIX shows that the average percentage excretions of CaO in the urines of groups I, II, IV and VI were 0.058, 0.081, 0.068 and 0.036 respectively with a mean of 0.061 per cent, while the values for groups III and V were 0.124 and 0.218 respectively with a mean of 0.171 per cent, which is nearly three times as much as in animals receiving sodium phosphate in their diets. Though the latter two groups of animals got a sufficiency of vitamins, chiefly as vitamin A, the fact that their urines contained large amounts of calcium may render them liable to stone formation. Conversely, the percentage urinary excretion of phosphates, in groups I, II, IV and VI were 0.042, 0.072, 0.067 and 0.047 respectively with a mean of 0.057 per cent; the corresponding values for groups III and V being 0.017 and 0.027 with a mean of 0.022 per cent,

which is roughly a third of that of the animals receiving sodium phosphate. Thus there seems to be an inverse relation between the urinary calcium and phosphorus. A similar observation was noticed by Meigs *et al* in their experiments on the *Physiology of Phosphorus and Calcium Metabolism of Dairy Cows*.¹

It is stated that calcium is excreted both by the kidney and the large intestine, the greater part by the latter route.^{2,3} It is also stated that diets rich in calcium cause only a slight increase in the urinary excretion of calcium. But as will be at once apparent from the results of the present investigation, these statements require qualification. Under normal conditions, practically all the calcium of the diet excepting that actually utilised in the system, is excreted through the bowels. But in rats fed on diets deficient in fat-soluble vitamins and containing an excess of calcium, a considerable amount of the calcium is excreted through the kidneys—an amount several times greater than that excreted by normally fed animals. Though the amounts excreted may not intrinsically be very great, yet in the light of the solubilities of salts like calcium hydroxide, calcium phosphate and calcium carbonate, the significance of the values of urinary calcium becomes at once apparent; it is one of the positive factors predisposing the animals to stone formation.

Deficiency of vitamin A is generally held to be one of the chief causes of stone formation. Provision of an adequate amount of this vitamin does prevent stone formation in rats fed on certain diets; but the results of the present investigation, wherein diets of such high stone-producing potency were employed, indicate that the mineral imbalance is a factor of even greater importance in the production of calcium carbonate or calcium hydroxide stones. It has been found in this investigation that the addition of fat-soluble vitamins to the diet, either as vitamin A alone or in association with vitamin D, did not materially alter the composition of the urine; in fact, the urinary excretion of calcium was much the same as when vitamins A, or A and D, were lacking. Yet the crucial point is whether such a state of affairs conduces to stone formation in

¹ Meigs, Blatherwick and Cary (1919): *Jour. Biol. Chem.*, xl, p. 469.

² Cushny (1918): *Text-book of Pharmacology and Therapeutics*, Seventh Edition, p. 559.

³ Husband, Godden and Richards (1923): *Biochem. Jour.*, xvii, p. 707.

the urinary tract. From the values obtained of the urinary excretion of calcium on diets deficient in fat-soluble vitamins as also on diets containing them in sufficient amounts, the conclusion is irresistible that stone formation is very likely. Nevertheless, not a single case of urinary calculus has so far been encountered in rats fed on diets adequate in vitamin A. There was the instance of a rat, a male, getting the basal diet *plus* vitamin A concentrate actually passing gravel in its urine. The discrete particles of gravel were found to be mostly of calcium hydroxide. Though most of the factors conducive to stone formation were present in this case, yet, consequent on the presence of vitamin A in the diet which 'maintained the functional and nutritional integrity of the cell walls', formed stones were not deposited in the bladder. Hence, as the particles of the calcium hydroxide formed, they were passed in the urine.

Again, the animals, though receiving adequate amounts of vitamin A, always ran the risk of developing stones in their urinary tract during any inadvertent cessation of the provision of this vitamin. The results of the present investigation suggest that this risk can to a great extent be minimised by balancing the diet as regards its CaO and P₂O₅ contents. The balancing of the CaO and P₂O₅ contents of the diets were found to be much more beneficial than provision of adequate amounts of fat-soluble vitamins. The true significance of this statement is better understood when the growth of the animals is taken into consideration. The growth obtained on diets, balanced as regards its CaO and P₂O₅ contents but lacking in fat-soluble vitamins, almost approximated the growth obtained on the stock diet. But by far the best approximation to the stock diet was obtained when the above diet contained in addition adequate amounts of the fat-soluble vitamins.

RELATION OF CALCIUM RETENTION TO PHOSPHATE RETENTION

Theoretically, on a normal diet, the ratio of retention of CaO to P₂O₅ should be fairly constant. Assuming all the calcium were to be retained in the system as its phosphate, Ca₃(PO₄)₂, then the ratio, CaO retained/P₂O₅ retained, should equal 1.18. It should not be understood that this value is absolute, for, all the calcium need not necessarily be retained as its phosphate alone. It has been found that the proportion of carbonate in

normal rat bone increases with age.¹ Hence the ratio is bound to vary a little from the theoretical. A study of Tables XIV (b), XVI (b) and XVIII (b) shows wide variations of the value, CaO retained/P₂O₅ retained, with variations in the diet.

Thus, it is seen that out of the thirteen different diets employed in the present metabolic studies, seven gave values approximating closely to the theoretical, while the remaining six gave far higher values ranging from over 3 to as much as nearly 12.5. It so happened that the animals on the former seven diets grew well, had good appetite and were free from disease, while those on the latter six diets suffered from either loss of weight or did not grow at all, and ultimately died. It is also to be noted that the former seven diets on which good growth was obtained were those that were well balanced with respect to their calcium and phosphate contents, whereas the latter six diets on which positively harmful and growth-inhibiting effects were observed were imbalanced as regards their calcium and phosphate contents. It is therefore obvious that a diet imbalanced with respect to its mineral constituents, although containing a sufficiency of the essential vitamins, is more harmful than a diet deficient in fat-soluble vitamins but perfectly balanced as to its mineral constituents. Further, it emerges from the results of these experiments that comparatively little fat-soluble vitamins is needed to maintain growth if the diet is perfectly balanced with respect to its mineral constituents.

COMPENSATING EFFECTS OF VITAMIN D ON MINERAL IMBALANCE

The Plimmers² have stated that vitamin D possesses a compensating effect on the imbalance between the supply of calcium and phosphates. The foregoing metabolic experiments do not support this statement; for, if it were true, there ought to have been good growth in Group V, Series III, where the animals received adequate amounts of vitamin D. On the other hand, when the calcium and phosphate contents of the diet were well balanced, good growth was obtained even when no extra vitamin D was added to it. The above results prove conclusively that vitamin A alone or in association with vitamin D

¹ Kramer and Shear (1928): *Jour. Biol. Chem.*, lxxix, p. 147.

² Plimmer and Plimmer (1929): *Food, Health and Vitamins*, p. 64.

exercised no compensating effect on the imbalance between the supply of calcium and phosphates.

The results of the above investigation bring out the importance of calcium-phosphorus imbalance in connection with the aetiology of calcium carbonate and calcium hydroxide stones in albino rats. They also show conclusively that comparatively little fat-soluble vitamins is needed to maintain good growth, if the diet be perfectly balanced with respect to its mineral constituents. Provision of adequate amounts of fat-soluble vitamins did not improve the growth, if the imbalance between the mineral constituents was not corrected. Further, a study of the values for the ratio, CaO retained/P₂O₅ retained, on the several diets examined suggests that this value may serve as a reliable criterion of the biological efficiency of a diet. Conformity of this value to the theoretical is a necessary pre-requisite to the efficient functioning of a diet. Its importance in devising a stock diet for control animals employed in nutritional researches can hardly be over-estimated.

URINARY CALCULI IN CATTLE

While the investigations on human and rat stones were proceeding apace, it was brought to the notice of Col. McCarrison that urinary calculus is a frequent condition in cattle in certain portions of India, and in response to a questionnaire issued, similar to that for human calculi, he collected twenty-three stones; seventeen were from the various parts of the Madras Presidency, four from Nadiad and Barsi in the Bombay Presidency and two from Jarwar and Fatehpur in the United Provinces. Twenty-one were vesical and urethral stones and two were renal. Particulars in regard to them are given in detail in the *Indian Journal of Medical Research*, 1931, xviii, p. 935.

Physical Characters.—Cattle stones are usually small, grain-like bodies, often little bigger than a No. 4 lead shot, having a light or deep golden yellow sheen about them. Most of them look alike in structure and shape; this is true of only the vesical and urethral stones. The two renal stones stand apart from the rest as regards their physical characteristics: they are of irregular shape, the shape presumably depending on the site of

formation of the calculus in the kidney, and devoid of the bright metallic sheen. The cattle stones differed in their physical characteristics from human stones in the following regards :—

(1) They are much smaller, rarely exceeding the size of a small pea whereas human stones are commonly of large size.

(2) They are usually multiple, often occurring to the number of 100 or more : less often they are few in number. Human stones, on the other hand, are commonly single : less often they are multiple.

(3) Cattle stones have a laminated structure of several layers all looking alike, the layers being thin and comparable to the thin coats of the onion; while the different layers of the human stones have a different composition, consisting either of calcium oxalate, or uric acid or urate, or calcium or magnesium ammonium phosphate, those of cattle stones consist for the most part of calcium carbonate. Again, the several layers of the human stone are differently coloured—the colours serving as an approximate guide to the chemical composition, e.g., uric acid or urate layers being light yellow to dark brown, phosphate layers white to dirty white and oxalate layers being chocolate coloured—whereas those of cattle stones have nearly the same colour.

(4) Cattle stones are quite hard, considerable pressure being usually necessary to powder them. Human stones may also be hard if they consist mostly of calcium oxalate, comparatively less hard if consisting of uric acid or urate and relatively brittle if of phosphates.

(5) Cattle stones have all nearly the same colour which ranges from whitish yellow to yellowish-brown; commonly they have a metallic sheen. Human stones do not all have the same colour nor have they the bright metallic sheen so common in cattle stones.

(6) Whereas all cattle stones resemble one another closely in most of their physical characters, human stones do not.

Chemical Composition.—The similarity of cattle stones in most of their physical characters is manifested in their chemical composition as well. Table XX shows the average composition of a cattle stone.

TABLE XX

		Per cent.
Total ash		54.5
P ₂ O ₅	0.90	...
CaO	44.0	...
MgO	4.84	...
	49.74	...
C ₂ O ₃	...	0.59
N.	...	0.37
CO ₂	...	39.07

The results of the chemical composition of individual cattle stones show that they all have a similar composition, consisting mostly of carbonate of calcium, with a little magnesium. The magnesium content varied from 2.2 to 9.4 per cent with an average of 4.84 per cent; presumably it exists for the most part as carbonate, though it is possible that some may exist in the form of phosphate. The average percentage of CaO being 44.0, it would require only 34.5 per cent of CO₂ to form CaCO₃; while there actually exists 39.07 per cent of CO₂. The remaining 4.57 per cent of CO₂ is presumably combined with magnesium to form magnesium carbonate; if that were so, it would require only 4.19 per cent of MgO whereas the average for MgO works out to 4.84 per cent. The balance of 0.65 per cent MgO is very likely united with the P₂O₅, the average content of which is 0.90 per cent.

Nitrogen is present only in traces, the average being 0.37 per cent. Insoluble matter—i.e., portions of the stone left undissolved after digestion with concentrated sulphuric acid—occurred only once, a kidney stone removed from an ox. The only other kidney stone did not contain any insoluble matter. The chemical composition of the only two renal stones encountered was not significantly different from that of the rest. In this respect, cattle approximate closely to rats, whose renal stones do not differ in their chemical composition from the vesical ones and differ from human beings in whom kidney and bladder stones are essentially different in their composition.

The composition of the stones does not vary appreciably with the age of the animal: that of a calculus from a six months old calf or from a twelve-year fully grown up bullock

being approximately the same. The chemical composition also seems to be independent of the place of nativity of the animals as also of their diet. So far as these limited observations are concerned, there seems to be an indication that stones from different provinces do not materially differ in their chemical composition or in their physical characteristics, notably structure and shape.

Calcium and Magnesium Content of the Waters drunk by Animals.—Samples of water, drunk by five animals suffering from urinary lithiasis were provided. Calcium and magnesium were determined in them, and the results show that the chemical composition of the stone seems to be unaffected by the mineral content of the water drunk by the animals; the composition remains approximately the same whether the stone came from an animal drinking water rich in calcium and magnesium or from one used to a water comparatively poor in these two elements.

The bright metallic sheen in most of the stones suggested that it might be due to the occurrence of iron. Quantitative estimations showed it to be contained in them from almost less than detectable amounts to about 42 mgs. per cent of iron.

PHYSIOLOGICAL SIGNIFICANCE OF THE ABSENCE OF URIC ACID IN RAT AND CATTLE STONES

A study of the results showing the chemical composition of human, cattle and rat stones, shows the conspicuous absence of uric acid in cattle and rat stones, while most of the human stones contain some uric acid or other. This difference has been attributed to a fundamental difference in the physiological disintegration of purine bodies, whereby the process in man stops short at the uric acid stage, while in cattle and rats the uric acid gets oxidised to allantoin. This conversion of uric acid to allantoin is an enzymatic one and is accomplished by the enzyme, uricase, which is found in all animals except man and higher apes. Allantoin is several times more soluble in water than uric acid and hence it never forms a constituent of either of rat or of cattle stones. Human beings do not possess this power, and in them the degradation of purine bodies stops short at uric acid; and as uric acid is very sparingly soluble in water, it is almost always found to be a constituent of urinary

calculi in man. This is the explanation why the rat and cattle stones are singularly devoid of even traces of uric acid.

The extent to which uric acid undergoes this final oxidation to allantoin is indicated by the 'URICOLYTIC INDEX', which represents the ratio of allantoin nitrogen to the sum of allantoin and uric acid nitrogen excreted.

$$\text{Uricolytic Index} = \frac{\text{Allantoin nitrogen}}{(\text{Allantoin} + \text{uric acid}) \text{ N.}} \times 100$$

Previous estimations of the uricolytic index of albino rats has given a value of 96.

Although realising that rats have a high uricolytic index, the author investigated the possibility of producing uric acid and urate calculi in rats; to this end, attempts were made to increase the uric acid concentration of their urine, both by the oral administration of uric acid and by feeding them on a glandular organ. It was found that the uric acid ingested orally did not lead to an increase in the excretion either of uric acid or of allantoin or of total nitrogen; nor was there an appreciable increase when the uric acid was administered with sodium carbonate in amounts sufficient to form the mono-sodium urate. Subcutaneous injections, and injections direct into the blood stream, of an isotonic solution of uric acid did increase the uric acid, allantoin and total nitrogen contents of the urine, but the increase was not commensurate with the amounts of uric acid injected. These injections of uric acid followed by the ingestion of 'atophan' led to a greater increase in the daily excretion of uric acid in the urine; the volume of urine voided was also increased so that the percentage concentration of uric acid in the urine was not materially altered. The results of experiments in this direction, completed after the submission of the present thesis, showed that the experimental production of uric acid calculi in albino rats is not possible (Ranganathan, S. : *Ind. Jour. Med. Res.*, 1934, xxii, p. 71).

PART IV

CAUSATION OF STONE

Having considered so far the physiological and the biochemical aspects of the problem, it now remains to be considered the actual mechanism that governs stone formation.

It has been recognised that stones can be formed within the urinary tract under a variety of conditions, and no single mechanism would suffice to explain the process. Leaving out of consideration the formation of stones arising out of foreign bodies, there are three important theories, each one of which may perhaps be enough to cause stone; but it seems more likely that all the three may play their part in the architecture of the human stone, laminated as we know it to be. The three theories are :—

- (1) Infection;
- (2) Dietetic or faulty metabolism; and
- (3) Physico-chemical theory of protective mechanism.

(1) *The Infection Theory*.—Though infection of the urinary tract as a predisposing cause of stone formation was recognised from a very long time, much thought was not bestowed on it till Rosenow and Meisser¹ experimentally demonstrated the formation of urinary calculi by the devitalisation and infection of teeth in dogs with streptococci from cases of nephrolithiasis. They found that the experimentally produced stones were similar in physical properties to those found in nephrolithiasis of man. They suggest on this basis that a stone forming infection may account for the prevalence of nephrolithiasis in certain localities.

The infection theory received its confirmation in the work of Hager and Magath² who actually isolated *Proteus Ammoniac* in their cases of urinary lithiasis. They also succeeded in experimentally producing vesical calculi by inoculating *Proteus Ammoniac* under favourable conditions. They noted that a deficiency of vitamin A was favourable to the implantation of the organism. The causation of stone by such an infection is explained by them as follows :—The specific bacteria liberate in their growth a urease capable of splitting urea into ammonia, thereby producing an alkaline reaction of the urine. This alkalinity precipitates the calcium, magnesium and ammonium salts which by some mechanism develop into a stone. Hager and Magath have also found *Salmonella Ammoniac* to be capable of causing incrustated cystitis and stone-in-the-bladder.

¹ Rosenow and Meisser: *Arch. Int. Med.*, xxxi, p. 807; *J.A.M.A.*, lxxxi, p. 503; *J.A.M.A.*, lxxviii, p. 266 (1922).

² Hager and Magath: *Ibid.*, lxxxv, pp. 1352-5; *Ibid.*, January 28th, 1928, p. 267.

In dealing with the theories of stone formation, it is difficult to separate them into water-tight compartments; one is so closely interrelated to the other. Thus Osborne and Mendel's¹ experimental production of stones on diets deficient in fat-soluble vitamins has been explained as due to a general debility or lowered vitality brought about by the deficiency of the vitamins, with a resultant invasion of the bladder, production of alkaline urine and consequent deposition of phosphates leading to calculus formation. Again, Fujimaki's² findings that the urine of animals kept on a diet deficient in vitamin A and having bladder calculi was alkaline and that, when the same animals were fed vitamin A, the urine became acid and the bladder stones disappeared, may be traced to an infection brought about by a deficiency of vitamin A which might have been got over by supplying an adequacy of the vitamin. Thus it is seen that the infection theory and the dietetic theory have slowly merged, the latter giving rise to the former.

Even in this infection theory, all organisms do not cause stone; special strains of organisms are necessary to establish the requisite conditions for stone formation. Thus, while, streptococci from cases of nephrolithiasis are able to cause stone formation, streptococci from arthritis do not.

Benjamin Moore³ does not believe in the causation of stone as arising out of infection. But the incidence of phosphatic calculi both in humans and in animals, suggests that infection of the urinary tract may also be a potent factor in the causation of stone. It should be emphasised here that infection need not be an essential factor in the causation of stone; for McCarrison has found in his experimental studies several cases of stones without cystitis or other inflammations of the urinary tract.

(2) *Dietetic or Faulty Metabolism Theory*.—Though dietetic deficiency may be a causal factor, it is stated that it does not directly lead to stone formation. Infection sets in and stone results. Lack of fat-soluble vitamins, especially vitamin A, has been credited with leading to stone formation. Lack of vitamins B and C is not concerned in such formation; nor is poverty of protein in the diet a directive factor. Fujimaki even

¹ Osborne and Mendel (1917): *J.A.M.A.*, lxi, 32.

² Fujimaki (1926): *Japan Med. World*, vi, No. 2, p. 1.

³ Benjamin Moore (1911): *Brit. Med. Jour.*, vol. i, p. 737.

succeeded in dissolving the formed stones by administering sufficient fat-soluble vitamins. Van Leersum,¹ and Perlmann and Weber² have also produced stones in rats fed on a vitamin A deficient diet.

Faulty metabolism is a factor of even greater importance. It may, in most instances, be brought about by any dietetic deficiency, or as in some instances by an excess of either vitamins, particularly vitamin D, or mineral salts. On no other basis can the occurrence of oxalate, urate, and cystine stones be explained. The chemical substances which go to make up the stone vary under different conditions, and are dependent in part upon the aetiological factor. Owing to an excessive ingestion of purine-rich bodies, like glandular organs, or owing to the imperfect oxidation of the uric acid, an intermediate product in purine metabolism, the excretion of uric acid may become enormous. Under favourable conditions, or under conditions simulated by the excessive excretion of uric acid, stones may develop. Again, in the case of oxalate stones, the oxalate may possibly be derived from the indulgence of foods rich in oxalates or more likely from the incomplete oxidation of carbohydrates. Oxalic acid is an intermediate product in the metabolism of carbohydrate; it is capable of being further oxidised into carbon dioxide and water. But under conditions of embarrassed oxidation or increased reducing conditions, oxalates are excreted in large amounts. As there is always an excess of calcium in the urine for combination with the oxalic acid, the oxalic acid in stones is always associated with calcium. This may also be due to the fact that magnesium oxalate is more soluble than the calcium oxalate.

(3) *Physico-chemical Theory*.—This is by far the most important theory and it is the one that can explain adequately the intricate process of stone formation. The physico-chemical aspects of stone formation is a problem which has received and is receiving considerable attention. It is recognised that normal urine contains both colloids and crystalloids in true solution. Great importance has been attached to the role of the urinary colloids in calculus formation. The actual mechanism underlying the process still lacks adequate explanation. One school

¹ Van Leersum (1927): *Ibid.*, vol. ii, pp. 873-4.

² Perlmann and Weber (1930): *Muench. Med. Woch.*, lxxvii, 680-1 (Surg. Clinic, Univ. Berlin).

of thought considers that the urinary salts are 'protected' from coalescing with one another by the colloids present. A second school postulates instead that the colloids form the binding matter which under certain pathological conditions serves as the scaffolding for holding the solid salts in the fully developed stone. There are besides other theories as to the function of the urinary colloids in stone formation. The theoretical ideas underlying these pictures appear to be very nebulous. All the investigators on this aspect of the problem have but recognised two factors in the causation of stone; the urinary salts (e.g., uric acid, phosphate and oxalate of calcium and magnesium etc.) constituting the 'bricks' and some organic matter, possibly fibrin or some other urinary colloid, constituting the 'mortar'. There is yet a third which is either dimly felt or overlooked by them. They have failed to recognise that mere 'bricks' and 'mortar' cannot by any stretch of imagination bring into existence the completed building. They want a mason or possibly several 'masons' to put the 'bricks' and 'mortar' alternately in regular succession and in a pre-arranged manner. Likewise in the formation and growth of stone, the urinary salts and the colloids require the services of a 'mason' in some motive force, either electrical or mechanical, that binds the urinary salts on to the colloids. On this basis, it is possible to explain the changes in the crystalline morphology of the urinary salts brought about apparently by the colloids, but presumably by the motive force.

Keyser,¹ one of the protagonists of the 'protective-mechanism-theory' believes that stone formation is due to a disturbance in the normal protective colloidal mechanism of the urine, either in holding water-insoluble substances in solution or in precipitating crystals in separate entities. Spitzer and Hillkowitz² who have bestowed considerable thought on this subject, postulate that the protective action of urinary colloids is of very delicate balance. The colloidal state is very unstable and there is always the tendency to assume the more stable condition by falling out of suspension. This can be brought about by a variety of ways: (1) an intrinsic reduction in the protective colloid content of the urine; (2) an enormous increase

¹ Keyser: *Annals of Surgery*, February 1923; *Archives of Surgery*, vol. vi, pp. 525-53.

² Spitzer and Hillkowitz: *J.A.M.A.*, vol. lxxxii, p. 1731.

in the crystalloid content of the urine which should be much more than what could be managed by the existing amount of the protective colloids; and (3) by the presence of other colloids of opposite electric charge. Thus, with the removal, or, the inefficient functioning of the protective colloid mechanism, the urine will become subject to the laws obtaining in aqueous solutions. The urinary salts would then get precipitated out easily; this supplies the necessary material for the building up of the stone. There is also the binding matter in the irreversible colloids that have been thrown out of suspension.

The other explanation of the action of the protective mechanism is by its influence on the crystalline morphology. Rainey,¹ and later Ord and Shattock² have established the physical principle that colloidal matter modifies crystalline morphology. Ord showed that non-coalescent crystals of calcium oxalate could be changed to the coalescent form by an alteration in the amount of colloid and salt present in the urine; and Shattock showed the coalescent forms constituted the structural units of calculi. Working in this direction, Keyser arrived at the following conclusions as to the possible mechanisms of stone formation in the urinary tract :—

(1) Normal urine contains a normal amount of crystalloid excreted *plus* a normal quantity and quality of urinary colloid yielding a solution of crystalloid or deposit of crystals in isolated non-coalescent forms.

(2) Stone may be due to an excessive quantity of crystalloid excreted *plus* a normal quantity and quality of urinary colloid resulting in a deposit of fusing atypical non-isolated crystalline units.

(3) Stone may also be due to a normal quantity of crystalloid excreted *plus* a deficient protective activity of urinary colloids brought about by either a deficient quantitative or qualitative excretion of urinary colloids, or by the precipitation of normal urinary colloid, or by masking its protective activity by foreign colloids in exudates of specific bacterial infection, by foreign colloids excreted as the result of abnormal metabolism or produced locally by the action of some toxic metabolites.

¹ Rainey (1895): *Trans. Path. Soc.*, London, xli, pp. 91-132.

² Ord and Shattock (1911): *Proc. Roy. Soc. Med.* (Path. Sect.), iv, pp. 110-46.

(4) Stone may also be due to excessive quantity of crystalloid excreted *plus* deficient protective activity of urinary colloids yielding excessive deposit of fusing non-isolated crystalline units.

Apart from these hypotheses as to the role of the colloids, the following points deserve attention :—

(a) The influence of the urinary colloids in increasing the solubility of the sparingly soluble substances present in the urine, chiefly uric acid, calcium oxalate and calcium phosphate.

(b) The state in which the substances that go to form urinary calculi are present in urine and deposited.

(c) The influence of the colloids in altering the morphological characters of the crystalline substances present in the urine.

(d) Lastly, the nature and general characteristics of the urinary colloids.

Taking the first point, it is known that the solubilities of sparingly soluble substances are considerably increased by small amounts of colloids of the type of gelatin. This property of such colloids has been invoked to explain the high concentration of substances in the urine. The concentration is at times as high as 20 or 30 times the concentration obtaining in distilled water. Csapo's¹ work on the influence of proteins on the solubility of calcium phosphate supports this idea. Hastings, Murray and Sendroy,² working on similar lines found that in such supersaturations the sparingly soluble compounds are bound to some substances which hold them in solution in an unionised form. Pauli and Stenzinger³ also report an increased solubility of the sparingly soluble salts in the presence of proteins. Ascoli,⁴ however, attributed this increased solubility only to the crystalloidal substances present in the urine rather than to the colloids. He finds that normal urine and dialysate, but not the dialysed urine, have considerable solvent power with respect to uric acid. Hohler⁵ too finds that colloids are superfluous or at least of secondary importance in so far

¹ Csapo (1927): *Jour. Biol. Chem.*, vol. lxxv, p. 509.

² Hastings, Murray and Sendroy (1926-27): *Jour. Biol. Chem.*, vol. lxxi, pp. 723, 783 and 797.

³ Pauli and Stenzinger (1929): *Biochem. Z.*, ccv, pp. 71-103.

⁴ Ascoli (1928): *Biochem. Z.*, cc, pp. 95-107.

⁵ Hohler (1919): *Z. Klin. Med.*, lxxxviii, p. 14; *Zentr. Biochem. Biophys.*, xxi, pp. 354-5.

as an explanation of the great solubility of uric acid in fluids of animal origin is concerned. The author's work,¹ carried out chiefly with uric acid and calcium phosphate, tends to confirm Ascoli's result, no great increase in the solubilities being found on the addition of gelatin. Varying concentrations of gelatin (0.01%, 0.02%, 0.04% and 0.08%) were employed and in no case was an appreciable increase in solubility of either uric acid or calcium phosphate observed.

Secondly, the state in which the sparingly soluble substances are present in the urine is obviously of considerable importance in relation to their abnormal solubilities. This will be discussed shortly under the X-Ray diffraction studies of calculi.

The third and the fourth points are still under investigation.

Apart from the above, some other aspects of the physico-chemical processes of stone formation have been studied. Schade² observes that supersaturation *per se* is not the true cause of stone formation. For instance, normal urine leads only to sediment formation and not to stone formation. He distinguishes three kinds of stones, pure colloid stones, pure crystalloid stones and mixed colloid-crystalloid stones. The first type of stones occurs when there is an excess of irreversibly precipitated colloids (fibrin and other albuminous substances); supersaturation need not be present. For the second type of stone, supersaturation is a necessary pre-requisite. Also, conditions should be favourable for the 'guttulate' separation of the crystalloids. As the mass of the guttulate particles increase, their kinetic activity decreases, which leads to the formation of spherulites. These two types of stones are very rare, while the third is very common. In the third type, it is believed that the colloids determine the striations. The presence of irreversible colloid explains, according to him, both the formation and layering of the stones. As to the function of the irreversible colloids in the urine, it is stated that, in their absence, the urinary salts are thrown out in crystalloidal precipitation, i.e., with absolutely no tendency for them to unite with one another and form a concrement. Only when, through morbid processes in the system, irreversibly separating colloids, such

¹ The author is indebted to Prof. J. N. Mukherjee, Professor of Physical Chemistry, Calcutta University, for facilities afforded to carry on this work in his laboratory.

² Schade, H. (1928): *Colloid Chemistry, Theoretical and Applied*, Edited by Jerome Alexander, p. 629.

as fibrin or other protein, are present in the urine, can transformation of the loose, crystalloid sediment to a stone take place. A small amount of an irreversible colloid is often enough for this purpose; Schade succeeded in transforming the sediment formation into that of stone formation by as low a concentration of fibrin as 0.007 per cent.

It is also believed that adsorption and surface tension may influence stone formation. Surface tension is assumed to be the controlling factor in deciding the form in which the salt will precipitate from a supersaturated solution. Under normal conditions, the mucous membrane and the physiological fluid bathing it are supposed to have a zero surface tension between them; thus there is no tendency for the precipitate to be adsorbed by (or rather adhere to) the healthy mucous membrane. In pathological membranes, profound colloidal changes are supposed to lead to a high surface tension between the membrane and the fluid bathing it, with the formation of an efficient adsorbing surface. Joly¹ assumes that urinary colloids adsorb the crystalloids in solution and thus increase their solubility, and this adsorption is due to the lowering of interfacial tension between the colloid-liquid interface due to the presence of urinary salts.

Most of the theoretical considerations detailed above do not bear close scrutiny. A systematic study of the subject, at present under investigation by the author, includes the composition of the normal urine, of the deposit formed after the urine has been left at rest, of the ultra-filtrate and the residue left on ultrafiltration; also a study of the changes in the composition necessary for the separation of the various substances present in urinary calculi; the inter-relationships between the electrolyte and the colloid matter in the urine with a study of the Donnan Equilibrium; and lastly the role of the mucous membrane on which the deposition takes place. The results, as far as these can be communicated up to the present, are as follows:—

The composition of normal urines from persons of different nationalities—English and American—was collected from the literature and compared with the author's data. It was

¹ Swift Joly (1929): *Stone and Calculous Disease of the Urinary Organs*.

found, in general, that Long and Frank Gephart's¹ data represented a much more concentrated urine than either Hawk's² or Cushny's.³ However, magnesium and uric acid in Long and Frank Gephart's data are very much higher. The author's figures differed from the foreign data in the following regards: chlorides and ammoniacal nitrogen were found in much higher concentration, while the uric acid content was very low. The concentration of calcium, magnesium and phosphate was much the same as that of the foreign data.

With the available data of the chemical composition of the urines—the author's, Cushny's, Hawk's and Long and Frank Gephart's representing in all nine specimens of urines—the equivalent ionic concentrations of the several constituents were calculated; therefrom the sum of the basic radicals expressed as the total of $\text{Na} + \text{K} + \text{Ca} + \text{Mg} + \text{NH}_4$, and the acidic radicals expressed as the total of $\text{Cl} + \text{PO}_4 + \text{SO}_4$ worked out. In every instance, the two were almost equal.

The processes happening in ultrafiltration as also in the natural sedimentation of urines were studied. For ultrafiltration, Zsigmondy's nickel-plated ultrafilter was used with collodion in glacial acetic acid. In ultrafiltration studies, the pH and conductivity measurements were made on the fresh urine, the ultrafiltrate and the residue in the ultrafilter at different stages of the process. The pH was measured both colorimetrically and by the quinhydrone electrode. The specific conductivity of the ultrafiltrate was greater than that of the urine and that of the residue; that of the residue was slightly less than that of the urine itself; the lowering of specific conductivity of the residue was most pronounced when it was highly concentrated. Corresponding to this decrease in conductivity, the residue showed a higher pH. The conductivity of the ultrafiltrate was correspondingly increased, though there was not observed any decrease in pH, presumably due to buffer action. During various stages of ultrafiltration, a chemical analysis of normal urine, its ultrafiltrate and the residue in the ultrafilter was made, particularly with reference to the uric acid and phosphate contents. These two ingredients were chosen for special consideration because of the impression that has gained currency that uric acid and

urates, and phosphates, which are supposed to be in not very stable combination, will be thrown out easily. Contrary to this popular belief, it was found that there was practically no difference in the uric acid and phosphate contents of the ultrafiltrate, the residue and the fresh urine. Even concentration of the residue in the ultrafilter did not make any difference in the uric acid and phosphate concentrations.

A more detailed study of the compositions of fresh urine and its ultrafiltrate showed that the latter contained less of chlorides and slightly more of calcium.

Urine was allowed to sediment for over 24 hours, when the clear supernatant liquid was decanted off and centrifuged at high speed. The clear liquid was analysed for as before and the figures obtained compared with those of the bottom liquid, i.e., the urine containing the whole of the sediment. The composition of the two, as also their pH, was much the same. The conductivity of the supernatant liquid was slightly more than that of the urine with the sediment, a result similar to those obtained in the ultrafiltration experiments. In particular, the uric acid and phosphate contents of the two were almost the same.

SCATTERING OF LIGHT IN URINES¹

It has already been pointed out that urine contains both colloids and crystalloids and that these colloids are believed to play an important role in the formation of calculi. The mechanism governing the process of calculus formation, the function of the colloids in normal and pathological urines, and the size and shape of these colloidal particles have not as yet been satisfactorily understood. It was thought that the scattering of light in urines, normal and pathological, would give some information as to the size and shape of the particles, and hence depolarisation values were determined. The experiments designed to this end, as also those designed to find out, if any, the relation between the size and shape of the particles and the particular pathological condition of stone formation were not very successful.

¹ Ranganathan, S. (1931): *Ind. Jour. Physics*, vol. vi, Part V, p. 463.

² Hawk (1921): *Practical Physiological Chemistry*, Seventh Edition.

³ Cushny, A. R. (1926): *The Secretion of Urine*.

² The author is indebted to Sir C. V. Raman, F.R.S., N.L., for affording facilities for carrying on this work.

X-RAY DIFFRACTION STUDIES OF CALCULI¹

The state in which the substance or substances that make up the urinary calculi are deposited has not been known with any certainty. So far, only chemical and physico-chemical methods have been attempted, but the results obtained by different investigators were not consistent. The above methods of investigation are but crude before purely physical methods and of these, X-ray diffraction studies afford a more definite method of deciding whether the substances in the stones are deposited in the colloidal or crystalloidal state. It is already known that crystals in a finely powdered state give rise to sharp and well-defined rings while colloidal substances give diffuse bands; crystals not powdered will give numerous 'Laue' spots.² Hence the present investigation was undertaken. And as this is the first attempt to study calculi by means of the X-ray, great interest is naturally attached to the present work. The results obtained are encouraging.

The diffraction patterns obtained for the vesical calculus and uric acid showed some interesting features in common. Pure uric acid gave rise to four rings; the first ring being made up of two rings touching each other, the second ring very sharp but of feeble intensity, the third very intense and little broad, and the fourth very faint and sharp. Compared to the outer edge of the first ring, the inner edge was fainter. The stone investigated was composed of uric acid and urates, magnesium ammonium phosphate and a little calcium phosphate; it contained a good percentage of ash. This stone gave rise to only two rings. The innermost ring in the uric acid pattern was very broad and faint whereas in the stone pattern, it was quite sharp and narrow. The latter did not seem to be made up of two rings. But the mean radii of the rings in both were exactly the same. The second ring seen in the uric acid pattern was not observed in the stone pattern. The third ring was quite sharp; yet its intensity was not as much as that in uric acid, and, hence, probably, the second and the fourth, the two comparatively faint rings, did not make their appearance.

The spacings, expressed in Angstrom units, of the two rings obtained with the stone show unmistakably that they correspond

¹ The author is indebted to Sir C. V. Raman, F.R.S., N.L., for affording facilities for carrying on this work.

² Clark (1927): *Applied X-Rays*, p. 178.

to the uric acid component of the stone. Though the stone contained besides the uric acid, a good percentage of magnesium ammonium phosphate and a little calcium phosphate—components containing elements of comparatively higher atomic weight—possibly on account of insufficiency of exposure, the ash rings were not excited. But the one definite result arrived at from X-ray study of the vesical calculus is that its uric acid component is deposited in a crystalline state, as shown by the identity of spacings of the rings obtained with the stone and with pure uric acid. Schade and Boden¹ believe that the uric acid is held in the urine in its colloidal state, while Lichtwitz,² and Gudzent³ are opposed to the existence of such a colloidal state. Haskins⁴ is inclined to believe that at least a part of the uric acid is held in the colloidal state. As the state of uric acid in the stone is likely to give a clue to the state of its existence in the urine, it is assumed on *a priori* considerations that the uric acid exists in the urine in its crystalline state. Likewise, in the cattle stone examined, the sharp rings obtained in the diffraction pattern show that the substances that go to make up the cattle stone are deposited in the crystalline state. The absence of uric acid in cattle stones is also indicated in the X-ray analysis.

PART V

SUMMARY AND CONCLUSIONS

The problem of the Urinary Calculus, with particular reference to India, the conditions under which it arises, the mechanism of its formation and the rationale of its prevention, have been dealt with in the preceding pages. Human stones were found to consist of a mixture of uric acid or urate, calcium oxalate and calcium phosphate and sometimes magnesium ammonium phosphate. They are rarely made up of any one constituent. The human kidney stones form a class apart not only in their origin and physical characters but in their composition as well. They are all essentially calcium oxalate stones. The

¹ Schade and Boden (1913): *Ztsch. Physiol. Chem.*, lxxxiii, 347-80; lxxxvi, 238-43.

² Lichtwitz (1914): *Ztsch. Physiol. Chem.*, lxxxiv, 416-8.

³ Gudzent (1914): *Ztsch. Physiol. Chem.*, lxxxix, 253-4.

⁴ Haskins (1916): *Jour. Biol. Chem.*, xxvi, 205-15.

'Nuclei' of urinary calculi were carefully studied and much of the confusing and contradictory statements in literature about it clarified. There was observed one fundamental difference between the composition of the experimentally produced stones and human stones. The former fell into two distinct categories:—phosphate stones where the phosphate existed invariably as magnesium ammonium phosphate, and calcium stones where the calcium existed either as the carbonate or as the hydroxide. The former set of stones were produced on deficient diets, the chief deficiency being vitamin A, while the latter occurred only on diets deficient in vitamin A and excessively rich in lime. It was thus brought out that the addition of lime to vitamin A deficient diets profoundly altered the composition of the stones produced. Evidently this was due to the diversion of the course of the ingested lime from its normal route.

Results of great physiological interest were arrived at as a result of the studies on calcium and phosphorus metabolism on such stone-producing diets. An inverse relation between the urinary calcium and phosphorus was observed. From the results of the above metabolic studies, it was at once apparent that the statements in text-books that calcium is excreted both by the kidney and the large intestine, the greater part by the latter route, and that diets rich in calcium cause but slight increase in the urinary excretion of calcium, require considerable qualification. Under normal conditions, most of the calcium of the diet, excepting that actually retained in the system, is excreted through the bowels. But on diets deficient in fat-soluble vitamins and containing an excess of lime, a good part of the calcium is excreted through the kidneys. The above studies also conclusively proved that mineral imbalance (here the imbalance between calcium and phosphorus) is a factor of even greater importance in the production of stones than deficiency of vitamin A, which, no doubt, is one of the predisposing causes of stone. Mere balancing of the mineral constituents of a vitamin deficient diet confers on the animals good appetite and growth, almost approximating that of the normally-fed animals; provision of adequate amounts of fat-soluble vitamins to diets imbalanced as regards their mineral constituents did not confer such beneficial results. But by far the best approximation to the stock diet was obtained when the balanced diet

contained in addition adequate amounts of fat-soluble vitamins. It was also shown that comparatively little fat-soluble vitamins was needed to maintain good growth, if the diet be balanced as regards their mineral constituents. The value of the ratio, $\text{CaO retained}/\text{P}_2\text{O}_5 \text{ retained}$, on the several diets investigated suggests that it might serve as a reliable criterion of the biological efficiency of a diet. Conformity of this value to the theoretical is a necessary pre-requisite to the efficient functioning of a diet.

An exact counterpart to the investigations on rat stones was provided in the problem of cattle stones. The cattle stones have a uniform composition, consisting mostly of calcium carbonate. They approximate closely the calcium carbonate stones produced experimentally. The experimental diets—deficient in vitamin A and rich in lime—were almost identical as regards their chemical composition with the diets of cattle that suffered from stone. In view of the results of the calcium and phosphorus metabolic studies, it can be suggested that the problem of cattle stone in India could be solved by maintaining the mineral balance, chiefly calcium and phosphorus, and providing adequate amount of vitamin A, through green fodder, in the diet of cattle (McCarrison, 1931).

The physiological significance of the absence of uric acid in rat and cattle stones and its frequent occurrence in human stones is discussed; it has been traced to the high 'uricolytic index' of the rat and cattle. The theoretical possibility of the production of uric acid stones in rats has been explored with negative results.

Discussing the causation of stone, the three important theories, the infection, dietetic and physico-chemical theory of protective colloid mechanism have been dealt at length. Especially on the physico-chemical aspects of the problem, the relevant portion of the author's work is set forth briefly. Methods of studying the problem by means of the 'scattering of light in urines' and the 'X-ray diffraction studies of calculi' have been fully explored. The state in which the substance or the substances that go to make up the urinary calculi has now been established beyond doubt by means of the X-ray study.

FINANCIAL PROSPECTS OF THE NEW CONSTITUTION

BY

P. J. THOMAS, M.A., B.LITT., D.PHIL.

(For a Summary, see pages 11-12.)

\$ 1. REVENUE POSITION

THE revenues of the Government of India have been undergoing ~~important changes in the recent years.~~ Customs duties which have in recent ~~times~~ supplied nearly 65 per cent of the Central Government's revenue are by no means a stable source. Import duties are the mainstay of the customs revenue. Of the imports, sugar and cotton piece-goods brought in the largest revenue in the past, but the adoption of a protective tariff has cut down revenue under both these heads. Sugar brought in Rs. 10.68 crores even as late as 1930-31, but produced only Rs. 3.75 crores in 1934-35 and the budget estimate for the current year is considerably less. Cotton goods which brought in Rs. 7.7 crores in 1924-25, produced Rs. 4.46 crores in 1933-34. Matches were responsible for Rs. 1.03 crores in 1921-22, but to-day this hardly figures in the import revenue. In spite of such radical fall in imports, customs revenue is still maintained at about Rs. 51 crores, but we must remember that this is due to the increase of rates and the emergency surcharges levied since 1931. The extent of the new burdens placed on imports can be seen from the fact that whereas in 1929-30, a revenue of Rs. 41 crores was raised on imports valued at Rs. 234 crores, the same amount of revenue was raised in 1932-33 when imports had fallen to Rs. 129 crores. The surcharges are but temporary and will have to be removed sooner or later. Further, an enquiry into the present system of revenue tariff is contemplated, and such an enquiry may result in a fall of rates. Although in some cases the fall in rate may be accompanied by an increase in revenue, that may not be the case in regard to many items.

As for export duties, a part has already been assigned to the jute-growing provinces, and another part will be lost when Burma is separated. We must also remember in this connection that countries in Europe are working towards self-sufficiency, and the future, at least the immediate future, of

world trade looks gloomy. Nor are there any sure signs yet of a revival of prices.

In these circumstances, it would be hazardous to build hopes on the customs revenue being maintained at the present high level. Nor is such heavy indirect taxation defensible in theory, seeing that the burden of it is unequally distributed. High protectionism is in fashion in America and elsewhere. India is also launching on the same course. Protection is a double-edged sword; if it is successful, the customs revenue will be lost, and if it is not, the consumer will have to bear the burden. There is a view that the loss in customs revenue resulting from protection can be made good by imposing excise duties, but it is no easy task to raise an adequate excise revenue from a nascent industry, and for some time at any rate, the excise duty will remain inadequate for filling up the gap. The sugar excise duty is estimated to produce a revenue of Rs. 1.50 crores, but the loss of revenue that has resulted from protection is as much as Rs. 9 crores (as compared with 1930-31).

Income-tax revenue has been keeping up, in spite of the depression, but there would have been a fall, had not rates been put up and surcharges imposed in 1931. Incomes below Rs. 2,000 were also brought within the scope of the tax. The profits of companies assessed to income-tax fell from Rs. 53 crores (average of 10 years ending March 1930) to Rs. 29 crores in 1932-33, and a corresponding fall must have occurred in personal incomes as well. Nevertheless, the total revenue under income-tax showed an increase from Rs. 16.6 crores (average of five years ending March 1930) to nearly Rs. 18 crores in 1932-33. No doubt, when business recovers, incomes assessable will increase again, and income-tax revenue will go up, even if the surcharges are removed; but by then the proceeds of the tax will have also to be shared between the Central Government and the provinces. The time and the nature of such assignment have not been fixed, but the provinces will make every effort to secure for themselves as large a slice as is available at as early a date as possible.

It is true that during the first half of the current financial year, both customs and income-tax have recorded a slight improvement on the estimates of March 1935, but no conclusions can yet be made about the outturn for the whole year. If

such improvement takes place, the surcharges imposed in 1931-32 will have to be reduced if not altogether removed, as they (especially those on customs) are regarded as a heavy burden on industry and commerce. Large inroads would be made in income-tax and customs revenues, if the surcharges of 1931 are removed.

The breakdown of non-tax revenue has been the most serious financial result of the trade depression. Under various heads,—railway contribution, opium sales, provincial contributions, etc.—the Government of India had been receiving large sums before 1927, but most of them have steeply declined and some have altogether disappeared. The revenue from these items fell from Rs. 30.45 crores in 1923-24 to Rs. 5.77 crores in 1933-34.

ITEMS	<i>Non-Tax Revenue in the years</i> (In crores of Rs.)		
	1923-24	1929-30	1933-34
Net revenue from commercial departments (chiefly railways) ...	8.97	5.24	—·56
Net revenue from opium ...	1.66	2.55	·88
Net revenue from currency and mint ...	2.14	2.00	·74
Interest receipts ...	3.16	4.40	1.63
Extraordinary receipts ...	2.60	1.89	·36
Other revenues ...	2.72	3.38	2.72
Provincial contributions ...	9.20	...	...
Total ...	30.45	19.46	5.77

Railways perhaps tell the most pitiable tale. This source of non-tax revenue which besides paying its way contributed handsomely to the general revenue has lately been accumulating deficits, amounting in four years (1931-32 to 1934-35) to Rs. 32 crores. The actual position seems to be even more disquieting, and it would appear that if a proper accounting system had been adopted and items legitimately chargeable to revenue had been charged to revenue and not to capital as now, the deficit would have been found to be even higher. For the current year, the estimated deficit is only Rs. 2 crores, but judging from the actuals of the first few months, the deficit may be larger unless considerable improvement takes place in the remaining months of the year. The Percy Committee estimated the revenue from railways at Rs. 5 crores annually, but in order to have such a surplus, the gross traffic receipts from railways must reach the figure of Rs. 113 crores. Even

in 1928-29 such receipts amounted only to Rs. 103½ crores. Indeed an economic recovery in India will increase railway earnings, but world conditions give no immediate prospect of any pronounced recovery. Further, the competition between roads and railways which has greatly affected railway earnings may increase rather than diminish, since it is in the interest of the provincial governments which control road transport to maximize the revenue from that source.

Salt has been a steady source of revenue in the past, and the budget estimate for 1935-36 under that item is Rs. 8.73 crores, which is Rs. 2 crores more than the Percy Committee's forecast. It is suspected that this increase is due to some temporary influences, and further a strong political party in the country is intent upon reducing this tax radically and would even like to see it abolished. With the Damocles' sword hanging on it, how can Government rest assured that the large revenue from salt will continue to come in?

The foregoing survey has perhaps brought it out that, although it is repeatedly said that the Government of India has most of the elastic sources of revenue, various circumstances have made nearly all those sources rather unreliable, and any immediate increase of central revenue is unlikely.

\$ 2. THE EXPENDITURE POSITION

But while revenue is shrinking, expenditure is on the increase. Apart from the existing expenses, Rs. 75 lakhs will be required for enlarging the central legislature and Rs. 1.05 crores for subventions to the new Provinces of Sind and Orissa (Rs. 75 lakhs + Rs. 30 lakhs). Further, the separation of Burma may reduce Indian revenue by Rs. 3 crores. Thus expenditure may at least increase by Rs. 1.80 crores and revenue may diminish by Rs. 3 crores, and assuming that revenue and expenditure remain as now, there may be a deficit of about Rs. 4.80 crores, when the Reforms are put into operation.

Expenditure (crores of Rs.)		Revenue (crores of Rs.)	
1935-36 Estimate	... 77.22	1935-36 Estimate	... 77.28
+ additional expenditure	... 1.80	Loss by separation of Burma	... 3.00
		Total Revenue	... 74.28
		Deficit...	... 4.74
Total ...	<u>79.02</u>	Total ...	<u>79.02</u>

But the above assumptions may prove too optimistic. The estimate of Rs. 1.80 crores for the inauguration of federation takes into account only the principal items. When constitutional reforms are put into operation in a country like India, expenses are liable to be underestimated, and this must be particularly so when (as now) a substantial transfer of power is made from a system of government controlled by officials to one progressively controlled by a people who have been for long feeling the need for a more liberal expenditure on social services. The new status that India is entering upon will create new needs, whether essential or ornamental, and such needs cannot all be estimated beforehand.

There are also other factors which may upset our estimate of expenditure. Two devastating earthquakes in two successive years have upset the Finance Member's calculations. The Quetta earthquake (1935) must have cost Government at least Rs. 1 crore. Similarly, certain fortuitous circumstances which have been helpful in the past may not continue to help. In the last four years, when the finances of Government were exposed to a severe strain, the copious exports of gold from India came to their rescue by maintaining the rupee exchange and by enabling Government to meet its dues in London. Already gold worth about Rs. 260 crores has gone out, and it is too much to expect that gold exports will remain for long at their present level. If they cease or fall off rapidly, and if in the meantime the balance of trade in India's favour has not improved, the Finance Member will have a very difficult problem to face.

\$ 3. SCOPE FOR RETRENCHMENT

It is generally believed that there is still considerable room for retrenchment in the Central expenditure. There is the standing complaint about military charges; then, there is the popular view that the Central Government will have fewer functions in future and that its needs must therefore be limited.

This latter view is now widely held; but to my mind it is against the whole trend of development in federal constitutions. In the old days when transport was slow and economic life functioned in narrow spheres, defence was the only function of a federal government. But to-day economic life is functioning on a world scale, and each country is compelled to have a

well co-ordinated economic policy. Politically, State autonomy may be a desirable thing, but economically it might lead to most injurious consequences as is evident from recent happenings in Australia and elsewhere. Most federal constitutions have taken account of this change in economic life and the scope of federal government has widened and its expenditure has largely increased in respect of functions primarily regarded as provincial, viz., education, public health, agriculture, industries and economic development generally. President Roosevelt discovered to his cost what a stumbling block State autonomy is to the economic advancement of the U.S.A. and there is a general desire in that country for a radical change in this respect.

India can benefit by what other countries have learnt by bitter experience. We must avoid the evils of a rigid federal structure—double taxation, overlapping tax jurisdictions, duplication of administrative machinery, multiplicity of tax formulas and forms, and inequality of fiscal arrangements.¹ In many ways the financial arrangements we are adopting may be an improvement on those of other federations. We must also recognize that the best interests of the nation are served by the federal government regulating and co-ordinating economic activities throughout the country. In commerce, the Centre has an important function to fulfil, and it may be a costly one too, as international trade is now becoming more and more subject to agreements and manipulations. In industry, and even in agriculture, not only research but a careful co-ordination of provincial activities must be undertaken by the Central Government. The same is true of education and public health. No doubt the Provincial Governments will have to bear the main burden of the nation-building services, and provincial expenditure will have to increase largely; but let us not forget that the Centre will have also to discharge some important functions in respect of them and that at least its present resources will be required for the purpose. Not only will Federal aid be necessary, especially to those Provinces 'where the available sources of revenue are never likely to be sufficient to meet any reasonable standard of expenditure',² but the

Federal Government will have also to incur additional expenditure on the regulation of external commerce, banking, shipping and certain industries, on agricultural and industrial research, and on marketing organisations. When the circumstances within and outside India are calling for a unified economic policy in this country, it would be fatal to curtail the scope of the Central Government's activities.

It is true that India's defence expenditure has been maintained at too high a level. Sir Walter Layton estimated it at 31½ per cent of the total central and provincial expenditure; although the proportion must have fallen since, owing to the recent cuts in military charges, India's defence expenditure is still high, in comparison with its civil charges, which are rather low. The disparity between military and civil charges in India is indeed striking. But it may be said that in defence the thing that matters is that you must keep up your armaments on the scale adopted by your neighbours and possible enemies. India is like a man who in the insecure times of old had to have a wall of hard stone although he lived in a mud-house himself. If his means improved, his house would be better built, but he would not be wise in taking away the stone wall till his neighbours took off theirs. India's defences have to be strong until disarmament becomes a reality.

We may remember in this connection that since the World War, considerable economies have been effected in defence expenditure. It fell from about Rs. 70 crores in 1921-22 to Rs. 55·10 crores in 1929-30, and although it was then stabilized at that amount the depression called for emergency economies and the expenditure last year (1934-35) came to Rs. 44·38 crores. A cut of about 11 crores in four years is no small achievement, although it was partly due to the diminished cost of stores. The Finance Member has warned the Assembly that 'the large reduction of defence expenditure in recent years had been secured to some extent by emergency measures of a temporary character', and that the new figure 'could not be regarded as representing a new permanent level of defence expenditure'.¹ When prices rise again, the expenditure may also increase. Even assuming that new ways of economising might be discovered in future, will not the savings be absorbed in aerial

¹ Adarkar, *Principles and Problems of Federal Finance*, p. 63.
² Report of the Joint Select Committee, p. 161.

¹ *Budget Statements for 1934-35 and for 1935-36.*

and naval defences? In the present state of things, one cannot build much hopes on any great fall of defence expenditure in the near future. When India obtains a higher political status, the burdens of defence may increase rather than diminish.

§ 4. PROSPECTS

Taking all these circumstances into account, one fears that the Central Government needs all its present revenue, and more, if it is to function properly. Hopes are entertained in certain quarters that a substantial part of the income-tax revenue will soon be assigned to the provinces, but in the light of the situation sketched above, one cannot see how this hope can be fulfilled in the immediate future. On every ground, it is essential that the Central Government should have a strong financial position when inaugurating the Reforms.

No doubt the provinces are in a bad way. Some of them have inadequate resources, and most of them have had unbalanced budgets recently. The *per capita* expenditure on education and public health in the thickly populated provinces of Bengal and Behar is deplorably low, and must be raised. Great expectations have been held out to the people in regard to nation-building services and these expectations will have to be fulfilled in some measure. It is certainly in the interest of the country that provincial resources should increase. The Central Government has lately made a generous gesture by making a grant to the Provinces for rural development. The Provinces would perhaps prefer an assignment from income-tax revenue to a grant, but the amount of such assignment cannot be large for some years. New resources will have to be tapped. Some of the resources (e.g. income-tax on agricultural incomes) can be tapped directly by the provincial governments, but others (e.g. death duties, terminal taxes) must be levied by the Central Government although the revenues will be handed over to the Provinces. The Central Government can also benefit by imposing surcharges or *centimes additionnels* on such levies. This step will soon become necessary both for the Centre and the Provinces.

The burden of taxation is fairly high in India, but it may not be so high as in many advanced countries. We have not got the statistical material necessary for an accurate estimate

of the burden, but it has been computed that the ratio of total taxation to national income is higher in the U.S.A., Great Britain and even Japan.¹ India is indeed a poor country, but, as Layton says, 'it is at the same time a country in which there are large accumulations of wealth on which the burden of Government rests very lightly'. Land revenue may yield more, if it is attuned to the principle of ability. Nor are there death duties. Commodities of common use like tobacco, on which much revenue is raised in Europe, are still untaxed or lightly taxed in India. Social ceremonies (like marriages) deserve to be taxed, on every ground. Increase of taxation had been hitherto unpopular because it was felt that the revenue was not properly spent, but now that provincial autonomy is becoming a fact, the public must be in a position to control expenditure more effectively. The country is calling for more roads and schools, clean water to drink and sure water supply for the fields; and expenditure on these items will be productive in every sense of the word. In the present state of the country, wise public expenditure is the royal road to increased economic welfare and to greater social harmony. As Layton has pointed out, 'taxation may be the only practicable means of creating a better and more secure livelihood'.² Such taxation will not reduce the income of the people but will increase it; it will enhance production and not diminish.

Although the economic depression has diminished money incomes, production has not fallen, but has increased. As I showed in a paper submitted to the Economic Conference last year, even in the period 1920-31 during which population increased in an unprecedented degree (about 11 per cent), agricultural production increased by 16 per cent and industrial production (as indicated by ten organised industries) increased

¹ The percentage of national income (central, provincial and local) taken as taxation in different countries has been estimated as follows by Prof. Findlay Shirras. *Poverty and Kindred Economic Problems*, pp. 48-49. The estimates may not be quite accurate, but they are adequate for purposes of comparison.

United Kingdom	...	(1929-30)	22·2 per cent.
France	..	(1928)	20·9 "
Germany	...	(1925)	20·1 "
U.S.A.	...	(1928)	10·7 "
Japan	...	(1925)	12·8 "
Canada	...	(1927)	9·5 "
Australia	...	(1924)	13·3 "
India	...	(1929-30)	5·9 "

² *Simon Commission Report*, Vol. II, p. 208.

by 51 per cent. Since 1929, production has diminished in most countries, but in India agricultural production has been maintained, and industrial production increased by 44 per cent (between 1928-29 and 1934-35). The only other country which recorded similar progress during the period was Japan (45 per cent). In Great Britain, the increase was only 6½ per cent, and in France, Germany and U.S.A., there was a decline of about 25, 15 and 20 per cent respectively.

Some details of Indian industrial production will be interesting in this connection. In 1900, hardly 500 million yards of cotton piece-goods were produced in India; in 1934-35, the amount produced was 3,400 million yards; hardly any pig-iron was made in 1900; in 1934-35, 1,343,000 tons of pig-iron and 834,000 tons of steel were made in the country. Even more striking progress was made in sugar and cement. In 1928-29, only 99,000 tons of sugar was produced in India; in 1934-35, in spite of the destruction of many mills in Behar, production amounted to 637,000 tons. Thus, sugar production has increased six-fold in six years.

These are the bases of India's real income and taxable capacity. When production increases, the outturn of existing revenues must increase, and a larger taxable capacity will be generated. With better employment, there will be greater demand for goods, mostly goods produced at home; and therefore trade and economic activity in general will increase. On the whole, the provincial governments derive greater benefits from increased production than the Central Government. Customs will have a temporary benefit by the increased importation of machinery, but will be adversely affected when imports fall off in consequence, as has happened in sugar and cotton piece-goods. Income-tax will increase, but not immediately, and by the time it increases, a substantial assignment will have to be made to the Provinces. Railways will benefit, but roads are a formidable competitor and increased road traffic will benefit the Province chiefly. Stamps, registration fees, etc. will increase and enhance provincial revenue; even the provincial liquor excise will swell when new factories arise in a region; and land revenue collection will become easier.

The whole trend of economic development to-day is in the province's favour. When economic internationalism functioned, India was linked to it as a primary producer and as a

steady consumer of textiles and iron goods; but to-day, with the growth of economic self-sufficiency in most countries, India's position in world economy is undergoing a radical change. The demand for India's primary products abroad has weakened; and India's demand for cloth, sugar, iron goods and other ordinary commodities from outside has also greatly fallen off. In the days when foreign trade loomed large, customs revenue had a wide scope, but when machinery and a few luxury goods become the principal lines of import trade, the scope for levying import duties will naturally narrow down. Indeed the Central Government can impose excises, but it will take time and when they increase, the provinces will have also a share in it. Thus, while the industrial development of India depends very largely on Central policy and direction, the chief beneficiaries of industrial progress will be the Provinces and the effect on Central revenue will be largely adverse. In these circumstances, the self-interest of the Provinces requires them to see that the Central Government's finances are strengthened and not weakened; for thereby they will pave the way for the plentiful increase of their own resources in future.

To conclude: **The unsteadiness of tax revenues, especially customs duties, the failure of non-tax revenues and the uncertainty of gold exports have made the financial position of the Government of India far from prosperous and have aroused pessimistic views about the prospects of inaugurating the Reforms. This may make it difficult for the Central Government to make any large assignments of its revenue to the Provinces, as was expected when the Peel and Percy Committees made their forecasts. Most of the Provinces have deficit budgets and the whole country is looking forward to an increase of expenditure on nation-building services; but it is too much to expect that the resources needed will come to any great extent from the existing revenues of the Central Government. India's credit depends largely on the financial position of the Central Government, and at a time like the present when the Reserve Bank is just beginning to function and when important constitutional reforms are contemplated, it is essential that its financial position should be strong. Whatever the Central Government can spare may be given to the Provinces in the form of assignments from the income-tax revenue, but these cannot be large and will have to be supplemented by**

fresh taxation. The striking increase of production in India even in a period of unexampled depression gives one the hope that fresh taxable capacity is being created and that it could be safely tapped in the near future.

THE DOUBLE-ACCENTED VEDIC COMPOUNDS

BY

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I HAVE already shown¹ that in Rv. V. 78, 7, the tatpuruṣa compound *dāśa-māsyāḥ* logically accented its first member and in Āpastamba Mantra Pāṭha while in one place it was double-accented², in another place it bore the accent on the last member³.

In fact, we find a large number of double-accented compounds in the Ṛg Veda, some belonging to the unepithetised class as शचीपति⁴, and some to the epithetised class, besides a few Dvandva compounds.

Some examples of these double-accented compounds I choose at random and give below.

sāhas-as-putrām (Rv. V. 11, 6.)

bṛh-as-pātiḥ (Rv. I. 62, 3.)

vān-as-pātiḥ (Rv. I. 90, 8.)

brāhman-as-pātiḥ (Rv. I. 18, 4.)

sādas-as-pātim (Rv. I. 18, 6.)

sād-as-pāti (Rv. I. 21, 5.)

gnā-s-pātiḥ (Rv. II. 38, 10.)⁵

gnā-s-pātnībhiḥ (Rv. IV. 34, 7.)⁶

jā-s-pātiḥ (Rv. VII. 38, 6.)⁷

rātha-s-pātiḥ (Rv. V. 50, 5b; X. 64, 10.)

indā-s-pātiḥ (Rv. I. 53, 2.)

jāgat-as-pātiḥ [Av. VII. 17, 1; *kāthaka saṃhitā* XIII. 16 (200, 8.)]

¹ In my paper 'Accentuation in Sanskrit Determinative Compounds' published in the *Journal of Oriental Research, Madras*, Volume VIII. Part II.

² *dāśa-māsyāya* (A.M.P. II. 11, 15.)

³ *dāśa māsyāḥ* (A.M.P. I. 13, 9.)

⁴ Rv. VIII. 15, 13. The pada text reads शची ३' पति'

⁵ The pada text reads ग्राः पतिः ।

⁶ The pada text reads ग्राः पत्नीभिः । (See *J. O. R. M.* Vol. I., 1927.

Dr. C. Kunhan Raja : 'Linguistic Notes', p. 21.)

⁷ But *jā-s-pātim* (Rv. I. 185, 8.)

- bhāradvājī-pūtra* (Ś B. 14, 9, 4, 30.)
śāvas-as-pātim (Rv. III. 41, 5; VI. 44, 4.)
dāsyave-vīkaḥ (Vākhilya 3, 2.)
prāti tyām (Rv. I. 19, 1.)
sū jigyūṣaḥ (Rv. I. 17, 7.)
citrāya-rādhase (Rv. I. 17, 7.)
*apām-nāpāt*¹ (Rv. II. 35, 1; 2; 3; 7; 9; 10; 13.)

It is clear that in the double-accented compounds like *वत्सपतिः* (Rv. I. 90, 8.) with *pāti-* as the second member, syntactical in origin, the first member has a genitive case form².

Scholars like Garbe³ once believed that both *vānaspāti* and *rāthaspāti* probably owed their *s* to the analogy of *bḥ-as-pāti*.

Bartholomae, however. (vide 'Arisches' Bezzenberger's Beitrage, Volume 15, page 15. Compare also Lanman: "The stem *vān* is supported only by *vāmsu*, found twice, with irregular accent. SV. i. 74 has a wretched variant, *vanā*." "A statistical account of noun inflection in the veda." J.A.O.S. Volume 10, page 353) went farther with Lanman in recognising the stem *vān-* of which therefore, the regular genitive singular is *vānas-*, but he was nevertheless inclined to treat *-s-* in *rāthaspāti* as due to analogy.

Wackernagel⁴ and Macdonell⁵ followed suit in thinking that in *vān-as-pāti-* the first member may be the genitive singular of *van-* wood, not so much in view of the genitive plural form *vanām* (for this form can be explained even if we assume the existence of a stem *vāna*) but particularly in view of the fact that we have the locative form *vāmsu*.

But these scholars too persisted in maintaining that *-s-* in *rāthaspāti* must be inorganic, for obviously it is impossible to assume the existence of a stem *rāth*.

¹ Cf. also Wackernagel:—*Altindische Grammatik* II. i, sections 41 and 103.

² Vide. Macdonell's *Bigger Vedic Grammar*, page 96.

³ Garbe: 'Das accentuationssystem des altindischen nominal compositum' page 490. Kuhn's *Zeitschrift*. Volume XXIII. [This volume was borrowed for me from the Bombay Branch of the Royal Asiatic Society, through the kindness of the Librarian, the University Library, Madras.] Cp. also Oswald Richter: 'Die unechten Nominal komposita des Altindischen und Altiranischen' page 17. *IndoGermanische Forschungen* volume IX.

⁴ Wackernagel: *Altindische Grammatik* II. i. page 247.

⁵ Macdonell: *Bigger Vedic Grammar*, page 96. Footnote 6.

Bearing in mind that the genitive singular termination *-as*¹ varied with *-s* in vowel declension, (i.e. when the nominal stem ended in *i-* or *u-* etc.), it may be assumed that in '*rāthaspāti*' perhaps the stem was *rātha-* to which the genitive singular termination *-s* (the weakened form of *-as*) was tacked on. Likewise in *vānaspāti* also, *vāna-* may be assumed to be the original stem to which the termination *-s* was added, instead of assuming *van-* to be the original stem even here. (In *vamsu*, no doubt *van-* is the stem.) This assumption is warranted by the fact that side by side with the stem *van-* there was also the stem *vāna-* in the vedic language (cf. Brugmann *Grundriss English Translation*. Vol. II. section 24, page 40). In classical language, only *vana-* was preserved and the stem *van-* was lost. Thus in a satisfactory manner, we may dispense with the assumption that *s* in *rāthaspāti* is inorganic and due to analogy.²

But the feminine form *gnās-pātni-* is however anomalous.

The compound *sādas-pāti-* probably stands by haplology for **sādasas-pāti-*. 'The only new instance of double accentuation of a compound with *-pāti-* after the Rv. seems to be *nṛms-pāti-* (MS).'³

There are two other double-accented compounds; *nābhā-nēdiṣṭha* which seems to contain an old locative in the first member and *ās-pātra-* (T.S. II 5.9.3.) where the uninflected stem appears.

It is indeed interesting to note that though *brāhmaṇas-pāti-* is not treated as a compound in Pada text, it is so treated in the Dvandva *indrā-brahmaṇas-patī* (Rv. II. 24, 12.).

Again it is of some significance to observe that *जस्पतिः* (Rv. I. 185, 8) is the only Tatpuruṣa in the Rg.-Veda in which double-accentuation does not take place when *-pāti-* is preceded by *s*. 'The only other instance in the Rv. of a *tatpuruṣa* with case-ending in the first member and yet singly accented is *divo-dāsa-* name of a king. Elsewhere occur *apsu-yogā-* (Av. X 5, 5.),

¹ **es* or **os* or **as*.

² Scholars like Macdonell being perhaps much influenced by forms like Sanskrit *हरेः* seem to feel that the genitive singular termination *-as* varied with *-s* in vowel declension, only when the nominal stem ended in *i-* or *u-* etc. But I suggest that perhaps it can be assumed that even with regard to a declension the same principle may hold good.

³ Vide Macdonell's *Bigger Vedic Grammar*, page 96, footnote 7. Cf. also Wackernagel II. i, p. 248d.

amhasas-pati—(VS), perhaps *mātūr-bhrātrā-* (MS. 1. 6. 12.) 'mother's brother' (the MSS read *mātūr-bhrātrā-*¹).

All the double-accented compounds like *बृहस्पतिः* are comprehended by Pāṇini's sūtra उभे वनस्पत्यादिषु युगपत् (P. VI. 2. 140.) Pāṇini's explanation of स् in compounds of the type of *वनस्पतिः* is that it is merely an augment. पारस्करप्रभृतोनि च संज्ञायां (P. VI. 1. 157).

तद्बृहतोः कर्पयोः चोरदेवतयोः सुट् तलोपश्च (vārtika).

(The word *brhāt* ordinarily bears the accent on the last syllable, but in the compound *brhaspati-* the *t* of *brhāt* is elided and the accent is moved back to the first syllable.)

Pāṇini has framed another sūtra too to comprehend the genitive compounds² like the following :—

वाचस्पतिः (Rv. X. 81, 7a; VS. VIII, 45 a; XVII, 23 a; TS 4.6. 2.5 a; MS. 2.10. 2 a [page 133, line 18. Schroeder's edition, second book] KS. XXI, 13a; XXX, 5 a; XVIII, 2; Ś B, 4.6. 4.5.)

दिवस्पुत्राय (Rv. X. 37, 1.)

दिवस्पृष्टं (Rv. III. 2, 12.)

तमसस्पारम् (Rv. I. 92, 6.)

इळस्पदे (Rv. I. 128, 1.)

दिवस्पयः (Rv. X. 114, 1.)

रायस्पौषम् (Rv. X. 17, 9.)

Considering the connections and surroundings of compounds with *-pāti* as the second member, they are certain to appear as

¹ Macdonell's *Bigger Vedic Grammar* page 96, Footnotes 4 and 5.

Schroeder says: 'so corrigirt; inden MSS मातु० ohne accent. Vide his edition of *Maitrāyaṇi Samhitā*, Book I, Page 106, Footnote 3.

• वज्राः पतिपुत्रपृष्ठपाशपयस्पौषेषु (P. VIII, 3. 53.)

old formations. *subhāspāti* for instance, occurs several times in the Ṛg Veda, always as epithet of the *Aśvins*. *Gnās-pāti* and *Gnās-pātni* are evidently old; they occur only in connections with *Tvaṣṭar*, and such a feminine as *gnās-pātni* would be impossible, from a newly coined word.¹ *divas* in *divo-dāsam* (Rv. I. 112, 4 b; IV. 26, 3 d; VI. 61, 1 b; VII. 18, 25 c.) too seems to occur only in composition for besides this compound we have *divas-prthivya* 'heaven and earth'. To this base *divas*-which is only found at the beginning of compounds, corresponds well the Latin *dies-* in *dies-piter*.²

The analogy of *apām-nāpāt* is followed by *tānū-nāpāt*. (*tanū-* has acute on the final but in the compound the accent is moved back to the first syllable. Thus *tanū-* behaves like *brhāt-* in compounds with regard to the shifting back of accent).³ E. W. Fay thinks that the double accent in the compound suggests that it is a *Dvandva* (Cf. *J.A.O.S.*, Volume 16, Proceedings, page clxxiv).

Another important double-accented compound is *नराशंसः* (Rv. I. 142, 3; II. 38, 10; I. 13, 3; 106, 4;) Skandasvāmin and Venkaṭamādhavārya take it as a determinative.

Says the former commenting on Rv. I. 13, 3. 'नराशंसं शंसिः स्तुत्यर्थः नरैः प्रशस्यत इति नराशंसो अग्निः तं नराशंसं ।' And says Venkaṭamādhavārya in his commentary :—नराशंसं नरैः शंसनीयमग्निं ।⁴

[There is a close resemblance between double-accented compounds of this type and the following passage from the

¹ M. Bloomfield is the only scholar who is somewhat inclined to think (rather ingeniously) that *s* before *-pāti* may be a trace of *spa*, a more ancient form of the root *pā*. Vide *J.A.O.S.* Volume II, Proceedings, page 5.

² Vide Bopp's, *Comparative Grammar*, Volume III, para 973.

³ तनूनपादुच्यते गर्भैः (Rv. III. 29, 11.) In only one place, this com-

pound accents the first syllable of the second member alone in A. V. तनूनपात् (V. 27, 1.)

⁴ Vide page 92 of 'The Rk Samhitā with the Bhāṣya of Skandasvāmin and the Dīpikā of Venkaṭamādhavārya, edited by K. Śāmbaśiva Śāstri, Curator of the Department for the Publication of Sanskrit Manuscripts, Trivandrum. Trivandrum Sanskrit series No. XCVI. Śrī Setu Lakṣmi Prasādamālā. No. VIII.

Atharva Veda where a particle and a following verb are both accented *hi śanti*. (Av. VI. 112,3.)¹

नराशंसं is one of the earliest of the loosely formed compounds between whose two component parts other words were also interposed.²

In Rv. IX. 86,42, the Samhitā text reads *īyate nārā ca śāmsam daivyaṃ ca dhartāri*³. [Cf. also *nairīmca Saṇḥdm* (yasna 57. Verse 3. Zend Avesta which corresponds to *narā ca śāmsam* Skt.)] The pada text reads *īyate nārāśāmsam ca daivyaṃ ca dhartāri*.

Again in Rv. X. 64,3, the Samhitā text reads *nārā vū śāmsam pūśānam āgohyam* and the pada text reads *nārāśāmsam vū puśānam āgohyam*.

Probably these interposed words च and वा originally brought out the dependency of the second member to the first which is the determinative element (the meaning here is clearly नराणां शंसः as Sāyana says under Rv. I. 13,3.) This view is supported by the fact that च itself, without always losing its

¹ ते प्राग्धातोः (P. I. 4. 80).

छन्दसि परेऽपि (P. I. 4. 81).

व्यवहिताश्च (P. I. 4. 82).

Pāṇini says that in the non-Vedic or classical Sanskrit language प्र and other particles come always before the verb, but that in the Vedic language such particles may come either before the verb or after it, and that sometimes in the Vedic language other words may intervene between such particles and the verb. Vide 'Were the Vājasaneyi Samhitā and the Śatapatha Brāhmaṇa unknown to Pāṇini' by K. B. Pathak, B.A., Ph. D., page 84, Volume 11 *Annals of the Bhandarkar Oriental Research Institute*.

² Compare Rg-Veda Prātisākhya, II. 43.

शुनश्चिच्छेपनिदितं नरावाशंसं पूषणम् ।

नराचशंसं दैव्यं ता अनानुपूर्व्यसंहिता ॥

See Uvaṭa's commentary on this.

³ A corresponding instance in the Atharva Veda is the following where द्रव is introduced in parenthesis between पिब and its object *ehimasyā drāvā piba*. (A.V. XX. 5.5).

signification 'and' or meaning distinctly 'if', is not very infrequently made use of to assist in indicating the conditionality or dependency of a clause, whose verb is then left orthotone in the Atharva Veda. An instance is स चातिमुजेजुहुयानचातिमुजेन जुहुयात्¹ 'And should he give permission, let him sacrifice; and should he not give permission, let him not sacrifice.'

Sometimes, indeed, the particle almost precisely equals यदि as in the following passage: हिंस्ते अर्दत्ता पुर्षं याचितं च न दिस्तेति² 'ungiven she harms a man, if he will not give her when demanded'.³

Of equal importance is the loosely framed double-accented epithetised compound शुनःशेषः (Rv. I. 24,12.)

The Samhitā text of Rv. V. 2,7 reads *śūnaś cic chēpam niditam* but the pada text reads *śūnaḥ śēpam cit niditam*.⁴

An example of the loosely formed Dvandva compound of this type is *dyāvā-prthivī*⁵ (Rv. I. 160, 1a; 115, 1; 35, 9b). Compare for instance Sāyana's comments on Rv. I. 159, 1. प्र यावा यज्ञैः पृथिवी Says Sāyana:—यावापृथिवी यावापृथिव्यो । दिवो यावादेश आद्युदात्तः । पृथिवोऽशब्दो ङोषंतोऽतोदात्तः देवताद्वंद्वे चेत्युभयपदप्रकृतिस्वरत्वम् ।

¹ Atharva Veda, XV. 12,3.

² Atharva Veda, XII. 4,13.

³ Vide Article IV in the fifth volume of the *Journal of the American Oriental Society*—'Contributions from the Atharva Veda to the theory of Sanskrit verbal accent' by William D. Whitney.

⁴ Vide Rgveda Prātisākhya XI, 8.

अनानुपूर्व्यपदसंध्यदर्शनात्

पदव्यवेतं च पदव्यवायि च ।

ततोऽपरे द्विक्रममाहुराश्रयात्

कृताविलुप्ताऽत्र हि वर्णसंहिता ॥

Uvaṭa makes clear the meaning of the word आश्रयात् through

लक्षणात् and says लक्षणे शास्त्राश्रयः कारणं । शुनःशेषं चिदित्येतयोः पदयोः स्यान्त्येन संघिरदृष्टो भवति ॥

⁵ Pṛthivīdyāvā occurs only once in the Rg Veda in III. 46, 5. Cf. Delbruck S.F., Vol. V. Page 98.

समासमध्ये पदांतरपाठः छांदसः. See also Yāska's comments on Rv. II. 41, 20. द्यावा नः पृथिवी इमं सिध्ममद्य दिविस्पृशं यज्ञं देवेषु यच्छताम् ॥ Says Yāska:—द्यावापृथिव्यौ न इमं साधनमद्य दिवि स्पृशं यज्ञं देवेषु नियच्छताम्. [Nirukta IX. 38.]

Another interesting double-accented Dvandva compound in the Rg Veda is नक्तोषसा¹ which the pada text reads नक्तोषसा । Skandasvāmin's comment on it is as follows:—नक्त इति रात्रि नाम उषा अपरात्रिकं ज्योतिः नक्ता चोषाश्च नक्तोषसा. Venkaṭamādhavārya translates the compound as अहोरात्रे².

Probably on analogy with compounds like अद्यानूनं³ where the last syllable of the first member is lengthened, the penultimate syllable of this compound नक्तोषसा⁴ is also lengthened, for the retention of the last syllable of the first member (even if it were lengthened) in this compound is impossible, since the resultant of अ or आ with उ would be ओ according to the well-known rule of euphonic combination. Hence to secure uniformity with similar compounds, it might have assumed the form नक्तोषसा⁵ here.

Significant indeed are the double-accented compounds whose components are separated by an interposed word.⁶ Brugmann's transpositional theory⁷ of the origin of Bahuvrīhi compounds has already been taken into account and given its due importance.⁸

But according to some⁹ the rise of the Bahuvrīhis is to be accounted for in another way. They say that perhaps through predicative or appositional use of groups of words characterising

¹ Rv. I. 13, 7.

² See page 95, 'The Rksamhitā with the Bhāṣya of Skandasvāmin and the commentary of Venkaṭamādhavārya.'

³ Rv. I. 13, 6.

⁴ On account of this fact, it might be assumed that the pre-Vedic language a short time before the composition of the Rg-Veda was a highly analytic one.

⁵ Vide Brugmann's 'Comparative Grammar', Volume II, page 88.

⁶ Vide my paper, 'The Accentuation of Determinative Compounds' in the *Journal of Oriental Research*, Volume VIII, part II.

⁷ Cf. Wackernagel:—*Altindische Grammatik* II, i, section 112.

a substantive, the epithetised compounds arose. Wackernagel exemplifies this use by the following passages from the Rgveda *urūh kākṣo nā gāṅgyāh*¹. 'Like the broad shoulder dwelling on the Ganges,' that is, for *urū-kakṣah* 'Broad shoulder' as a proper name; *sā jāyase mathyāmānaḥ sāho mahāt*² 'thou art born a great power' (= *mahā-sahāh* 'one having great power'); *tvācam kṛṣṇām arandhayat*³ 'he delivered over the black skin' (that is, 'those having a black skin,' 'the black skins') *drôghāya cid vācasa ānavāya*⁴ 'to Anava, deceitful speech,' that is, 'who utters deceitful speech' (compare *drogha-vāc* 'uttering deceitful speech') and *narām nā śāmsaḥ*⁵ 'praise of men' as representing an earlier stage than *nāra-śāmsa* 'receiving the praise of men' as a Bahuvrīhi. Appositional Bahuvrīhis, Wackernagel thinks, similarly arose from explanatory clauses, as the following *indra-jyēsthā devāsaḥ*⁶ 'the gods having Indra as their mightiest' from *devāḥ indra jyēsthāh* 'the gods—Indra their mightiest'.

An unconsummated Bahuvrīhi with *rūpam* may be found in Rv. I. 114, 5 *varāhām aruṣām kapardīnam tveṣām rūpām*.⁸

I suggest that it may be possible to find through a study of the Vedic double-accented compounds, a tie of union even between views as contrasting as those of Brugmann and Wackernagel—the transpositional theorist and the juxtapositional theorist (if such terms are permissible).

A reconciliation seems to be possible between the two camps; neutral observers are likely to see bonds between the two parties. These links by which the two seemingly irreconcilable points of view with regard to the origin of Bahuvrīhis can be brought to team work, are sought to be clearly indicated in the subsequent paras.

It might be that at one stage in the pre-Vedic period, there was no way of distinguishing one class of compounds from another, except perhaps through context for we may be sure of

¹ Rv. VI. 45, 31.

² Rv. V. 11, 6.

³ Rv. I. 130, 8.

⁴ Rv. VI. 62, 9.

⁵ Rv. II. 34, 6. Compare also *sāmso narām* (Rv. VI. 24, 2).

⁶ Rv. I. 23, 8a.

⁷ See also section 291 of Macdonell's *Bigger Vedic Grammar*.

⁸ Vide Batakrishna Ghosh's review of 'The use of the cases in Vedic Prose' by Sukumar Sen, Page 169. Volume X, No. I. of the *Indian Historical Quarterly*.

the fact that compounds then arose only through sheer juxtaposition of words¹ and each of them being an independent unit, should doubtless have borne the accent.

At this stage, even finite verbs occurring in the middle of the principal clauses (though these clauses might even contain prepositions which are separated from the finite verb) should not have been enclitic, but borne the accent.

The following passages may probably point to such a conclusion.

*ādabdhacakṣuḥ pāri viśvam babhūva*², *āha krā-tāv āsaḥ*.³
ādāha svadhām ānu pūnar garbhatvām eriré | dādāhānā nāma yajñīyam.⁴

Pāṇini's explanation for the accentuation of the verb in the last two instances is on a semantic basis. तुपश्यपश्यताहैः पूजयाम् (P. VIII 1. 39.)

The finite verb in subordinate clauses as it is well known is accented. Some of the instances are the following:

पुत्रा यदभवत्सूरहैभ्यो मघवा विश्वदर्शतः (Rv. I. 146,5).
यदग्रे स्यामहं त्वं (Rv. VIII. 44,23).

¹ In Lithuanian, the consciousness of the original independence of the constituents of all compounds is still alive. Cf.—page 16 'Accentuation of Nominal Compounds in Lithuanian' by Frederick Turnbull Wood. Language Dissertations published by the Linguistic Society of America. Number VII. December 1930.

² A. V. XIII. 2.44.

³ A. V. I. 34,2.

⁴ Rv. I. 6,4; A. V. XX. 40,3; 69,12. Of six passages in which *āha* is found in the first Aṣṭaka of the Rgveda, I. 6,4. is the only one where it exercises a power to accent the verb. Sāyaṇa's remarks on this passage are the following:

एरिरे । अन्तर्भावित ण्यर्थाद् ईरगतावित्यस्मात् अनुदात्तैः परस्य “*कटिस्त-
झयोरेरिरेच्*” (P. III. 4.81). इति इरेच् । चित्वादन्तोदात्तः । सह सुपा (P. II. 1.4.) इत्यत्र सुपेतियोगविभागादाड्वा सह तिङ्समासेऽपि समासस्येत्य-
न्तोदात्तत्वम् “*इजादेश्च गुरुमतोऽनृच्छः*” P. III. 1.36.) इत्याम् न भवति ।
मन्त्रत्वात् अहशब्दयोगान्निघाताभावः । “तुपश्यपश्यताहैः पूजयां” (P. VIII. 1.39.) इति निषेधात् । [Vide also page 416. Article IV.

Contributions from the Atharva Veda to the theory of Sanskrit Verbal accent' by William D. Whitney. Volume 5. *The Journal of the American Oriental Society*.]

युवा यदो कृयः (Rv. V. 74,5).

कुविदंग नमसा ये वृधासः पुरा देवा अनवचास आसन्

(Rv. VII. 91,1).

(See also Atharva Veda XX. 24,2; 4; where the particle कुवित् exercises an influence to accent the finite verb. These two passages are the only instances in the Atharva Veda where this particle occurs.¹)

nét tvām sabhāyām āha tvām vāda. (Av. VII. 38,4).

यद्वाऽवमे वृजने मादयासे (Rv. I. 101,8).

पुत्रासो यत्र पितरो भवति (Rv. I. 89,9).

These instances are covered by Pāṇini's sūtra

निपातर्यद्यदिहन्तकुविनेच्चेच्चण्कच्चिद्यत् युक्तम्².

Similarly we have the following instances where the particle हि influences to accent the verb.

आ हि ष्मा याति³

आ हि रुहति⁴

These instances are covered by the sūtra हि च,⁵

The sūtra अभ्यस्तानामादिः⁶ is intended to cover passages like the following अप नः शोशुचत् (Rv. I. 97,1).

The accentuation of the verb *atti* is optional in the following passage by the sūtra एकान्याभ्यां समर्थाम्याम् (P. VIII. 1.65

¹ *Ibid.* page 418. [As Whitney observes one cannot see how the accentuation after *kuvid*, any more than after *hanta*, marks the clause as dependent. Vide *A. J. P.* Vol. XIII, page 298. Cp. also *S. F.* Vol. V, page 551.]

² Pāṇini VIII. 1.30.

³ Rv. IV. 29,2.

⁴ Rv. VIII. 22,9.

⁵ Pāṇini VIII. 1.34. Sāyaṇa brings इंदवो वामुशन्ति हि (Rv. I. 2, 4) under this sūtra of Pāṇini. But we can bring the passage under the sūtra यद्वितुपरं छन्दसि (P. VIII. 1.56.) also.

⁶ Pāṇini VI. 1.189.

where the anuvṛtti of विभाषा is made from चादिलोपे विभाषा (P. VIII. 1.63).

तयोरन्यः पिप्पलं स्वाद्वत्त्यनश्नन्नन्यो अभिचाकशीति (Rv. I. 164,20.)

Instances like यत्कामास्तेजुहुमः (Rv. X. 121,10) are comprehended by Pāṇini's sūtra यद्वृत्तान्नित्यम् (P. VIII. 1.66).

Delbruck¹ observed that the dependent clause in Sanskrit is oftenest one of necessary condition, and oftenest precedes the clause on which it depends. 'In such a case,' he goes on to observe, 'the practice of our own languages shows that the verb of the dependent clause has the superior emphasis.' And this is to be inferred according to him from such an example as the following:

WAS MAN NICHT NÜTZT, IST EINE SCHWERE LAST, 'what one uses not is a heavy burden'—where ist (is) is unemphatic as compared with Nützt (uses).

Whitney² points out how Delbruck here fails to observe that his dependent verb is one which, owing to the content of the word, and not at all to the form of the sentence, is the emphatic predicated element, while his independent verb is the mere copula, unemphatic for that reason and for no other³. Whitney goes on to show that in every other like case, the emphasis of the verb depends on the relation of its significant content to the sum of significance of the sentence, and not in the least on its occurrence in a clause of the one kind or of the other. Whitney proceeds then to give his own view that the whole aspect of the phenomena of verbal accentuation is to him that of a historic verity which those who handed down to us the R̥g Veda did not themselves understand or, for the most part, even try to understand—much less try to regulate on such shadowy principles as Delbruck thinks to recognize.

¹ In 1871, in the first part of his *Syntactische Forschungen* (pp. 96-98) [vide Whitney page 278 'On Delbruck's Vedic Syntax.' A. J. P. Vol. XIII].

² Vide his review of Delbruck's *Vedic Syntax*, *American Oriental Society's Proceedings*, April 1892, *Journal of the American Oriental Society*, Volume 15.

³ Whitney shows the flaw in Delbruck's theory thus: if Delbruck's sentence reads instead, WAS UNS NICHT NÜTZLICH IST, BELASTET UNS, 'what is useless to us burdens us', the relation of the two verbs in respect to emphasis would seem to be reversed; the independent one would be obviously better entitled to the accent!

Delbruck in his later work¹ says the accentlessness of the verb of the independent clause is 'merely the external sign of the fact that the verb appears as a relatively dependent member of the sentence, attaching itself to a noun, a preposition in such a way as to limit these ideas.' Whitney points out clearly how this statement of Delbruck seems little short of absurd and no theory built upon such a foundation can possibly be anything but a failure. 'The sentence consists of subject and predicate; and one of these is just as primary and just as secondary as the other. A subject, noun or pronoun, is even more meaningless without a verb to tell what it is there for than is a verb without a subject, since a subject can be on the whole much more easily inferred for it from the circumstances. But not only a preceding subject, even a preceding object, or adverb, or prefix takes away the accent from the verb in the Sanskrit sentence; and that the verb is a "relatively dependent" word as compared with its own modifiers, that it is attached to a preposition in order to limit the meaning of the preposition, is a view which no reasonable person can fairly be expected to accept on Delbruck's authority.'

But after all is said, it seems to me that we can not do anything better than to assume that as perhaps the preposition was felt to possess a tendency to modify the sense of verbs, the latter were made enclitic when used along with preposition for the observed fact is as Brugmann records² that the finite verb was enclitic to a large extent, always if the temporal particle *é, the augment, immediately preceded it and also because many prepositions were originally adverbs like *dpa*, *prá* and *pára* in Vedic Sanskrit.³

But as Whitney shows Delbruck's statement that 'the verb has only in exceptional cases a primary value for the sentence and that then it is moved back, toward the beginning of the sentence' is hardly satisfactory.

¹ *Allindische Syntax* (*Syntactische Forschungen V*) by Delbruck, section 29, page 50. Die Nichtbetonung des Verbums im Hauptsatze ist nur das äussere Zeichen für die Thatsache, dass das Verbum als ein relativ unselbstständiges Glied des Satzes erscheint, welches sich an ein Nomen, ein Pronomen eine Praeposition derartig anschliesst, dass es diese Begriffe näher bestimmt.

² *Comparative Grammar*, Volume I, section 669. Vide *infra*.

³ Vide *infra*. All prepositions must have been originally adverbial in character before they became adnominal. The temporal particle *é is certainly a preposition as indeed it denoted a time (the Past). In this connection it is well to remember that Pāṇini's name कर्मप्रवचनीय suggests the original character of the prepositions being adverbial.

A certain order of the clause having become established as normal, any deviation from it is made a means of the different distribution of emphasis, to the members moved either backward or forward. But the Sanskrit verb, however it may change position, gets no accent unless it be placed at the very head; nor do the other members, though moved to the end, lose their accent.

As Whitney indicates though there is a certain measure of truth in the statement that the sentence is naturally a diminuendo, beginning strong, to attract the attention of the listener, and then toning gradually down to the end as Delbruck claims, in a first direct address, it seems wholly out of place as applied to continuous discourse, as for instance in a hymn, or a piece of exposition.

And as regards the accented verb of the dependent clause, a double expression viewed as a single one is furnished us. First, if the dependent clause precedes the other, the diminuendo of the whole sentence has not become complete when the dependent verb is reached, and hence that the verb has not become entirely toneless. And then this non-tonelessness, originally a result only of the position, of the clause, is historically generalised into a means of distinction of all dependent clauses which express an incomplete sense or involve a suspension of sense as compared with the main clause.

Thus we see the glaring inconsistency in Delbruck's theory in that it states that a verb in general is not accented because it is dependent; but this dependent member, if it belongs to a clause which is a dependent member, attains independency and gets an accent. A result, too, quite the reverse of that in German as Whitney says, where the dependent verb, instead of being made emphatic, takes its position at the very end, which signifies tonelessness!

Whitney seems to be perfectly right in totally rejecting Delbruck's explanation of the problem of Sanskrit Verbal accentuation both in its earlier and later form.

But the three passages¹ quoted above though they may not be conclusive and may not decisively prove our point, still would

¹ A.V. XIII. 2, 44.
A.V. I. 34, 2.
R.V. I. 6, 4; A.V. XX. 40, 3; 69, 12.
Vide *supra*.

give us at least for the time being some sense of relief for doubtless it appears to one 'that a form of the finite verb which one is wont to regard as the very life of the sentence, as by itself capable of constituting a sentence complete in all its parts, which so often combines in itself ideas and relations that in another language, or in other parts of the same language, appear as independent words or accessory clauses that this, of all other words, should lose its independent tone, and be reduced to the subordinate position of an enclitic in the sentence, is certainly strange enough; and consequently, one might, at first sight almost feel justified in denying its truth.'¹

The Vaiyākaraṇas recognise two kinds of सामर्थ्य—एकार्थीभाव and व्यपेक्षा. In समास we have the former, that is, in the formation of compounds a sort of semantic unity is secured between the constituents of the compound as a result of a kind of semantic amalgamation and fusion.² व्यपेक्षा exists between any one word and another in a sentence. In other words, a sort of semantic unity is secured through several words that compose a sentence through some kind of semantic agglutination परस्पराकाङ्क्षारूपा व्यपेक्षा (Kaiyaṭa's प्रदीप Bombay Nirṇaya Sāgar edition, Vol. II, page 314.)

Here we have to keep clear the notions of three distinct unities in our mind, viz. the semantic unity, the inflectional unity and the accentual unity. In this connection, it is best to remember what W. V. Humboldt says regarding the accentual unity: 'The unity of the word is produced by the accent. This, by itself, is of a more spiritual nature than the sounds, and it is therefore called the soul of speech, not only because it is really the element which carries intelligibility into speech, but because it is, more

¹ Cf. Bopp's 'Comparative Accentuation of Greek and Sanskrit languages' by W. D. Whitney, *Journal of the American Oriental Society*. Volume V (1856), page 214.

² Kaiyaṭa defines it thus in his प्रदीप. यत्र पदान्युपसर्जनोभूतस्वार्थानि निवृत्तस्वार्थानि प्रधानार्थोपादानाङ्गार्थानि, अर्थान्तराभिधायीनि वा स एकार्थी भावः Bombay Nirṇaya Sāgar edition. Vol. II. page 314.

than other factors in speech, the immediate expression of feeling' (cited by Göttling, *Accent der Griechischen Sprache*, p. 8. Cf. also Maurice Bloomfield: 'Historical and Critical Remarks introductory to a Comparative Study of Greek accent' in the *American Journal of Philology*, Volume IV. 1883, page 21.)

In double-accented compounds like *vānas pāti* in general we have only the semantic unity between the constituents of the compound. As invariably in these compounds, the inflectional unity is not secured, we find consequently that the accentual unity also is not secured. Here is the parallelism to the व्यपेक्षासामर्थ्य that exists in every independent word of a sentence—a relation of one word to another semantically correlated.

As only a semantic agglutination occurs in every sentence between word and word, every word we should expect as a matter of course to retain its individual accent. So logically the finite verb should also possess its own accent even in the principal clause, not to speak of the subordinate clauses where the accent of the verb is preserved. An explanation I shall attempt to offer following the lines of arguments indicated by scholars like Maurice Bloomfield to account for the phenomenon of enclisis of the finite verb in the principal clauses and now having examined to some extent one phase of sentence accentuation, let me enter into an interesting discussion on the other phase, viz. vocative accentuation. I shall dwell on this at some length in the subsequent paras. of this paper.

Just as finite verbs must have been accented even in principal clauses at one time in the pre-Vedic language, even so should the vocatives have retained their own word accent. We have for instance आदित्यासः¹.

Sayana comments upon it as follows:—

हे आदित्यास आदित्या देवाः । व्यत्ययेनाद्युदात्तत्वाभावः । यद्वा

आदित्यानामिम आदित्याः तस्येदमित्यर्थे प्राग्दोष्यतो योऽप्यप्रत्ययः ।

There are a few cases in the Rg Veda where an interior vocative co-ordinate with an initial accented one from which it is disjoined, has its own accent, not following the general rule by

¹ Rv. VII. 52, 1.

which it should lose its accent¹; an example is *sū putra ādu sūnuṣe* (Rv. x. 86, 13b.) In *ā prā yāta māruto viṣṇo āsvinā* (Rv. viii. 27, 8a.) all successive interior vocatives are accented.

In Rg Veda vii. 59, 1c. three accented vocatives follow an interior un-accented one,

तस्मा अग्ने वरुण मित्रार्यमन् मरुतः शर्म यच्छत ॥

One can safely hazard a conjecture here that even this first vocative should have accented at an earlier stage, and the loss of its accent can very well be regarded as an error of the tradition. In Rg Veda ii. 27, 14a, all the vocatives where each is an independent invocation are accented: *ādite mitra vāruno tā mṛta*. In Rg Veda i. 117, 18 an accented vocative follows two un-accented vocatives *शुनमन्धाय भरमङ्गयत्सा वृकोरश्विना वृषणा नरेति* ॥²

Venkaṭamādhava says: नरेति परिदेवनासूक्तम् आमन्त्रितमुच्चैर्लौकिका वदन्ति । तत्कृतो निपात इत्युक्तं ॥ (Paper manuscript Venkaṭa Mādhava Bhāṣyam Adyar, library, Vol. I. page 320.) The examples of co-ordinate epithets of the same subject where each is alike accented are the following:—

āsvinā yājvarīṣo drāvātṣpāṇi śubhaspati pūrubhujā canasyātām (Rv. I. 3, 1.).

bṛhadbhāno yāviṣṭhya³ jātavedo vicarṣaṇe⁴ ōjīṣṭha trātār

¹ See for instance: *imām me gaṅge yamune sarasvatī śūtudri stōmam sacata pāruṣṇyā* (Rv. X. 75, 5b.) 'We are probably to read *pāruṣṇyā* (instrumental) instead of *pāruṣṇyā* as the corresponding cases in the other half of the verse indicate.' Vide Article 2. 'On the accentuation of the vocative case in the Rg and Atharva Vedas.' By Willabe Haskell, Ph.D., of New Haven. Volume II. *Journal of the American Oriental Society*.

² Mādhavabhāṭṭa gives this instance in support of his favourite semantic theory which I am discussing at great length in a paper entitled, 'The Accentual Variation in relation to Semantic Variation.' Mādhavabhāṭṭa says:

अङ्गयच्छुनमन्धाय सा वृकोरिति वक्ष्यति ।

नरेति तत्राद्युदात्तमेवं हि परिदेवनम् ॥

Rgvedānukramāṇī, Part I, i, ii. 4. "Here the accentuation indicates that *nārā* alone is the cry of the she-wolf, and that *āsvinā vṛṣṇā* are the utterance of the poet; if all the three vocatives belong to the former, we can hardly avoid amending the reading to *āsvinā vṛṣṇā nārē 'li*." Vide page 60. 'On the Accentuation of the vocative case in the Rg and Atharva Vedas' by Willabe Haskell, Ph.D., of New Haven. Presented to the Society, October 25th, 1877.

³ J.A.O.S. Volume 11.

⁴ Rv. I. 36, 15 d.

⁵ Rv. I. 78, 1b; VI. 16, 29b; 36b; VIII. 43, 2b;

āvitah¹ (*āgne . . .*) *māndra svādhāva ṛtajāta sūkrato²* (*sā . . .*)
vāsupate vāsudāvan³ (*varuṇa*) *sāmraḥ ṛtavaḥ⁴* *āmbitame*
nāditame (*dēvitame sārāsvati*)⁵ (*agne*) *sūścandra dāsma*
viśpate hāvyaṇā⁶ (*māruto*) *tūvimaghāso āmrta ṛtajñāḥ*
sātyaśrutah kāvayo yūvāno (*bṛhadgirayah*),⁷ (*Vīrāsaḥ*)
māryāso bhādrajānayah⁸ *sūjāte dāsvasūnrte⁹* *sāhasramuṣka*
tūvinrma sātate¹⁰ (*agne*) *vāsiṣṭha sūkra dīdivah pāvaka¹¹*
śiprinn ṛṣivah śācivah¹² (*śubhas-pati*) *dāsrā hiranyavartanī¹³*
(aśvinā) pūruścandrā nāsatyā¹⁴ *dhījavanā nāsatyā¹⁵* *śācigo*
śācipūjana¹⁶ *śāvapate gōpata ūrvarāpate¹⁷* (*mahemate*) *sāhasrote*
śātāmagha¹⁸ *śātāmūte śātakrato¹⁹* *sānitah sūsanitar ūgra citra*
cētiṣṭha sūnrta²⁰ (*śātakrato*) *prācāmanyō āhamsana* (Rv. VIII. 61, 9d.)

tūviśuṣma tūvikrato śācīvo Viśvayā mate²¹ *ūrjo napād*
bhādraśoce²² *ūrjo napād āsvamiṣṭe²³* (*āgne*) *māndra sūjāta*
sūkrato 'mūra dāsmātithē²⁴ (*subāho svangure*) *pṛthusto pṛthujā-*
ghane (*śūrapatni*)²⁵ *uttānaparṇe sūbhage dēvajāte sāhasvati²⁶*
(maghavan) *dhātā vidhātah²⁷*

Rv. I. 3, 1. can be effectively contrasted with ऋतेन मित्रावरुणावृतावृतावृतास्पृशा । (Rv. I.2. 8.)²⁸ [See Sāyana's commentary under both.]

At one time in the pre-Vedic period each word should have been an independent unit and the language should highly have been an analytic one, like the modern English, so much so even

¹ Rv. I. 129, 10d.

² Rv. I. 144, 7b.

³ Rv. II. 6, 4b.

⁴ Rv. II. 28, 6b.

⁵ Rv. II. 41, 16b.

⁶ Rv. V. 6, 5c.

⁷ Rv. V. 57, 8b; c.

⁸ Rv. V. 61, 4b.

⁹ Rv. V. 79, 1-10e.

¹⁰ Rv. VI. 46, 3c.

¹¹ Rv. VII. 1, 8b.

¹² Rv. VIII. 2, 28c.

¹³ Rv. VIII. 5, 11b; cf. 8, 1c;

¹⁴ Rv. VIII. 5, 32c.

¹⁵ Rv. VIII. 5, 35c;

¹⁶ Rv. VIII. 17, 12a.

¹⁷ Rv. VIII. 21, 3b.

¹⁸ Rv. VIII. 34, 7b.

¹⁹ Rv. VIII. 46, 3b.

²⁰ Rv. VIII. 46, 20a; b;

²¹ Rv. VIII. 68, 2 a, b.

²² Rv. VIII. 71, 3 b.

²³ Rv. II. 6, 2 b.

²⁴ Rv. VIII. 74, 7 c, d

²⁵ Rv. X. 86, 8 b.

²⁶ Rv. X. 145, 2 a, b.

²⁷ Rv. X. 167, 3 d.

²⁸ 'The only exception in the Rg-Veda to the general rule for the accent of initial vocatives is the above passage, where such a vocative, standing between two unaccented vocatives, is itself unaccented. It must unquestionably be regarded as an error of the tradition.' Vide Volume II, J.A.O.S., page 58.

euphonic combinations might not have occurred. There are doubtless historic survivals of this practice even in later times.¹

That mode of mental action, their deficiency in which especially puts language out of the reach of other animals, which is the power of distinct reflection on the facts of consciousness, of analysing impressions, and perceiving that the parts are capable of receiving distinct signs was perhaps very clearly manifest in the language of the pre-Vedic period. Hence the problem of the origin of the double-accented compounds in the Veda can be stripped much of its difficulty and mystery.²

¹ Cf. Pāṇini's sūtras निपात एकाजनाङ् (I. 1. 14.) and ओत् (I. 1. 15.)

which comprehend instances like

इ इन्द्रः (इ expresses wonder)

उ उमेशः (उ expresses the idea of वितर्क)

आ एवं नु मन्यसे ।

आ एवं किल तत् ।

अहो ईशाः ।

See also page 51 of Bhaṭṭoji Dīkṣita's *Siddhānta Kaumudī*. Bālaṃanoramā edition.

² It is interesting to see the पूर्वपक्ष given by Patañjali in his *Mahābhāṣya* (I.

1, 2) that even the *phoneme* इ has a full meaning. Says he :—अर्थवन्तो वर्णाधातु प्रातिपदिकप्रत्ययनिपातानामेकवर्णानामर्थदर्शनात् (Vartika 9). धातव एकवर्णा अर्थवन्तो दृश्यन्ते । एति अध्येति अधोत इति । प्रातिपदिकान्येकवर्णान्यर्थवन्ति आभ्यां एभिः एषु प्रत्यया एकवर्णा अर्थवन्तः ओपगवः कापटवः । निपाता एकवर्णा अर्थवन्तः अ अपेहि । इ इन्द्रं पश्य । उ उत्तिष्ठ । धातुप्रातिपदिक प्रत्ययनिपातानामेकवर्णानामर्थदर्शनान्मन्यामहे अर्थवन्तो वर्णा इति ॥ *Mahābhāṣya*. Kielhorn's edition. Volume I, page 30, lines 2 to 6. In his *Praughamanoramā*, Bhaṭṭoji Dīkṣita refers to this passage under Pāṇini's Sūtra I. 2, 45. Says Dīkṣita :—

तथा च प्रत्याहारद्विके अर्थवन्तो वर्णा इति प्रषट्ठके अध्येति अधोत इत्यन्ते-कारोऽर्थवानिति भाष्ये स्पष्टमेवोक्तम् ॥

These passages show how the state of analysis of the language at one time prior to the composition of the Veda was still further extended in later times in purely a theoretical way by grammarians to find ample scope for scholastic discussions.

At this analytic stage of the pre-Vedic language independent words might have been glued to form compounds in a loose manner, all the three unities indispensable for the emergence of full-fledged real compounds not being secured.

Sometimes, however, probably to indicate that the words in sheer juxtaposition form a compound, signifying a unitary concept (i.e., securing a semantic unity between them), the last syllable of the first member when that syllable is short is lengthened, [Whitney: *Sanskrit Grammar*. Section 247] as in नूनु (Rv. I. 17, 8) or as in अद्यानूनं च (Rv. I. 13, 6.) where नूनं seems to gain a special signification (forming of course a compound with अद्य) according to Skandasvāmin:—नूनशब्दोऽत्र समुच्चयार्थचशब्दश्रुतेः अद्य इत्येतेन स (ह ? माहा) रार्थस्य समुच्चया (र्थ) स्य योग्यत्वात् पुराशब्दार्थे । अद्य च पुरा च इदानीं पूर्वस्मिंश्च काल इत्यर्थः¹

[The Greek and German *nun* (which remains only an adverb as it does not affect the case of nouns) meaning 'now' corresponds to Skt. नूनं ।]

Probably in the later stages of the Vedic language there came into existence many compounds of the type of *vanas-pati* and *dravino-dā*.²

These (the old models as well as the new formations) are the so-called unreal or case compounds in which the prior member appears in an oblique case-form and hence in general accent both the members. Such unreal or case compounds are opposed to the stem compounds in which the constituents are more closely fused together and which give up one accent in favour of the other.³

Viewing the double-accented compounds such as

nū-nū (Rv. I. 17, 8.)

adyā-nūnām (Rv. I. 13, 6.)

Mitrā-vārunāv (Rv. I. 35, 1.)

¹ Vide page 94. *The Ṛksamhitā with the Bhāṣya of Skandasvāmin and Venkatamādhavārya*.

² Brugmann: *Comparative Grammar*. Volume II, pages 31 and 40.

³ Cf. page 15. *The Accentuation of Nominal Compounds in Lithuanian*. By Frederic Turnbull Wood. Language Dissertations published by the Linguistic Society of America Number VII. December 1930. Compare also Wackernagel:—

Altindische Grammatik II. i, sections 41 and 103.

Dyāvā-prthivī (Rv. I. 35, 9.)

nārā-śāmsam (Rv. I. 13, 3 ; 18, 9.)

where the last syllable of the first member is lengthened, I am tempted to suggest (of course with much hesitation) that perhaps to show that the two words in sheer juxtaposition signifying a unitary concept form a compound, the last syllable (if short) of the first member might have been lengthened. In *Mitrā-vārunāv*, it may be purely accidental that the first member *Mitrā-* as we find in the compound is in its dual form. E. W. Fay suggests that *mitrā-* was but an epithet, in the nom.-voc.¹

In this matter, parallels are not wanting in the related languages. In Avestan the thematic vowel of the prior member is lengthened in many compounds. Cf. *vaēdyā pati*, *ahurōt kaēša*.²

-ē- became a composition vowel in Greek compounds where it was felt to be necessary to avoid a succession of four short syllables *καλαθηφόρος*. This statement, to be sure, is only true in so far as it concerns compounds the final members of which begin with a consonant. (Cp. pages 21 and 22 of '*The Accentuation of Nominal Compounds in Lithuanian*.')

Furthermore, before the suffixes—*τερος* and —*τατος*, adjectives which have a short penult lengthen their-o-ending to-ō-: *σοφώτερος*, *σοφώτατος*, but *δεινότερος* (Hirt: *Indo-Germanische Grammatic*, 4, 79.)

Again it is a matter of common knowledge that in Sanskrit there is a lengthening of the final stem vowel in the feminine forms of words in *-mant*, *-vant*, (which is perhaps caused also by "the effort to put the original stem into word-rhythm with the suffix *-matī*, *-vatī*."). Note *anjanāvati*, *amarāvati*, etc.³ The stem vowel *-a-* of masc. *o*-stems in Lithuanian is lengthened and stressed upon the addition of the derivational suffix *-vimasis*. cf. *darbā vimasis* 'activity' (*dārbas* 'work').⁴

¹ Vide footnote 2, page 430, *A.J.P.*, Volume 15. Cf. Delbruck, *S.F.*, Vol. V, Section 58, page 98.

² Vide A. Bezenberger:—*Beiträge zur Geschichte der Litauischen Sprache*, 106. For composition vowel, see Wackernagel: *Das Dehnungsgesetz Griechischen Nominal Composita* 16; 10ff; 5.

³ Cf. H. H. Bender: The suffixes *mant* and *vant* in Sanskrit and Avestan 47-8. Baltimore, 1910.

⁴ Cf. F. T. Wood: On the declension of substantive compounds in Lithuanian. *American Journal of Philology*, Vol. 50, 160.

Perhaps at one time, prior to the composition of the Veda, the impression that the prepositions (which were all originally adverbial in character) had exercised much influence in modifying the sense of verbs, should have gained considerable ground so much so that finite verbs used in association with the prepositions in principal sentences might have been enclitised. This assumption is borne out by the fact that finite verb was enclitic to a large extent, always if the temporal particle **é*, the augment immediately preceded it. e.g., **é- dr̥ket*. Skr. *adr̥śat* Gr. *ἔδραχε* ¹ **é- dr̥kom*.² Brugmann regards the augment *é* as a temporal particle.

'Apparently already in the period of the Indo-Germanic primitive community an agglutination had taken place here which obliterated the feeling for *é* as an independent word. Further, the verb in the principal sentence might have been frequently appended with the low tone to those adverbs which appear in the separate languages as prepositions* *pró bherō*=Skr. *prá bhavāmi*. So also the passive participles and verbal abstracts with suffix *-ti* had the tone on the prefix, e. g., **pró- bhr̥to-s* **pró bhr̥ti-s* (Skr. *prá-bhr̥ta-s*, *prá bhr̥ti-s*) beside **bhr̥tó-s* **bhr̥ti-s* (Skr. *bhr̥tá-s*, *bhr̥ti-s*). More rarely the verb was welded into unity with living case forms.'

Probably later on, 'apart from such definite categories of words with which the verb showed a special preference for enclitic connection, the verb in principal sentences in general came to have the low tone.' Perhaps at a later stage this phenomenon of enclisis spread to the interior vocatives too. [But initial vocatives and initial finite verbs as well as the finite verbs in subordinate clauses in Sanskrit, however, were not enclitised.]

Jacob Wackernagel,³ showed that the Greek verbal recessive accent is nothing more than this enclisis of the finite verb extended to all kinds of sentences, subordinate as well as principal, but at the same time modified by that peculiar law of

¹ Brugmann : *Comparative Grammar*, Volume I, Section 669, page 534. (See also Volume II, Section 19, page 37.)

² Brugmann : *Comparative Grammar*, Volume IV, Section 462, page 8. See also Zimmer : *Weber Gurupūjā kaumudī*, p. 83.

³ 23rd Volume of Kuhn's *Zeitschrift*, page 457, fg. ('*Der griechische verbal accent*')

Greek according to which enclisis can not extend beyond three moræ.

'While the Sanskrit verb is inclined in independent paratactic clauses, (except when it stands at the beginning of the clause) and the verb in hypotactic clauses or at the beginnings of paratactic clauses, etc., is orthotone, the Greek has forgotten and given up this original distribution of orthotonesis and enclisis, and has spread the analogy of inclined forms over the entire finite verb.' The phenomenon of enclisis should certainly be a pre-historic one.¹

Finite verbs in Veda are not only not enclitised at the beginning of a pāda, but they are allowed to be accented even if they stand at the head of their own particular clauses in the sentence.

In Rg Veda, then, I. 79, 11, we read यो ना अग्नेऽभिदास्यंति दूरे पंदोष्ट सः : 'whoso, O Agni, near or far, would do us harm, let him fall !' In X, 101, 8, again, मावः सुलोच्चमसो दृढंता तं । 'let not your bowl of offering spill, hold it firm.' In I. 31, 17, आ सोदय बर्हिषि यक्षि च प्रियम् 'cause them to take seat upon the barhis, and make acceptable offering'. In I. 94, 4, भरामेभ्यं कृण्वामा हवीषो ते । 'we will bring fuel, will make libations to thee.'

As Whitney says, 'here the several verbs *padīṣṭā*, *dṛmḥata*, *yāksi*, *kṛṇāvāma* retain their accent in virtue of the general principle of the accentuation of a verb when it occupies an initial position (even in a clause).²

Whitney observes that the only instance anywhere noted of a violation of the principle is Rk. I. 134, 3, प्रचक्षय रोदसी वासयोषसः ; where, if *rōdasī* is to be connected with the preceding verb, as the sense seems to demand, and as the commentator also understands it (says Sāyaṇa: रोदसी द्यावापृथिव्यो प्रचक्षय । प्रकर्षेण प्रख्यापय ।

¹ Vide Bloomfield : 'Historical and Critical Remarks—Introductory to a Comparative Study of Greek accent.' Vol. IV (1883), *A.J.P.*, pages 27, 58 and footnote 1 on page 58.

² Cf. 'Bopp's Comparative accentuation of Greek and Sanskrit languages by Whitney in Volume V (1856) of the *Journal of the American Oriental Society*, page 218.

प्रकाशयेत्यर्थः । तत्प्रकाशार्थमुषसो वासय । उषः कालानपि यथावस्थापय ।

प्रभातं कुर्वित्यर्थः ।) the following verb ought to have been accented, *vāsāya*: that it is not so accented is simply an error in the tradition, as Whitney maintains.¹ The classes of the accented finite verbs so far enumerated coupled with the not infrequent instances of a more isolated character, and less reducible to rule² go only to strengthen the belief that at one stage prior to the composition of the Veda, even finite verbs in the principal clauses should have been, in all probability, accented.

Just as the finite verbs came to be enclitised in principal clauses, words in the genitive case depending on vocatives came to form as it were single words or phrases with it, and shared in its accent.³ Thus, for example, 'O son of strength' is *sūno sahasaḥ* or *sāhasaḥ sūno* if initial, and *sūno sahasaḥ* (the enclisis of interior vocatives might at the beginning be simply due to an extension of the practice of enclitising finite verbs in principal clauses) or *sahasah sūno* if interior. (Brugmann: Grundriss I. ii, section 1074, page 957.)

Such cases are calculated to be about 180 in the Rg Veda, the dependent genitive preceding the vocative in about three-quarters of them. The cases in which such a genitive has an independent accent are only two or three.⁴

Brugmann⁵ conjectures that this practice in Sanskrit as in other languages, if it did not occasion, at any rate helped the formation of improper compounds. Cp. e. g., Skr. *jās-pati-s* 'lord of the family' Gr. *δεσ-πότης*. Voc. *-πο* 'housemaster'. Gr. *Διός-χουροι* 'sons of Zeus', Latin *Juppiter, Diespiter*—

The view that an internal vocative is a mere parenthesis in the sentence, uttered, like any other parenthesis, in an undertone or mono-tone, for the attention of the person addressed seems to have been already gained (since otherwise the name would be

¹ Cf. 'Bopp's Comparative accentuation of Greek and Sanskrit languages' by Whitney in Vol. V. (1856) of the *Journal of the American Oriental Society*, page 217.

² That they are such has been pointed out by Whitney. *Ibid.*, Page 218.

³ Cp. सुबामन्त्रिते पराङ्मत्सरे (P. II. 1. 2.)

⁴ Vide *J.A.O.S.*, Vol. 10, Proceedings, page 152. 'On the accent of vocatives in the Rg-Veda', by W. Haskell. Cp. also Whitney, *Sanskrit Grammar* Section 314 d. Also see 'Agglutination and Adaptation', (p. 417. *A.J.P.*, Vol. 15). E. W. Fay.

⁵ Vide *Comparative Grammar*, Vol. I. Section 672, page 538.

first called and have a full tone on it) might have been largely responsible for the enclisis of interior vocatives.¹

The third class of compounds (according to Brugmann's classification)² whose first part was an old adverbial word was perhaps the earliest in the pro-ethnic period. Verbal prepositions were probably the first to be compounded with verbal nouns and past passive participles like *āpi-hita-s*³ *āpa-citi-s*⁴, *abhi-vrtam* (Rv. I. 35, 4.) *prā-yatam* (Rv. I. 154, 3.) *purō-hitam* (Rv. I. 1, 1.) *sū-kṛtas* (Rv. I. 35, 11.) *sū-kṛtam* (Rv. I. 85, 9.)

In these compounds, the accent perhaps acted as the principal unifying agent of elements which were at one time separate.⁵

'Primitive emotional man was doubtless prone to blurt out his reactions to things without reflecting that the listener could not understand him unless he knew what was being reacted to. Until a look of incomprehension was seen on the listener's face would such a speaker add the name of the thing that was being reacted to as *kṛtam* in *sū-kṛtam* ('skilfully fashioned'). It would be a far more sophisticated and intellectual method to name the stimulus first and to add the reaction afterwards as we would have in modern English.'⁶

We see the stimulus named first in some later Sanskrit compounds for instance *kṛta-kṛtyaḥ* which is covered by Pāṇini's sūtra निष्ठा⁷ But the Vārtika जातिकालसुखादिभ्यः परानिष्ठा वाच्या read under this sūtra and Pāṇini⁸, VI. 2 170, take into account the compounds where the *niṣṭha* participle stood as the second member.

It will be a mistake to suppose that the earliest Indo-Germanic compounds of the type *purō-hitam sū-kṛtas* were the determinative compounds of the descriptive class, for such an

¹ Vide 'Bopp's Comparative accentuation of Greek and Sanskrit languages' by W. D. Whitney, *J.A.O.S.*, Volume 5, page 214.

² Brugmann: *Comparative Grammar*, Vol. II, Section 10, page 23.

³ *Ibid.*, Section 15, page 30.

⁴ *āpi-dhṛto-s*

⁵ *āpa-citi-s*.

⁶ F. T. Wood: 'Accentuation of Nominal Compounds in Lithuanian', page 16.

⁷ Vide A. H. Gardiner: *The Theory of Speech and Language* page 277, para 69.

⁸ P. II. 2.36.

⁹ Vide my paper 'Five stages of determinative Compound Accentuation in the pre-Vedic period as surmised by their historic survivals in Vedic Sanskrit.' Volume IX, Part II, page 125. *J.O.R.M.*

assumption would be against reason. As I maintained,¹ along time should have elapsed between the stage of dependent determinative compound formation and the stage of descriptive determinative compound formation; and the descriptive compounds must be later in origin.

But possibly it can be maintained that the earliest compounds might have been of the type—*puró-hitam* if it is assumed that in that remote period of prehistoric times the thing meant by the first member should have been presented to the minds of the speakers of the language, not as an attribute but as a thing itself. Very likely these compounds might have been on a par with that class of determinative compounds which later on came to be designated as the व्यधिकरणतत्पुरुष in the separate history of Sanskrit.

At a further stage in the pro-ethnic period (be it remembered only after the stage of dependent determinative compound formation), the earliest compounds of the type *puró-hitam* should have passed into a new phase when the thing meant by the first member could not have been presented to the minds of the speakers of the language as a thing, but must have been presented as an attribute. This should have been the stage of descriptive determinative compound formation which with ample justification I maintained² as later in origin.

For the sake of convenience, the first phase of the earliest compounds of the type—*puró-hitam* may be denoted as the determinative Karmadhāraya phase and the second phase as the descriptive Karmadhāraya phase.

In all probability in pre-Pāṇinian times, the word Karmadhāraya signified only the latter phase. Both Pāṇini and the author of BRHADDEVATA might have borrowed this word as well as *tatpuruṣa* from a common source. But Pāṇini, with his gifted insight, noting carefully the close similarity between determinative Karmadhārayas and descriptive Karmadhārayas very likely did not favour the idea of taking Karmadhāraya compounds as constituting a class different from the *tatpuruṣa*

class. Pāṇini brought Karmadhārayas as well as *Dvigu* under *tatpuruṣa*, as special varieties of the last. Hence his sūtras are :—

तत्पुरुषः समानाधिकरणः कर्मधारयः (P. I. 2. 42.)

द्विगुश्च (P. II. 1. 23.)

In this we see Pāṇini's superior genius for 'psychologists' are agreed that the ability to detect similarities is one of the most valuable qualifications for the extension of knowledge and the integration of the ideal world which is the creation of thought. The recognition of analogies is, therefore, a matter of consequence in the development of science and to the genius who is extraordinarily apt at discovering resemblances which escape the notice of most men, progress is due. Noting an analogy however implies the recognition of differences as well as agreement, although the latter may for the moment appear to receive more emphasis. In this sense the operation prepares the way for further classification.¹

But the author of Brhaddevata perhaps following the still more ancient tradition takes Karmadhāraya and *Dvigu* as two separate classes of compounds different from the *tatpuruṣa* class.²

But it is most probable, that the word *tatpuruṣa* in pre-Pāṇinian days might have comprehended only the determinative karmadhāraya compounds and the descriptive karmadhāraya compounds, more especially the latter, for most (if not all) of the original determinative karmadhāraya compounds must have passed into the second phase and become the descriptive karmadhāraya compounds by the time of the compilation of the Samhita portion of the R̥g Veda; and these descriptive compounds in their turn, soon after, should have been transmuted into a new class, the *bahuvrīhi*. Having this in view alone, I observed³ that in all probability, in times very much earlier than the

Vide page 139, Chapter IV—'Analogy'—from *The Heroic Age of Science.—The conceptions, ideals, and methods of Science among ancient Greeks* by William Arthur Heidel, Research Professor of the Greek Language and Literature in Wesleyan University Research Associate of the American Council of Learned Societies of the Carnegie Institution of Washington.

² Vide Brhaddevata II, 105, quoted in my paper published in *J.O.R.M.*, Volume VIII, Part II.

³ 'Accentuation in Sanskrit Determinative Compounds', *J.O.R.M.*, Volume VIII, Part II.

¹ Vide *J.O.R.M.*, Volume VIII, Part II.

² Vide 'Accentuation in Sanskrit Determinative Compounds', Vol. VIII Part II, *Journal of Oriental Research, Madras*.

author of *Bṛhaddevatā*, the word तत्पुरुष connoted the sense of the व्यधिकरणतत्पुरुष only and so it does perhaps in the sentence अव्ययोभावतत्पुरुषद्वन्द्वबहुव्रीहयः in Uvāṭa's commentary on I, 27 of Kātyāyana's Vājasaneyā Samhita Prātiśākhya. This may be an old way of enumerating the different classes of compounds in order and very likely Uvāṭa might have made a confusion between the pre-Pāṇinian *tatpuruṣa* and Pāṇinian *tatpuruṣa*—and this confusion is clearly seen in *ṭippanī* of the said Prātiśākhya.¹

That we are justified in drawing a line of demarcation between the determinative karmadhārayas and descriptive karmadhārayas is amply borne out by the following evidences.

Bhaṭṭoji Dikṣita, commenting on the sūtras नञ् (P. II. 2.6.) न लोपो नञः (P. VI. 3.73.) and तस्मान्नुडचि (P. VI. 3. 74.) says the following in his *Siddhāntakaumudī*:

अर्थाभावेऽव्ययोभावेन सहायं विकल्प्यते । 'रक्षोहागमलध्वसंदेहाः प्रयोजनं' इति 'अद्रुतायामसंहितम्' इति च भाष्यवार्तिकप्रयोगात् तेन अनुपलब्धिः अविवादः अविघ्नम् इत्यादि सिद्धम् ।

The Bālamānoraṃ commentary has the following comment on it:

अर्थाभावे इति । रक्षेति । पस्पशाङ्गिकभाष्ये इदं वाक्यम् । 'रक्षाच ऊहश्च आगमश्च लघुच असंदेहश्च इति द्वन्द्वः । 'परवलिङ्गः' इति पुंस्त्वम् । अत्र संदेहाभाव इत्यर्थः असंदेहशब्दस्य असंदेहा इति प्रयोगात् तत्पुरुषो विज्ञायते । अव्ययोभावे रक्षोहागमलध्वसंदेहमिति स्यात् । अद्रुतायां असंहितमिति । "परः सन्निकर्षः संहिता" इति सूत्रे पठितं इदं वार्तिकम् । अद्रुतायां वृत्तौ संहिताभाव इत्यर्थः । अत्र अव्ययोभावे सति असंहितमिति प्रयोगात् अव्ययोभावेऽपि अर्थाभावो नञा गम्योभवतीति विज्ञायते । अन्यथा तत्पुरुषे सति परवलिङ्गत्वात् असंहितेति स्यात् । ततश्च नञागम्ये अभावे तत्पुरुषाव्ययोभावयोः विकल्प इति स्थितम् । तेनेति । अनुपलब्धिः इत्यत्र अविवाद इत्यत्र च तत्पुरुषः अविघ्नमित्यत्र अव्ययोभावश्च सिध्यतीत्यर्थः ।

¹ 'Accentuation in Sanskrit Determinative Compounds', *J.O.R.M.*, Vol. VIII, Part II.

The sentence अपचसि त्वं जारुम् which serves as an illustration of the operation of वार्तिक "नञो नलोपस्तिङ्क्षेपे" read under Pāṇini's sūtra "नलोपो नञः" (VI. 3. 73.) wrests from वासुदेवदीक्षित the following significant comment:

"नञ्समानार्थकेन अ इत्यव्ययेनापि सिद्धमिदमिति वार्तिकं विफलमेव । केचित्तु अस्मादेव वार्तिकात् अव्ययेषु अ इत्यस्य पाठः अप्रामाणिकः इत्याहुः

Nāgeśa's comments, in his *Laghūśabdendū śekhara* on Bhaṭṭoji Dikṣita's "अर्थाभावे अव्ययोभावेनायं विकल्प्यते ।" are really very significant.

Says he पूर्वपदार्थप्राधान्ये अव्ययोभाव उत्तरपदार्थप्राधान्ये अयमित्यादि रीत्या इति भावः ।

न्यायसिद्धेऽर्थे लिङ्गमप्याह । रक्षोहेति । असंदेहा इत्यस्य आरोपितः संदेहः इत्यर्थः संदेहाभावः प्रयोजनमिति यावत् । अव्ययोभावेन द्वन्द्वे हि परवलिङ्गेन इति अनुपपन्नमिति भावः । इदं पस्पशायां भाष्ये । असंहितमिति संहितासंज्ञासूत्रे भाष्ये वार्तिकम् । द्रुतभिन्नायां मध्याविलम्बितवृत्तौ संहिताभाव इत्यर्थः ।

The *ṭippanī* on Nāgeśa's *Śabdendūśekhara* has the following significant observation on this: 'अनुद्रा कन्या' इत्यादावलपत्वादि-नोद्राभावमारोप्य नञ्समभिव्याहारे आरोपितोदरबुद्ध्या तन्मूलाल्पत्वादौ विश्रामः । (Vide also page 649 of Nāgeśa's *Laghūmanjūṣa* Chowkambha Series).

The view that the thing meant by नञ् presents to the mind not as an attribute but as a thing itself, is not peculiar to any particular system or school of Indian thought.

द्रव्यगुणकर्मसामान्यविशेषसमवायाभावाः । सप्तपदार्थाः

I. Annambhaṭṭa's, *Tarkasamgraha*. अभाव is considered as a पदार्थः. अभाव is considered to be a reality (and hence a thing) by the Naiyāyikas and the Vaiśeṣikas.

Cf. द्रव्यं गुणस्तथाकर्म

सामान्यं सविशेषकम् ।

समवायस्तथाभावः

पदार्थाः सप्त कीर्तिताः ॥

Kārika 2 of Kārikāvalī of विश्वनाथ. Commenting upon this Kārikā, Viśvanātha says in his *Muktāvalī*:

एते च पदार्थाः वैशेषिकनये प्रसिद्धाः । नैयाभिकानामप्यविरुद्धाः,
प्रतिपादितं चैवमेव भाष्ये¹

(Vide *Muktāvalī*: page 50. Bālamānoramā Series, No. 6.)

Perhaps in their origin, the negative compounds might have been genetically affirmative ones.² Later on, they might have undergone a transformation by which they could have been no longer felt as predication first affirmed, and then subjected to refusal; but language might have changed the idea of negation in these compounds into attributions rejected from the very start.³

It has been shown that the earliest compounds in the proto-ethnic period were probably the determinative Karmadhārayas (the prepositional compounds or the अव्ययीभावसमास of the Sanskrit Grammarians).⁴

¹ The भाष्य referred to is the Vātsyāyanabhāṣya.

² Perhaps this is meant by the महाभाष्यकार's phrase प्रसिद्धार्थपरित्याग (under नञ् सूत्र). (See also page 649 of Nāgeśa's *Laghu māñjūṣā*).

³ Cp. *The Theory of Speech and Language* by Alan H. Gardiner, Chapter V, para 72.

This is probably the अप्रसिद्धार्थपरिग्रह of the महाभाष्यकार.

⁴ Along with the general inclination towards the oxytonisation of the final member in Sanskrit compounds (cp. Justi: *Über die Zusammensetzung der nomina in den Indogermanischen Sprachen* 75), the view that the second member is semantically more important than the first (compare Mādhavabhāṭṭa's *Rgvedānukramāṇī*, Part I. i. iii. verses 14, 15 and 16).

अन्तोदात्तोऽव्ययीभावः

सोऽनुकामान्तर्पयेथाम् ।

प्रतिदोषङ्गुणानश्च

तादृशाः सन्ति चापरे ॥

अनुकामं विभक्त्यर्थे

नानोऽर्थोऽस्ति कश्चन ।

Doubtless, some of these prepositional compounds were transmuted into the *bahuvrīhi* (possibly passing through an intermediate stage corresponding to the compounds of the tatpuruṣa class). The following are perhaps some of the instances: *āpa-bhī-s* 'fearless, having fear away.' Latin *ab-normis*. Gothic *af-guds* 'Godless, ('having god away') in opposition to *ga-guds* 'piows' properly, 'having god with' *nir-mala-s* 'spotless' properly, 'having the spots out.'

Old High German *ur-hērzer*, *ur-luzēr*, *ur-mōt* 'spiritless' *ur-wāfan* 'unarmed, defenceless.'

The preposition *sa* 'with' which occurs only as prefix, is employed in Sanskrit to express persons or things which possess that which the final substantive expresses, e.g., *sā-kama-s* 'with wish,' i.e., 'being with the circumstance of the wish, having a satisfied wish.'¹

Again there are the following compounds:—*ānu-rūpa-s* and *anyā rūpa*.

It is well known that the epithetised compounds where the prefix *su* stands for adjective, logically accent the last member. But this kind of logical accentuation is not preserved in Sanskrit in the same class of compounds where *dur* stands for adjective.

पश्चात्कामस्य यद्वास्तु

तथाप्यन्तो खरो भवेत् ॥

प्रतिदोषङ्गुणानोऽत्र

वीप्सां शोतयति प्रतिः ।

दोषाशब्दो वाचकश्च

ततस्तस्मिन्स्वरः स्थितः ॥)

might have exercised an influence to shift the accent from the first member to the second member in some of the prepositional compounds like अनुकामं (Rv. I. 17, 3.) and प्रतिदोषं (Rv. I. 35, 10.) in the later Vedic period.

Perhaps this tendency to end-accentuate the prepositional compounds was so powerfully active that at a later stage it came to be definitely believed that the normal accent of the अव्ययीभावसमास is the accent on the last member alone.

¹ Vide Bopp's *Comparative Grammar*, Volume III, para 983.

Instances are *dūr-ātman* 'having a bad soul', *dūr-bala-s* 'having bad strength'.

There is room for the surmise that these (prepositional compounds in their origin) might have once passed through an intermediate tatpuruṣa stage (for side by side with *dūr-ātman*, *dūr-bala-s*, we have tatpuruṣa compounds like *dūr-dinam*, which literally means 'hard day') when it is very likely that the accent on *dūr* alone was retained. Eventually as they passed into a new class—the Bahuvrīhi, probably owing to the prevalence of the view then that only in tatpuruṣa compounds the second member should be accented, the first member might have come to retain its accent, though we can not explain how the logical accent of the tatpuruṣa compounds like *dūr-dinam* was not tampered with.

However, compounds formed with *su* as the first member, not only logically accent the first member if the compound is a tatpuruṣa, (as in *sū-prīta-s* 'much beloved', *sū-nīti-s* 'good behaviour'), but also quite logically accent the last member if the compound is a Bahuvrīhi as in *su-parṇā-s*.

It is significant that the Greek epithetised compounds formed with the prefixes *δυσ* and *εὖ* corresponding to Sanskrit *dur* and *su* quite logically accent the last member alone.¹

To sum up, then, after the formation of the prepositional compounds in the pro-ethnic period there would have occurred a slow emergence of the pure tatpuruṣa compounds (which originally did not include the descriptive class) and compounds of the adjectivally descriptive class should have originated at a still later stage.

Compounds like *शचोपतिः* are perhaps relics of those earliest loose compounds in the pro-ethnic period which arose through sheer juxtaposition of two separate words, considered to be independent and distinct units.

At a considerably late stage in the pre-Vedic period, the Dvandva compounds should have had their origin and the older Dvandva compounds like *dvā-daśa*² had a case form for the initial member. Brugmann conjectures that except these, there were no compounds of the co-ordinating class, at one time in

¹ Cf. Bopp's *Comparative Grammar*, Volume III, para 984.

² *द्वदशम्*.

pro-ethnic Indo-Germanic. Cf. *Comparative Grammar*, Vol. II, page 90, Section 49.

It has been already shown¹ that the accentuation of the compounds of this type was due to analogy with those tatpuruṣa compounds which preserved the original logical accentuation. It is to be noted that the Dvandva compounds with a stem for initial member only arose when compounds containing a case were remodelled on the analogy of the older subordinating class, which had the simple stem. This process of conversion may often be traced with certainty in historical times as Brugmann² says e. g., *parjānya-vāta* instead of *parjānyā-vāta*; *pūrva-pūrvas* for *pūrvas-pūrvas* and the like. It is true that the use of the stem instead of a case cemented the combination more firmly. It is best to remember what Brugmann³ says here:

'Such a process would all the more be natural because many compounds of the subordinating class approach very closely to the co-ordinating compounds in regard to the particular relation subsisting between their parts, and there was no sharp distinction between the two groups Both subordinating and co-ordinating substantives are found with epithetised meaning.'⁴

hiraṇya-keśa-s

adhara-hanū-s

a-putrā-s.

Parallel to these is the tatpuruṣa *ā-kumāra-s*

The Dvandva compounds—a special feature of classical Sanskrit were no doubt developed on analogy with the tatpuruṣa compounds.

Perhaps, some of the oldest pre-historic double-accented compounds survived in the R̥g Veda like *Mitrā-vāruṇā* and as these had the sense of co-ordinating compounds, they were probably classified together with the later Dvandva. Perhaps too, due to analogy, some more like compounds were formed during

¹ Vide 'Accentuation in Sanskrit Determinative Compounds', *J.O.R.M.*, Volume VIII, part II.

² *Comparative Grammar*, Volume II, page 90.

³ *Ibid.*, Volume II, pages 90 and 91.

⁴ Brugmann: *Comparative Grammar*, Volume II, pages 90 and 93.

the Vedic period and as these exceptionally double-accented compounds came to be increasingly formed, the force of analogy (with the accentuation of the earlier determinative compounds of the pro-ethnic period by which the prior member would receive the accent) would have been considerably weakened with regard to these exceptional cases and this would have resulted in a systematic and consciously accepted phenomenon of double-accentuation of all similar Dvandva compounds. Hence is the following sūtra of Pāṇini:— देवताद्वन्द्वेच (P. VI. 2. 141.)

It is this double-accent, I argued as the normal of the Dvandva compounds, on a strictly semantic basis.¹

Enough has been said in my paper, 'Accentuation in Sanskrit Determinative Compounds' (*J. O. R. M.*, Vol. VIII, part II), about the origin of the epithetised compounds in the pro-ethnic period from out of the earlier tatpuruṣa compounds. Perhaps, as some co-ordinating compounds containing substantives were found with epithetised meaning, on analogy with earlier Bahuvrīhis which logically should have accented the last member, in the pro-ethnic period, these Dvandvas too might have come to accent their last member and this practice might have spread to other Dvandvas also on further analogy in the Vedic period whence it came to be regarded as the normal accent.

In all probability, an explanation as the one offered by Mādhavabhaṭṭa² with much force might have appealed to the Vedic bards and they might have come to believe that the normal accent of the Dvandva compounds must be the accent on the last syllable of the second member.

कार्ययोगो यदि द्वन्द्व
उभयोरपि दृश्यते ।
स्थिते पूर्वपदस्यार्थे
द्वितीयस्यापि सङ्ग्रहः ॥

अन्तोदात्तस्ततो द्वन्द्व
इन्द्रवायू बृहस्पतिं
ऋक्सामभ्यामभिहिता-
बिहेन्द्राग्नी उपङ्गये ॥
इन्द्रवायू बृहस्पतिं (Rv. I, 14, 3.)

ऋक्सामभ्यामभिहितौ गावौ (Rv. X. 85, 11).
बिहेन्द्राग्नी उपङ्गये (Rv. I. 21, 1.)

It is not unlikely that the end-accentuation of later determinative compounds too might have analogically influenced the Dvandva compound accentuation in the same direction.

One thus sees a rationale in the enumeration of the different classes of compounds in the order found in Uvaṭa's commentary on Kātyāyana's *Śuklayajurveda Prātiśākhya*, already cited, as indicating the various stages of formation and evolution of the different classes of compounds in the pro-ethnic period. We can read a great meaning in Uvaṭa's statement which he and his predecessors in the field would not have dreamt of in their wildest dreams.

By way of passing, it may be remarked that Bhaṭṭojī Dikṣita also in his *Siddhānta Kaumudī* arranges Pāṇini's sūtras in the same order in the समासप्रकरण with a very slight alteration—putting Dvandva after Bahuvrīhi.

¹ Vide my paper 'Five stages of determinative compound accentuation in the pre-Vedic period as surmised by their historic survivals in Sanskrit' *J. O. R. M.*, Volume IX, part II, page 123.

² *Rgvedānukramāṇī*, Part I, i. iii, verses 7 and 8

PLANKTON RECORDS FOR THE YEARS 1929 & 1930

BY

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K. SANKARA MENON, M.A.

AND

M. G. K. MENON, M.A.

The following tables are records of Plankton collections made by the Zoological Department of the Madras University during the years 1929 and 1930.

A good portion of the work was done in the Laboratory attached to the Madras Aquarium and the authors wish to express their sense of indebtedness to Dr. B. Sundararaj, Director of Fisheries, for the facilities given them for working there.

The methods employed in the collection and examination of the Plankton are described in a 'Preliminary Account of The Madras Plankton'¹ and it only remains here to explain the symbols used to indicate the relative abundance of the different organisms.

In the case of the smaller forms, their numbers in 1 c.c. of the preserved sample were counted and, as shown below, letters² were employed to indicate their presence within certain numerical ranges.

r.....	1—5.
f.....	5—20.
c.....	20—100.
p.....	100—200.
s.....	200 and above.

With regard to the larger forms, like Hydromedusae, as grave errors might arise if relative abundance of these forms

¹ Menon, K. S. 1931, 'A Preliminary Account of the Madras Plankton'. *Rec. Ind. Mus.*, Vol. XXXIII, Pt. IV, pp. 489-516.

² r.—rare
f.—few
c.—common
p.—plenty
s.—swarms

were to be judged from such small samples, their numbers in the total catches as a whole were estimated and the same symbols were used.

It will be noted that records are not available for certain months of the year. Thus collections were not made during May and part of June in 1929, these being vacation months. It has also not been possible to include records for Hydro-medusae during the months of January, February and March in the same year. In the year 1930 it will be seen that only desultory collections were made in October. In November the monsoon prevents regular plankton collection work.¹

Conclusions arrived at from a study of the Plankton as a whole have already been given in three papers² from this Laboratory. Here we have merely recorded the collections made during the two years in the form of tabulated statements mentioning also the dates of the catches without any remarks in the hope that workers in the same field will find the information given of some use.

¹ Further collections have been made in subsequent years and when these are worked out it is hoped it will be found possible to present a more detailed list of the plankton fauna of this coast.

² (i) 'A Preliminary Account of the Madras Plankton'. By K. Sankara Menon, *Rec. Ind. Mus.*, Vol. XXXIII, Pt. IV., pp. 489-516.

(ii) 'The Hydromedusæ of Madras'. By M. G. K. Menon. *Bull. Madras Govt. Museum*, New Series, N. H. Section, Vol. III, No. 2.

(iii) 'Preliminary Observations on some Polychæte Larvæ of the Madras Coast'. By R. Gopala Aiyar, *Journal of the Madras University*, Vol. V., No. 1.

1929

JANUARY

FEBRUARY

Diatoms

[illegible]

Protozoa

44.	<i>Acanthometron pellucidum</i> .	f	f	f	f	f	f	f	f	f	f	r	r	r	r	r	r	r	r
45.	<i>Noctiluca miliaris</i>	..	..	..	..	f	f	..	..	..	..	r	r	r	..	f	r	..	r
46.	<i>Prorocentrum micans</i>	..	..	..	..	..	..	..	..	..	..	r	r	r	..	..	..	..	..
47.	<i>Dinophysis miles</i>	..	f	f	..	r	r	..	..	..	..	r	r	r	..	..	r	r	..
48.	" <i>homunculus</i>	..	..	..	..	..	..	..	..	..	..	r	r	r	..	..	r	r	..
49.	<i>Ceratocorys horridus</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
50.	<i>Ornithocircus sp.</i>	..	..	..	..	..	..	..	..	..	..	f	..	r	..	..	f	..	r
51.	<i>Diplopsalis lenticula</i>	..	..	..	..	..	..	..	..	..	..	..	f	r	r	..	r	..	..
52.	<i>Peridinium oceanum</i>	..	f	r	r	..	r	..	..	..	..	..	..	..	..	..	r	r	..
53.	" <i>depressum</i>	..	..	..	..	r	..	..	..	..	..	r	..	r	..	..	r	r	..
54.	" <i>ovatum</i>	..	..	..	..	..	..	..	..	..	..	r	r	r	..	..	r	f	f

MARCH

94143

APRIL

MAY

JUNE

[illegible]

* Records not available for January, February and March.

	JANUARY														FEBRUARY													
	8	10	11	13	15	17	18	19	21	23	25	27	28	1	2	5	7	9	11	13	15	17	19	21	23	25	27	
Siphonophora —(Contd.)																												
104. <i>Porpila porpila</i>				f															r	r	f			f				
105. <i>Physalia physalis</i>																				r								
106. <i>Cannophysa</i> sp.																												
Scyphomedusae																												
107. <i>Nausithoe punctata</i>																												
Zoantharia																												
108. <i>Arachnactis albida</i>				f		f								f	f	f	r		r		r		r	f	c	f	f	
109. <i>Semper's larva</i> (long)														c	f	f			f		c		f		r		f	
110. „ „ (round)																			f	f		r		r				
Ctenophora																												
111. <i>Pleurobrachia globosa</i>		f	f	f	f	r	r								r						f	r		r				
112. <i>Beroe flemingi</i> ?				f	f	r	r														r							
113. <i>Ocyroe</i> sp.																												
Platyhelminthes																												
114. <i>Muller's larva</i>			f	f	f	f	r					f		r									r				r	
Nemertinia																												
115. <i>Pilidium</i> larva		f	f		r					r			r				r			r	r		r				r	
Annelida																												
Archiannelida :																												
116. <i>Polygordius</i> larva		f	r	r		r		f		f	r		r	r	r		f	r			f			r	r	r		
117. <i>Chaetogordius</i>					f	r	f	r		r			r	r					r	f	r			r				
Polychaeta :																												
118. <i>Tomopteris</i> sp.							f												f	f					r		r	
119. <i>Autolytus</i> sp.																												
Polychaete larvae :																												
120. <i>Nephtyid</i>		r	r		f		f	r			f		f	f			r			r	f	r	f	f	f	f	c	f
121. <i>Capitellid</i>		r	r			r	f	c		c	f	c	f	c	f	f	r			r						r		
122. <i>Phyllodoceid</i>		f	c	f	f	f	c			c	c	f	f	f	f	c	f	f	f	f	f	r			r	r	r	
123. <i>Eunicid</i>		f	r			r	r						r									r	f	r		r	f	
124. <i>Polynoid</i>		f	r		r		r						r				r				r	r				r	r	
125. <i>Nereid</i>			f		f		r			r				f	f	r	r	r	f			r	f	f	r	r	r	
126. <i>Spionid</i>		c	c	f	f	f	c	c	f	f	f	c	f	f	f	f	f	f	f	c	c	f	f	f	f	c	f	
127. <i>Polydorid</i>		f	r		f	r			f	r		r	r	f					r	f				f	r		r	
128. <i>Chaetosphaerid</i>						f		r		r												r	r	r	r	r	r	
129. <i>Magelonid</i> (<i>Magelona papillicornis</i>)		f	f	r			f	r			f			r	r				r			r	r	r	f	f	f	
130. <i>Mitraria</i>		f	f	f	f	r				f	r	r	r	r	r	f	f	r			r		r				r	
131. <i>Chaetopterid</i>						r								r											r		r	
132. <i>Terebellid</i> (<i>Loimia medusa</i>)		f	f	f	f	r		r			f	r		f	f	r		r	r		r		r		r	f	f	
133. <i>Sabellarian</i> (<i>Sabellaria spinulosa</i>)		r			f			f					r		r		f	f	r		r	r		r	f	f	f	
Chaetognatha																												
134. <i>Sagitta</i> spp.		f	f	f	f	c	f	r	r	f	r	f	f	c	c	c	c	f	r	r	f	f	c	f	r	f	f	

[illegible]

1929		JANUARY												FEBRUARY																
		8	10	11	13	15	17	18	19	21	23	25	27	28	1	2	5	7	9	11	13	15	17	19	21	23	25	27		
Schizopoda																														
186.	<i>Schizopod (Rhopalophthalmus egregius, Macropsis orientalis)</i>	...								r				r				f				f	c	f	r	f	f	f	c	p
Decapoda																														
187.	<i>Leucifer</i>	...	r										r																r	r
Crustacean Larvae																														
188.	<i>Cirripede nauplii</i>	...	f	r					r	f	f		r		r	r	f	f	f	f	f	f	f	r	r	f	f	c	c	
189.	<i>cypris</i>	...													r	r	r	r			r		r		r	f	f	f	f	
190.	<i>Copepod nauplii</i>	...							r																					
191.	<i>Stomatopod larvae</i>	...							f				r		f					r	f	c	f		r		f			
192.	<i>Penaeid larvae</i>	...							r	r			f								f				f	r	r	f	f	
193.	<i>Zoea larvae</i>	...	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	
194.	<i>Phyllosoma larvae</i>	...	f	f	f	f	f	f	f	f	f	f	f	f	r	r	r	r	r	r	r	f	f	f	f	f	f	f	f	
195.	<i>Megalopa larvae</i>	...	f	f	f	f	f	f	f	f	f	f	f	f	r	r	r	r	r	r	r	f	f	f	f	f	f	f	f	
Mollusca																														
196.	<i>Glaucus forsteri</i>	...																												
197.	<i>Ianthina communis</i>	...																												
198.	<i>Atlantea sp.</i>	...	f	f	f	r	r	r		r		r	r	r																
199.	<i>Creseis acicula</i>	...	f	f	f	f	r					r		r					r	f	r	f	r							
Molluscan Larvae																														
200.	<i>Lamellibranch</i>	...																												
201.	<i>Scaphopod</i>	...	c	c	c	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	r	r						
202.	<i>Gastropod</i>	...	f	f	f	r		r			r									r	r	r								
Echinoderm Larvae																														
203.	<i>Bipinnaria</i>	...	c	c	c	f	c	c	f	r		f	c	c	f	f	f	r	r	f	r	r	r	r				r	r	
204.	<i>Brachiolaria</i>	...	f	r	r					r			r	r	r	r	r	r	r	f	r	r	r	r				r	r	
205.	<i>Ophiopluteus</i>	...	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	r	r	r	r	f	r	r	
206.	<i>Echinopluteus</i>	...	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	r	r	r		r	r	
207.	<i>Auricularia</i>	...	f	f	r		r		r				r	r	r	r														
Tunicata																														
208.	<i>Thalia democratica</i> (and other forms)	...	c	f	f	f	f	f	f	r	r	f	f	c	f	f	r	r	r	r	r	f	c	c	c	f	c	f	c	
209.	<i>Appendicularia sp.</i>	...	f	f	f	f	f	r	r	r	r	f	r	r	r	f	f	r	r			r	f	r	r		r	r		
210.	<i>Fritillaria borealis</i>	...							r	r		r										r	r				r			
Enteropneusta																														
211.	<i>Tornaria larvae</i>	...				f				f	f					f	f	f												
Cephalochordata																														
212.	<i>Amphioxus pelagicus</i>	...																												

[illegible]

	JULY												AUGUST															
1929	1	2	3	7	9	12	16	17	23	24	25	26	1	2	3	5	7	9	11	14	16	19	20	23	25	27	29	
Diatoms																												
1. <i>Coscinodiscus concinnus</i> ...	r			f	f	r		f		f	r	r		r				f			r	r			r		r	
2. " <i>excentricus</i> ...																												
3. " <i>radiatus</i> ...					r												r			r					r			
4. " <i>lineatus</i> ...																			r					r				
5. <i>Planktoniella sol</i> ...					r																							
6. <i>Bidulphia regia</i> ...	e	e	c	f	e	c		e	e	c	e	e		e					f			r			r			
7. " <i>mobilensis</i> ...	f		f	r	f	f		f		f	r	r					r		r		r							
8. " <i>sinensis</i> ...																	r		r									
9. " <i>grammata</i> ...																	r											
10. " <i>rhombus</i> ...																												
11. <i>Rhizosolenia shrubsolei</i> ...	e	e	e	f	f	f		f	f					r			r		r	f	f		r		r			
12. " <i>semispina</i> ...	e	e	e	f	f	r		r	r						f	r									r			
13. " <i>stolterfothii.</i> ...																												
14. " <i>calcar avis</i> ...	e	f	e	r	r	f		f																				
15. " <i>alata</i> ...	f	f	f	f	f	r		r	r																			
16. " <i>setigera</i> ...								r											r				r					
17. " <i>acuminata</i> ...	f					f	r										r			r	r	r			r			
18. " <i>robusta</i> ...						r			r																			
19. <i>Chaetoceras boreale?</i> ...	f	f	f	f	f	f		f	f	f	f	f						r	f									
20. " <i>decipiens</i> ...	s	s	s	s	p	p		c	e	f	f	f																
21. " <i>debile</i> ...	s	s	s	s	s	p		p	c	f	f	f			r	r			r		r				r		r	
22. " <i>sociable</i> ...				f	f	f	r	r																				
23. " <i>spp.</i> ...	e	c	e	e	c	f	f		f	f	f	f																
24. <i>Bacteriastrum varians</i> ...																												
25. <i>Bacillaria paradoxa</i> ...																												
26. <i>Asterionella japonica</i> ...	e	c	e	f	c	e		f	f	r	r																	
27. " <i>bleakleyi</i> ...					f				f									r			r	r		r				
28. <i>Thalassiothrix nitchooides</i> ...	e	c	e	c	p	p		f		f	f	f			r				r	r		r					r	
29. <i>Ceratulina bergonii</i> ...				f	f	f		f																				
30. <i>Climacodium frauenfel-</i> <i>dianum...</i> ...				e	f	c	e		e	f	r		r															
31. <i>Climacodium biconcavum.</i> ...				f			f		e	f	f																	
32. <i>Bellarochea malleus</i> ...																												
33. <i>Nitzschia closterium</i> ...																												
34. " <i>seriata</i> ...																												
35. <i>Ditylium brightwelli</i> ...																												
36. <i>Lauderia borealis</i> ...				f	c	e	e		f		f	f																
37. <i>Detonula schroderii</i> ...		f	f	f	f	f		f	f	f	f	f																
38. <i>Eucampia zodiacus</i> ...																												
39. <i>Pleurosigma sp.</i> ...					r	r	r		r	r					r	r			r			r						
40. <i>Stephanopyxis sp.</i> ...									f		f				r			r				r					r	
41. <i>Skeletonema costatum</i> ...																												
42. <i>Trichodesmium erythraeum</i> ...																												
43. " <i>thiebauti...</i> ...																												
Protozoa																												
44. <i>Acanthometron pellucidum</i> ...																r					r							
45. <i>Noctiluca miliaris</i> ...			e	e	f	f		f	f	f	f	f		f	f	f	r	f	f	c	s	s	s	s	c	f		
46. <i>Prorocentrum micans</i> ...																												
47. <i>Dinophysis miles</i> ...				f																								
48. " <i>homunculus</i> ...																												
49. <i>Ceratocorys horridus</i> ...																												
50. <i>Ornithocircus sp.</i> ...																												
51. <i>Diplopsalis lenticula</i> ...																												
52. <i>Peridinium oceanum</i> ...						f		r						r	r	r	r		r	r	f	r	r		r	f		
53. " <i>depressum</i> ...		f	r	r	r	f	r		r	r	r	r	r					r	r	r								
54. " <i>ovatum</i> ...		f																										

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	JULY											AUGUST																
1929	1	2	3	7	9	12	16	17	23	24	25	26	1	2	3	5	7	9	11	14	16	19	20	23	25	27	29	
Siphonophora—(Contd.)																												
104. <i>Porpita porpita</i>						r			r									r		r								
105. <i>Physalia physalis</i>																		r			r							
106. <i>Cannophysa</i> sp.																												
Scyphomedusae																												
107. <i>Nausithoe punctata</i>																												
Zoantharia																												
168. <i>Arachnactis albida</i>														r		r	r	f	f	f	c	c	f	f	f	f		
109. <i>Semper's larva</i> (long)																												
110. " " (round)																												
Ctenophora																												
111. <i>Pleurobrachia globosa</i>					r	r			r		f	f	f	f	r	r		r	r	f	c	c	c	f	c	f	f	
112. <i>Beroe flemingi</i> ?											f	f	f			r	r											
113. <i>Ocyroe</i> sp.																												
Platyhelminthes																												
114. <i>Muller's larva</i> ...				r		r	r												r									
Nemertinia																												
115. <i>Pilidium larva</i>																												
Annelida																												
Archiannelida :																												
116. <i>Polygordius larva</i>																												
117. <i>Chaetogordius</i> ...																												
Polychaeta																												
118. <i>Tomopteris</i> sp.						r						r						r							r			
119. <i>Autolytus</i> sp.																			r									
Polychaete larvae																												
120. <i>Nephtyid</i> ..																												
121. <i>Capitellid</i> ..																												
122. <i>Phyllodocid</i> ..																												
123. <i>Eunicid</i> ..																												
124. <i>Polynoid</i> ..																												
125. <i>Nereid</i> ..			f	f	f																							
126. <i>Spionid</i> ..			f	f	f	f	f		p	p	p	p	f	f	f	f	f	f	f	f	f	f	f	r	f	f	f	
127. <i>Polydorid</i> ..														r				r		r								
128. <i>Chaetosphaerid</i>						r																						
129. <i>Magelonid</i> (<i>Magelona pallicornis</i>)																		r					r		r			
130. <i>Mitraria</i> ..			s	s	p	c	c	c		f	f	f	f	f	f	f	f	f	f	f	f	r	r	r	r	r	r	
131. <i>Chaetopterid</i> ..																												
132. <i>Terebellid</i> (<i>Loimia medusa</i>)			c	c	c	f	f	f	r	r								r						f				
133. <i>Sabellarian</i> (<i>Sabellaria spinulosa</i>) ..			c	c	c	f	f	f	f	f	f	f	f	f									r	r	r	r	r	
Chaetognatha																												
134. <i>Sagitta</i> spp. ..			c	c	c	f	f	f		f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	

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1930		JANUARY												FEBRUARY											
		13	15	17	19	21	23	25	27	29	31	3	5	7	10	12	14	15	17	19	22	24	26	28	
Protozoa—(Contd.)																									
55.	<i>Peridinium</i> sp.																								
56.	<i>Ceratium tripos</i> var. <i>subsala</i>	f	r	r	r	r	r		r	r	r				r				f	f	c	f	r	r	
57.	<i>Ceratium tripos</i> var. <i>subsala</i> forma lineala		r																						
58.	<i>Ceratium tripos</i> var. <i>subsala</i> forma hiemale																								
59.	<i>Ceratium massiliense</i>		f	f	f	f	r	f		r	r	r		r	r	f	r	r	f	f	f	f	f	f	f
60.	" <i>breve</i>									r	r	r		r	r		r	r		r	r				
61.	" <i>schmidti</i>			r						r						r				r	r				
62.	" <i>trichoceras</i>			r	r	r				r	r	r		r	r	r		r	r				r		
63.	" <i>furca</i>					r				r															
64.	" <i>fuscus</i>		r																					r	
65.	" <i>reticulatum</i>														r					r					
66.	<i>Glenodinium</i> sp.																								
67.	<i>Tintinnus</i> sp.				r					r	r				r	r	f	r	r	r					
Hydromedusae																									
68.	<i>Hybocodon</i> sp.					r																			
69.	<i>Sarsia</i> sp. (1)																								
70.	" sp. (2)																								
71.	<i>Halitiara formosa</i>						r																		
72.	<i>Merga violacea</i>								p	p	f	r		r							r		r		
73.	<i>Amphinema dinema</i>					r																			
74.	<i>Leuckartiara octona</i>		r										r												
75.	<i>Cytaeis tetrastyla</i>		r	f		f	p				r	f	r	r		r		r	r	r		r	r	r	
76.	<i>Bougainvillia fulva</i>			r	f		f	s		r	r	f	r	r		r		r							
77.	<i>Köllikeria constricta</i>																								
78.	<i>Proboscoidactyla ornata</i>						p		r									r		r	r				
79.	" <i>conica</i>																								
80.	<i>Staurodiscus tetrastaurus</i>						f																		
81.	<i>Eucopa</i> sp.																								
82.	<i>Obelia</i> sp.			f												r				f	f		r		
83.	<i>Phialucium multitentaculata</i>		r	r	r						f	f	f			r		r				r			
84.	<i>Eucheilota</i> sp. (1)																								
85.	" sp. (2)																								
86.	<i>Eutima mira</i>					r	r	f			f														
87.	<i>Phortis</i> sp.		f	f	r		r	f		f		r	p	f		p		p	r	r	r	s	s		
88.	<i>Irenopsis hexanemalis</i>																								
89.	<i>Eirene malayensis</i>																								
90.	" <i>madrasensis</i>																								
91.	<i>Octocannoides ocellata</i>																								
92.	<i>Octocanna solida</i>																								
93.	" <i>polynema</i>		f	f						f	f	f					r								
94.	<i>Aequorea macrodactyla</i>																								
95.	" <i>pensile</i>																								
96.	" <i>parva</i>																							p	
97.	<i>Zygocanna buitendijki</i>																r							p	
98.	<i>Gonionemus suvaensis</i>																							r	
99.	<i>Olinidias singularis</i>						f					f	r	p					r	f					
100.	<i>Liriope tetraphylla</i>							p			f		r	f				r		r					
101.	<i>Solmundella bitentaculata</i>			p		s	p			r	p	r	r	f	r			f		r					
102.	<i>Cunoctantha octonaria</i>						r																		
Siphonophora																									
103.	<i>Diphyes dispar</i>										c	c	c	f	f	r				r	c			e	

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1930		JANUARY												FEBRUARY											
		13	15	17	19	21	23	25	27	29	31	3	5	7	10	12	14	15	17	19	22	24	26	28	
Polyzoa																									
135.	<i>Cyphonautes larva</i> ...																								
Phoronidea																									
136.	<i>Actinotrocha larva</i> (1)																								
137.	" " (2)																								
Crustacea—Cladocera																									
138.	<i>Evadne sp.</i> ...																								
139.	<i>Podon intermedius</i> ...																								
140.	<i>Cladoceran</i> ...																								
Crustacea—Copepoda																									
141.	<i>Nannocalanus minor</i> ...																								
142.	<i>Canthocalanus pauper</i> ...																								
143.	<i>Undinula vulgaris</i> ...																								
144.	" <i>darwini</i> ...																								
145.	<i>Eucalanus elongatus</i> ...																								
146.	" <i>attenuatus</i> ...																								
147.	" <i>crassus</i> ...																								
148.	" <i>subcrassus</i> ...																								
149.	<i>Paracalanus parvus</i> ...																								
150.	" <i>aculeatus</i> ...																								
151.	<i>Acrocalanus longicornis</i>																								
152.	" <i>gracilis</i> ...																								
153.	" <i>monacus</i> ...																								
154.	<i>Calocalanus pavo</i> ...																								
155.	" <i>plumulosus</i>																								
156.	<i>Centropages furcatus</i> ...																								
157.	" <i>orsinii</i> ...																								
158.	" <i>tenuiremis</i>																								
159.	" <i>dorsispinatus</i>																								
160.	<i>Temora discaudata</i> ...																								
161.	" <i>turbinata</i> ...																								
162.	<i>Candacia bradyi</i> ...																								
163.	" <i>truncata</i> ...																								
164.	<i>Calanopia elliptica</i> ...																								
165.	<i>Labidocera acuta</i> ...																								
166.	<i>Pontella danae</i> ...																								
167.	" var. <i>ceylonica</i>																								
168.	" <i>securifer</i> ...																								
169.	<i>Acartia erythraea</i> ...																								
170.	<i>Torians barbatus</i> ...																								
171.	<i>Oithona rigida</i> ...																								
172.	" <i>plumifera</i> ...																								
173.	<i>Eulerpina acutifrons</i>																								
174.	<i>Macrosetella gracilis</i>																								
175.	<i>Microsetella rosea</i> ...																								
176.	<i>Clytemnestra rostrata</i>																								
177.	<i>Oncaea conifera</i> ...																								
178.	" <i>venusta</i> ...																								
179.	<i>Corycaeus elongatus</i>																								
180.	" <i>furcifer</i> ...																								
181.	" <i>obtus</i> ...																								
182.	" <i>venustus</i> ...																								
183.	<i>Saphirina ovato-lanceolata</i>																								
184.	" <i>stellata</i> ...																								
185.	" <i>nigromaculata</i>																								

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1930	JANUARY												FEBRUARY															
	13	15	17	19	21	23	25	27	29	31	3	5	7	10	12	14	15	17	19	22	24	26	28					
Schizopoda																												
186.	<i>Schizopod (Rhopalophthalmus egregius, Macropsis orientalis)</i>																											
Decapoda																												
187.	<i>Leucifer</i> ... 5 9																											
Crustacean Larvae																												
188.	<i>Cirripede nauplii</i> ... r r r r f f ... c f r c f f r f f f r r r f c c																											
189.	<i>cypris</i> ... r r r r r r ... r r r f r r f f r r r f c c																											
190.	<i>Copepod nauplii</i> ... r ... r ... r r r r r r ... r ... r r r r r																											
191.	<i>Stomatopod larvae</i> ... r ... r ... r r r r r r ... r ... r r r r r																											
192.	<i>Penaeid larvae</i> ... r ... r ... r ... r ... f ... f ... r r r r r r																											
193.	<i>Zoea larvae</i> ... f f f f f f ... f f r r f r f f f r r c p p c																											
194.	<i>Phyllosoma larvae</i> ... r ... r ... r ... r ... r ... r ... r ... r ... r f f f																											
195.	<i>Megalopa larvae</i> ... r r r ... r r ... r ... r ... r ... r ... r ... r f f f																											
Mollusca																												
196.	<i>Glaucus forsteri</i> ... 1																											
197.	<i>Lanthina communis</i> ...																											
198.	<i>Atlantea sp.</i> ...																											
199.	<i>Creseis acicula</i> ... r ... r ...																											
Molluscan Larvae																												
200.	<i>Lamellibranch</i> ...																											
201.	<i>Scaphopod</i> ... f f f f f f ... f f f r r ...																											
202.	<i>Gastropod</i> ... r f r r ... r r r ...																											
Echinoderm Larvae																												
203.	<i>Bibinnaria</i> ... f c f f c ... f f ... r f f c s f f ...																											
204.	<i>Brachiolaria</i> ... r ... r ... r ... f ...																											
205.	<i>Ophiopluteus</i> ... r r r r r r ... r r ... r f ... r r f ...																											
206.	<i>Echinopluteus</i> ... r r r r r r ... r r r c r f ... f ... f f f r ...																											
207.	<i>Auricularia</i> ...																											
Tunicata																												
208.	<i>Thalia democratica</i> (and other forms) ... f f c f f c ... c c c c s c f f f ... r ... f																											
209.	<i>Appendicularia sp.</i> ... f f f f f f ... f f f r r r r r r r ... r ... f																											
210.	<i>Fritillaria borealis</i> ... r ... r ... r r ... f r r ...																											
Enteropneusta																												
211.	<i>Tornaria larvae</i> ... r ... r ... r ... r r ... r r ... r r ...																											
Cephalochordata																												
212.	<i>Amphioxus pelagicus?</i> ...																											

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1930		JUNE							JULY												
		4	10	11	13	18	21	25	30	2	4	6	10	14	16	18	20	24	26	28	
Protozoa—(Contd.)																					
55.	<i>Peridinium</i> sp.	...	...	...	r	r	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
56.	<i>Ceratium tripos</i> var. <i>subsala</i>	...	...	...	r	r	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
57.	<i>Ceratium tripos</i> var. <i>subsala forma lineata</i>	...	...	...	r	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
58.	<i>Ceratium tripos</i> var. <i>subsala forma hiemale</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
59.	<i>Ceratium massiliense</i>	...	...	...	r	...	r	r	f	...	f	f	f	f	f	...	...	...	...	...	
60.	" <i>breve</i>	...	...	...	...	...	...	...	...	...	f	f	f	f	f	...	...	...	...	...	
61.	" <i>schmidti</i>	...	...	...	...	...	...	...	...	...	f	...	...	...	...	...	...	...	...	...	
62.	" <i>trichoceras</i>	...	...	...	...	...	...	...	...	...	f	...	...	...	...	...	...	...	...	...	
63.	" <i>furca</i>	...	...	...	...	...	...	...	...	...	...	...	...	r	...	...	...	...	...	...	
64.	" <i>tusus</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
65.	" <i>reticulatum</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
66.	<i>Glenodinium</i> sp.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
67.	<i>Tintinnus</i> sp.	...	...	...	f	...	f	c	f	...	...	...	...	...	...	...	...	...	...	...	
Hydromedusae*																					
68.	<i>Hybocodon</i> sp.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
69.	<i>Sarsia</i> sp. (1)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
70.	" sp. (2)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
71.	<i>Halitiara formosa</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
72.	<i>Merga violacea</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
73.	<i>Amphinema dinema</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
74.	<i>Leuckartiara octona</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
75.	<i>Cytaeis tetrastyla</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
76.	<i>Bougainvillia fulva</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
77.	<i>Köllikeria constricta</i>	...	...	...	f	c	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
78.	<i>Proboscoidactyla ornata</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
79.	" <i>conica</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
80.	<i>Staurodiscus tetrastaurus</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
81.	<i>Eucopa</i> sp.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
82.	<i>Obelia</i> sp.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
83.	<i>Phialucium multitenaculata</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
84.	<i>Eucheilota</i> sp. (1)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
85.	" sp. (2)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	r	...	...	...	...	
86.	<i>Eutima mira</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
87.	<i>Phorlis</i> sp.	...	...	...	...	...	f	...	...	...	...	...	...	...	...	...	...	...	...	...	
88.	<i>Irenopsis hexanemalis</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
89.	<i>Eirene malayensis</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
90.	" <i>madrassensis</i>	...	...	...	p	...	...	s	r	...	...	c	f	f	...	...	...	...	...	...	
91.	<i>Octocannoides orellata</i>	...	...	...	s	s	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
92.	<i>Octocanna solida</i>	...	...	...	...	...	...	...	...	...	...	f	...	...	...	...	...	...	...	...	
93.	" <i>polynema</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
94.	<i>Aequorea macrodactyla</i>	...	...	...	...	r	p	...	...	...	...	...	...	...	...	...	...	...	...	...	
95.	" <i>pensile</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
96.	" <i>parva</i>	...	...	...	...	r	r	...	...	...	...	...	...	...	...	...	...	...	...	...	
97.	<i>Zygocanna buitendijki</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	f	...	...	...	...	
98.	<i>Gonionemus suvaensis</i>	...	...	...	r	c	...	...	...	...	...	...	...	r	...	...	...	...	...	...	
99.	<i>Oolindias singularis</i>	...	...	...	...	...	...	s	...	...	...	...	...	...	f	...	...	...	...	...	
100.	<i>Liriope tetraphylla</i>	...	...	...	...	...	p	f	...	...	...	...	...	...	...	...	...	...	...	...	
101.	<i>Solmundella bilentaculata</i>	...	...	...	...	...	f	...	...	...	...	...	...	...	f	...	...	...	...	...	
102.	<i>Cunoctantha octonaria</i>	...	...	...	...	r	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Siphonophora																					
103.	<i>Diphyes dispar</i>	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
* Records incomplete for October and November																					

[illegible]

¹ Records incomplete for October and November.

[illegible][illegible]

186. *Schizopod (Rhopalophthalmus egregius, Macropsis orientalis)* ...

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UNIVERSITY NOTES

Technological Courses

THE Committee appointed to advise the Syndicate on the question of introducing technological courses in the University has reported as follows :—

‘The two chief industries of South India are those connected with leather (hides and skins), and with seeds and oils.

LEATHER : This industry is most important for South India and the export of hides and skins last year was approximately the same as in the year of depression some years ago.

Little or no assistance can be obtained from the members of the trade, which is not sufficiently well organised and developed at the present time and will not be sufficiently developed for at least ten years to require or be able to employ graduates of a University who have received a training in Leather Technology of a University standard. There are only two Firms in South India which would be prepared to employ a highly trained Technical Assistant and with these Firms a vacancy would occur very very seldom, only once in twenty years or so.

So far as leather is concerned, a rejuvenation of the Leather Trades Institute appears to be the best solution at the present time, the University to consider the question of the introduction of Leather Technology only ten years hence.

OIL SEEDS, SOAP, ETC. : The Kerala Soap Institute in Calicut is run as a commercial concern and is able, with the profits which it obtains from selling its products, soaps, etc., to pay for some of the experimental work which is being conducted in it. There are only four other concerns in South India in which seeds are treated on a scale sufficiently large to employ graduates in Technology. There is little hope for graduates trained by the University being employed at present in sufficient number to make it worth while for the University to open courses in Technology.

CHEMICAL INDUSTRIES : If some Chemical Industries are introduced in South India, the Honours graduates in Chemistry such as are turned out by the Presidency College suffice for purposes of employment in Chemical Industries, the subsequent

technical training being acquired in the Industrial Institute itself.

PRINTING: A training in Printing Technology would be useful. A preliminary apprenticeship is required which could be obtained at the Government Press, Madras, the Railway Printing Press, Royapuram, or the Diocesan Press, Vepery. If the University has a Printing Press of its own, most of the training could be given in its own Printing Press.'

New Courses

The Academic Council has approved of a scheme for Diploma in journalism and the details are under consideration. A Diploma in politics and public administration is also being considered.

Catalogus Catalogorum of Sanskrit MSS

The University has decided to draw up a complete up-to-date catalogue of Sanskrit Manuscripts, with a view to supplementing the work published in 1903 by Dr. Aufrecht. The work will be undertaken by a Board consisting of Mahamahopadhyaya S. Kuppaswami Sastri (Editor-in-chief), Dr. C. Kunjan Raja and Prof. P. P. S. Sastri. The University has addressed the Inter-University Board and the authorities of the All India Oriental Conference bringing to their notice this special work undertaken by the University and requesting their assistance.

Since the success of the undertaking is largely dependent upon the co-operation and help of scholars interested in Sanskrit, the Madras University would earnestly request scholars and Head of Institutions interested in Sanskrit and Indology to assist it by furnishing information on any or all the following points:—

- (1) Places where manuscripts are available, with particulars regarding owners and authors.
- (2) Lists of manuscripts.
- (3) Other suggestions for the preparation of the proposed new Catalogus Catalogorum.

It is requested that all communications regarding this matter may be addressed to 'The Editor-in-chief, Catalogus Catalogorum, Government Oriental Manuscripts Library, Museum Buildings, Pantheon Road, Egmore, Madras.'

REVIEWS

EVOLUTION OF HINDU MORAL IDEALS. By SIR P. S. SIVASWAMI AIYAR. Published by the Calcutta University, 1935. Price Rs. 2-8-0 or 4s. 6d.

The book represents the Kamala Lectures delivered by Sir P. S. Sivaswami Aiyar under the auspices of the University of Calcutta. It is divided into thirteen chapters, and the main thesis of the learned author is to indicate the evolutionary character of the moral ideas of the Hindus. In other words it is contended, possibly rightly, that the Hindu ethical code was never rigid or stationary, unaffected by changes, political and economic in the march of time. Sir Sivaswami Aiyar has approached this subject in the light of comparative thought, and has pointed out, with ability and acumen, born of ripe experience, the contribution of Hindu thought to moral culture. While he is quite alive to the defects of Hinduism in certain particulars, he has succeeded in answering attacks recently made by Western writers on the cardinal principles of Hinduism. Among other interesting topics his clear exposition of the much misunderstood doctrine of Karma may be particularly mentioned.

Sir Sivaswami Aiyar is one of those who genuinely feel the need on the part of the Hindus to adapt themselves to the changing conditions and tendencies of modern life. But still he is not in favour of effecting changes by the instrument of legislature, heterogeneous as it is in character. Every one will agree with his statement that 'legislation which is much in advance of public opinion is bound to be a failure'. In his thoughtful reflections of the drift of modern forces and their bearing on the future of Hindu society, the learned author puts forth an eloquent plea for the abandonment of two things, above others, (1) ritualism and ceremonial observances and (2) the institution of caste which may in his opinion go a long way to make Hinduism survive as a religion. But with regard to these particulars differences of opinion are bound to exist, and will exist.

V. R. R.

BOOKS RECEIVED

1. *Industrial Organisation of India.* By P. S. Lokanathan (George Allen and Unwin Ltd.).
2. *Hydrostatistics.* By A. S. Ramsey. Cambridge University Press. 7s. 6d.
3. *Questions and Answers on Hindu and Mahomedan Law.* By J. Chinna Durai and G. Evelyn. London: Stevens & Sons, 1935. 6s.
4. *A Concise History of Britain.* By Robert M. Rayner, 1934. 6s. 6d.
5. *A Study of Economic Depression in Rural Kistna.* By Ch. Sitarama Sastri and C. Sriramanarasimhan. Madras Provincial Co-operative Union.

The following books were received from Messrs. Macmillan & Co.:—

6. *A First Trigonometry for Fourth and Fifth Forms.* By Jacob Morgan. 1936. 1s. 3d.
7. *A Class Book of Magnetism and Electricity.* 1936. 6s. 6d.
8. *The British Empire and Commonwealth—a History for Senior Forms.* By James A. Williamson. 1935. 6s.
9. *Intermediate Botany.* By L. J. F. Brimble. 1936. 8s. 6d.
10. *History of Rome down to the reign of Constantine.* 1935. 10s.
11. *The Ancient World.* By I. Tenen. 3s. 6d.
12. *Outline of English Verse.* By George Cowling.

THE HAND-LOOM INDUSTRY

IN

SOUTH INDIA

BY

K. S. VENKATARAMAN, B.A. (HONS.), B.L.,
(SIR PARASURAMBHAO COLLEGE, POONA)

*"There is only one way of seeing things
rightly and that is seeing the whole of them."*

MADRAS

PRINTED AT THE DIOCESAN PRESS, VEPERY

1936

CHAPTER XVI

HAND-LOOM VERSUS POWER-LOOM

'It is generally believed that the hand-loom weaving industry is doomed. I am not so pessimistic as that. Indeed I am confident that it is capable of great expansion. Handweaving is capable of competing with power weaving in a factory The weaver in the cottage has got everything to his advantage. His stores cost very little; he has no depreciation, no interest or excise duty. The only thing against him is production.'—B. D. MEHTA, *ex-Manager, Empress Mills, Nagpur, at the Indian Industrial Conference, 1907.*

'If the hand-loom can compete with the power-loom in England, where the cost of skilled labour is many times greater than it is in India, where the perfect weaving machinery worked by steam and electricity is in use, what a much greater prospect must there be in India, where you have an unlimited supply of the most skilful hereditary weavers, content with earnings of three to eight annas per day. There are splendid possibilities open to the hand-loom industry in India, and it is a preventible loss to India that the skilled weavers should day by day leave their looms and add to the already overgrown agricultural population.'—*Bulletin of the Department of Industries, of Bihar and Orissa.*

The critics of the hand-loom are generally of opinion that hand-loom cannot hope to supersede the power-loom, nor can it resist for long its advance. They conclude from their experiences in western countries that man-power cannot compete with mechanical power and ere long all handicrafts will give place to factory and machine production.¹ They assign one reason for this inevitable consummation which, according to their wisdom, applies with equal force to all handicrafts; further, they believe that because the rate of production in the hand-loom is far less than it is in the power-loom, the cost of production on the hand-loom must be greater. We shall examine the truth of this conclusion.

¹ A writer in the *International Labour Review*, June 1928, shows the remarkable expansion of handicrafts in many industrial countries and their persistence elsewhere in spite of the growing competition of large scale industries. The data, he has collected, are instructive. In Germany out of 1,000 non-agricultural workers, 373 are still employed in handicraft undertakings. According to the French occupational census of 1921, out of 551,141 undertakings in the transforming industries alone employing 4,027,335 wage-earners, 466,036 employ fewer than 5 wage-earners each. In Great Britain 40 per cent of the industrial workers are employed in undertakings not using motive power. In Switzerland 328,008 are handicraftsmen out of a total of 827,624 workers. Japan, Russia, U. S. A. and the Balkan States are no exceptions.

The writer further points out that the modern handicrafts are not the relic of the past but play a very important part in modern industrial organisations. They have a great future as indicated by the industrial policies of Russia and Germany.

RATE OF PRODUCTION AND ITS RELATION TO THE COST OF PRODUCTION

The production on the power-loom is ordinarily five times as much as it is on the hand-loom. This, however, does not mean that the cost of production in the power-loom is only a fifth of the cost on the hand-loom; for, besides the cost of labour, there are other items of expenditure which must be included in the cost of production on the power-loom e.g. overhead costs arising from expensive machinery, building, and other equipments; their repair and maintenance charges, taxes, fuel and power charges, cost of establishment, supervision etc. The high initial cost of equipment and the recurring cost of maintenance and the scarcity of skilled labour in Indian industrial centres are some of the factors which may outweigh for a long time all the advantage of the speed of power-looms. In India the minimum cost of erection per loom in a mill is Rs. 600 and the average cost is Rs. 800 while an efficient hand-loom fitted with a flyshuttle sley and weaver's beam can be set up for Rs. 30. A comparison of the rate of production may be instituted between 20 hand-looms and one power-loom if the initial cost alone is the basis for comparison, for, 20 hand-looms can be set up for the cost of one power-loom. Now the quantity of production on 20 hand-looms will be nearly five times as much as it is on a power-loom. But this comparison is equally fallacious. The real efficiency of the power-loom and the hand-loom can be measured only in the light of initial cost, running and other costs. It is loose thinking if one states that the power-loom is superior to the hand-loom because the production in the former is four times greater; it is equally wrong to say that the power-loom weaver is more efficient than the hand-loom weaver because the former attends to four looms in India and to nearly twelve looms in U.S.A. and produces over 80 yards a day, while the poor hand-loom weaver struggles to manufacture 10 yards. 'Efficiency' without reference to the cost of production has no meaning. The high speed of production does not minimise the cost on the power-loom and it has no relation to the cost of production which alone can determine the real advantage of mechanical power over man-power.

This brings us to the question of mechanical power versus man power. The main cause of the introduction of machinery and the employment of more capital than labour in an industry is the comparative cheapness and efficiency of capital. Generally speaking, in industrially advanced countries labour compared to capital is dearer from the producer's point of view and therefore the tendency in rationalising industry is in the direction of increasing employment of capital in the form of machinery and improved implements. In countries like India and China, on the other hand, labour is abundant and is cheaper than capital in spite of its low productive power. And this explains the hesitation in increasingly employing capital in agriculture and industry in these countries. Costly plant driven by power cannot be employed in many branches of industries as long as its introduction has not got a decided advantage in reducing the cost of production (e.g. in spinning mills) or in eliminating time and space (e.g. in transport industries). In many cases the advantage accruing from its introduction is only temporary; for labour, unfortunately, in certain countries is prepared to compete with capital for employment on any terms. Where time is not an essential factor in production, labour in such countries competes successfully with capital and mechanical power. This is the condition in Indian industries, particularly in textile industries today. So long as there is this abundance of labour and skill which cannot find more remunerative occupation, the present quantum of production can be, and will be, well maintained by hand-looms. Further so long as the present economic order is not thoroughly changed increasing substitution of mechanical for man-power cannot be hoped for and where it does, it creates unemployment.

The remarks of E. B. Havell will bear repetition. After carefully considering the ethics of machinery and the limits of hand-loom weaving, he concludes, 'Weaving is not one of those operations in which steam or electric power has an inherent superiority over hand-loom labour. There are many operations in which the superiority of the former is incontestable as wielding a huge mass of iron, railway engines and steamships. But a loom is a machine in which the force re-

quired to work it does not usually exceed the strength of one man and any excess of the force required absolutely prevents good weaving. In all countries where skilled manual labour is plentiful and cheap, the power-loom has no inherent superiority over the hand-loom, provided that the latter is made as mechanically perfect as the former, so that the working power of the hand-weaver is not wasted. The only question is whether the unit of mechanical power can be produced at a cheaper rate than the average cost of manual power'.¹

To come back to the original theme, we have found that it is very nearly impossible to ascertain the exact point at which any useful comparison can be made between the hand-loom and the power-loom; that neither the initial cost, nor the rate of production, nor working expenses can alone prove useful and that it is the final cost of production per unit of output on the power-loom and the hand-loom that can determine their real efficiency. The retail prices of hand-loom and power-loom manufactures will not afford us any basis for this purpose, for the trade and commercial organisations for the mill and hand-loom products are different and any conclusion based on the difference of their retail prices will be misleading. For our present enquiry the prices of cloth ex-mill and ex-handloom must be ascertained. This we shall do in the next chapter. Definite data as to the cost of production in the mill are not available. Yet certain inferences regarding the cost of production in the mill and in the hand-loom can be made from certain observations and statements of writers on the cotton textile industry; and on that basis we shall ascertain the differences in the cost of production and examine whether the hand-loom can manufacture the same cloth at the same cost as the mill does, if not at a lower cost; and if so, under what conditions it is possible.

First there is the statement regarding the cost of production in mills prepared by Sir Victor Sassoon in 1926 and presented to the Royal Commission on Indian Currency. The statement is published as an appendix to the memorandum presented by the Bombay Millowners' Association to the Cotton Textile Tariff Board (Refer: Statement A). He

¹ E. B. Havell : *Artistic and Industrial Revival in India*, p. 163.

has given the cost of production of a piece of standard shirting cloth with 20s warp and 20s weft with details of the cost of converting raw cotton into finished cloth. Deducting three annas per pound of yarn used as the spinning cost¹ when cotton sells at Rs. 300 per candy, and four annas per pound when cotton sells at Rs. 700, the cost of weaving, according to Sir Victor Sassoon, is 5½ annas per pound of cloth (inclusive of size) when cotton sells at Rs. 290 per candy and 6 annas when it sells at Rs. 700 (the difference being due to the weaving waste and insurance). The cost does not include the excise duty on cloth. The statement does not give anything about the ends and picks per inch, the amount of size in the cloth and other relevant details.

Secondly, there is a statement of cost in the memorandum presented to the Textile Tariff Board, 1927, by the Bombay Mill Owners' Association (Statement B). This does not give any specifications of the cloth taken for costing. Nothing is said about the dimensions of the cloth, the counts of yarn used and the ends and picks per inch. Like Sir Sassoon's, it includes the cost of spinning and weaving but not of spinning and weaving waste. It includes also the cost of dyeing and excise duty. Deducting the cost of dyeing and excise duty and 3 annas as spinning cost, the cost of weaving per pound of cloth comes to a little less than 4 annas. It must be remembered, however, that no reduction is made for the size in the cloth and the cost given here is for the weight of cloth and not for the nett weight of yarn used.

Thirdly, there is the statement of the cost of maintenance per loom in Bombay, in up countries and in Ahmedabad in the Report of the Indian Tariff Board 1927 (Statement C). The average daily cost in Bombay is 517 pies and in Ahmedabad and up country mills 470 pies. The average production per loom depends on the kind of yarn used and the kind of cloth woven. The average output of cloth of

¹ The cost of maintaining one spindle according to the report of the Tariff Board is 10·6 pies in Bombay and 9·4 pies in upcountry mills. The average outturn per spindle of 20s is 6½ oz. and is seldom less than 5½ oz. Assuming that 3 spindles can produce one pound of 20s the maximum cost of production is 32 pies in Bombay and 28 pies in other places. We have assumed throughout that the cost of producing one pound of 20s is 36 pies. This error will underestimate the weaving costs in mills.

20s is about 10 lbs. of cloth or 50 square yards and if we deduct the size used in it, 10 per cent of the weight of cloth, the daily output is 9 lbs. The cost of weaving a pound of cloth is 47 pies in Ahmedabad and 52 pies in Bombay. The cost of size used must be added to this, which will make the cost of weaving for an ordinarily sized cloth in Ahmedabad $4\frac{1}{2}$ annas per pound and in Bombay 6 pies more.

There are yet two other statements regarding the cost of production on power-looms in India prepared in 1930, by Arno S. Pearse of the International Master Spinners' Association, Manchester. In a first class mill in Ahmedabad (Statement D) whence he collected details regarding costing of cloth with $24\frac{1}{2}$ s warp yarn, the cost of spinning per pound of yarn is 3.04 annas and the cost of weaving is 4.98 annas per pound. He has also prepared a statement showing weaving charges per piece of cloth of different sorts in Indian mills. The cost of weaving varies from 9 pies to $13\frac{1}{4}$ pies per yard and from 45 pies to 67 pies per pound of yarn. The Statement E (p. 202) can be briefly stated thus :

Name of cloth.	Dimensions.	Reeds.	Picks.	Count of		Weaving charges per	
				Warp.	Weft.	Yd.	Lb.
						Pies.	
Dyer's cloth ...	41" x 36 yds.	36s	36	24s	20s	9	49
Shirting ...	35" x 22 "	56s	52	24s	20s	$12\frac{3}{4}$	45
Dhoti ...	28" x 7 "	48s	52	$\left. \begin{smallmatrix} 24s \\ 2/32 \end{smallmatrix} \right\}$	20s	$11\frac{1}{2}$	67
Dhoti ...	39" x 10 "	48s	52	$\left. \begin{smallmatrix} 24s \\ 2/32s \end{smallmatrix} \right\}$	20s	$13\frac{1}{4}$	59
Dhoti ...	49" x 11 "	48s	48	24s	34	$13\frac{3}{4}$	$58\frac{1}{2}$

In the above statement excepting for shirting where the cost of weaving per pound of yarn is 3 annas 9 pies only, in all other cases, it does not seem in any way to compare favourably with that on the hand-loom. It must also be noted that the cost of production per yard of cloth is one anna where the picks per inch are 52 and the width of the cloth is 36 in. and it is 9 pies per yard where the picks per inch are 36.

The costing sheet of an up country mill prepared in respect of grey chaddar in 1908 is appended herewith as Statement F. Even though trade union activity was then less effective and so wages were low, though the burden of taxation was light and though the general level of prices was low, the cost of wearing in 1908 was $5\frac{1}{4}$ annas per pound of cloth and 3 annas 9 pies per yard excluding railway charges and excise duty.

How far these widely differing estimates of the cost of production can be relied upon is a legitimate question. But let us for the purpose of comparison take the lowest estimate i.e. $3\frac{3}{4}$ as. per pound of cloth, though it does not obtain in most of the mills in India.

COST OF PRODUCTION ON HAND-LOOM

Two statements regarding the cost of production on hand-loom are appended to this chapter as Statements G and H one from the memorandum of the Textile Expert presented to the Textile Committee of the Madras Legislative Council (1928), and the other from the writer's enquiry in Kumaramangalam in Salem District (1928). According to the former, the cost of winding, warping, sizing and weaving of one pound of yarn is 4 annas 9 pies. If we include the weight of size so that this can be compared with mill cloth, the cost of manufacturing one pound of cloth will be 4 annas 4 pies on the assumption that 10 per cent of size is retained in the cloth. And in Kumaramangalam in Salem District the cost of production of cloth per pound of yarn of $18\frac{1}{2}$ s varies according to the prices of mill cloth in the market between $3\frac{1}{4}$ annas and $4\frac{1}{2}$ annas. But this cost will go up by 2 pies in the case of 20s and this is more than set off against the weight of size in the cloth which will reduce the cost of production per pound of cloth. In a village in Chingleput district the cost of production per pound of grey cloth is 2 annas 3 pies.¹

The writer is aware of the dangers of so many assumptions and hypothetical calculations but he ventures to state that if the weight basis for comparison of cost on power-loom

¹ The Report of the Special Officer for Cottage Industries.

and hand-loom is taken the error will be very negligible. If linear basis is taken the results will be very misleading unless the cloths of power-looms and hand-looms are comparable in all respects. Also he is aware that in the hand-loom industry, there is nothing like costing. The handweaver is content to make a living and accepts whatever price he gets for his manufactures as a result of the mill competition. His earnings have all the characteristics of profits rather than of wages.

However, a careful examination of the cost of production shows that the minimum cost in mills is 4 annas per pound of cloth of 20s with size but excluding the excise duty while the cost runs upto 6 annas where the yarn used is about 25s. In the hand-loom the respective costs are $3\frac{1}{2}$ annas and 5 annas. Thus it is clear that the cost of production on the hand-loom, if not always lower than it is on the power-loom, is not much higher. For, the hand-loom weaver adjusts himself according to trade conditions and accepts higher or lower wages and competes with the mill.

This persistence of competition of the hand-loom with the power-loom brings out certain facts which one must bear in mind in any scheme of industrial reconstruction. The abundance of cheap skilled labour and the comparatively high and sometimes prohibitive cost of capital equipment are two limiting factors in the expansion of cotton mill industry in India. This explains why still a fourth of the total consumption of cloth in India and four-fifths of the consumption in China, where labour is abundant and cheap, are still produced on the hand-loom. Now, one cannot deny the advantages of mechanised mass production. But there is a limit to the concentration of the industry and with the increased cost of land transport and labour troubles on the one hand and the possible abolition of customs duties on imported yarns, the weaving section of the Indian mill industry will have to face a serious situation,¹ in which the hand-loom

¹ The great losses that many weaving mills are sustaining and the number of weaving mills that are annually going into liquidation are clear indications that these mills driven by power have their own difficulties which the hand-looms have not to face. The weaving mills as a rule fare worse than spinning mills which means that power-loom weaving is not as economically sound as it is generally assumed. Eighteen Indian cotton mills with an authorised

weaver may probably triumph if he is now properly organised. It would be either stupendous folly or wickedness to waste the inherited skill of the Indian weaver by forcing him to power-loom factories as a means of educating him in the science of modern industry. 'Rationalisation'—that magic word of modern industrial organisation—is not open only to power driven factories but also to small scale industries. But it is not courageously advocated by its well-wishers, for they are haunted by the fear of gigantic machines driven by mechanical power. This fear is unfounded. How the mill industry is rationalised and how the hand-loom industry can be modernised will be indicated in a later chapter. It is attempted here to show that the case for the mill industry is exaggerated; and it is loose thinking that leads to the conclusion that the higher the speed of production the lower is the cost of production. It is made out in this chapter that the cost of production in mills is not very much lower than in hand-loom though the speed of the power-loom is greater. It may safely be asserted that if the import duty on yarn is abolished and the industry is properly organised in its technical and commercial aspects, the hand-loom in India can turn the tables against the power-loom.

capital of Rs. 4.7 crores, fifteen mills with Rs. 2.36 crores, twenty-three mills with Rs. 4.97 crores went into liquidation in 1925-26, 1926-27 and 1927-28 respectively. The Lancashire mills fared no better. The liquidation of the weaving mills was more common than that of the spinning group. All schemes of cartellisation and rationalisation have so far proved ineffective. It is wrong to imagine that since India imports 1,000 million yards and manufactures over 2,000 million yards in indigenous mills that power weaving is flourishing. A number of mills have been forced into liquidation and what is most striking is that the average dividend paid by the Lancashire weaving mills for the past several years ranges only from 2 to 3 per cent. In fact very few mills are working very satisfactorily in spite of the great financial assistance given by the bankers. These mills can be said to be run merely to find employment for the people; and in spite of the huge outlay invested in maintaining and running 1,200 weaving concerns with 739,000 looms the number of persons employed is comparatively insignificant. This is due to the fact that it is not possible on the one hand to employ the minimum labour by installing labour saving appliances in order to obtain adequate return on the capital invested and on the other to provide employment instead of doling large sums of money to the unemployed. It is for this reason that the placing of the hand-loom on an economically sound basis so as to provide adequate remuneration to the weaver is urged as a means of preventing the unemployment problem assuming such large proportions in India as to necessitate the grants of doles to the unemployed.—Mr. Amalsad, *Cotton Cloth Impasse*, pp. 13-14

STATEMENT 'A'

Allocation of cost as given by Sir Victor Sassoon in 1926 before the Indian Currency Commission, page 385 of Vol. II *Evidence: Indian Tariff Board (Cotton Textile)*, 1927.

ALLOCATION OF COST OF STANDARD SHIRTING 9 LBS. 40
YARDS 20S WARP AND WEFT WITH COTTON

	Price of cotton per candy of 784 lbs.	
	at Rs. 290.	at Rs. 700.
Raw cotton	45.46 annas	109.82 annas
Waste in spinning	6.80 "	16.47 "
Waste in weaving	3.96 "	7.67 "
Insurance, spare parts	3.01 "	3.01 "
Stores	7.44 "	7.44 "
On cost	11.21 "	11.21 "
Power	5.82 "	5.82 "
Mill management	5.22 "	5.22 "
Wages	30.93 "	30.93 "
Commission	1.91 "	1.91 "
Total	121.76 "	199.50 "

Taking the cost of spinning at 3 annas per pound when raw cotton sells at Rs. 290 and 4 annas per pound when it sells at Rs. 700, the cost of spinning and weaving may be analysed thus:—

	COTTON			
	@ Rs. 290		@ Rs. 700	
Cost of cotton	45.46 As.	37.35%	109.82 As.	54.90%
Cost of spinning including spinning waste	27.00 "	22.19%	36.00 "	18.85%
Cost of weaving including waste in weaving and size	49.30 "	40.46%	53.82 "	26.95%
Cost of weaving per yard of cloth	1.23 "		1.345 "	
Cost of weaving per pound of cloth	5.48 "		5.98 "	

If 10 per cent size were to be allowed the weaving cost per pound of yarn used will be from 6.08 annas to 6.64 annas.

STATEMENT 'B'.

Cost of production of 1 lb. of cloth in mills as given by the Bombay Millowners' Association in their Memorandum to the Cotton Textile Tariff Board.

Coal	10.09
Stores	14.46
Labour	39.69
Office supervision	3.41
Fire Insurance	1.67
Municipal and other taxes	1.57
Interest	5.66
Commission on cloth	4.60
Agents' Commission	0.83
Excise duty	9.35
Dyeing charges	4.40
Income and super-tax	1.94
Total	97.67*
Total less excise duty and dyeing charges	83.92
Total less spinning and dyeing charges and excise duty	47.92

* This includes the cost of spinning, weaving, dyeing and the excise duty. Deducting 36 pies for spinning and 4.4 pies for dyeing and 9.35 pies for excise duty, the cost of weaving including preparation of warp and finishing and folding and baling of cloth is 3.95 annas per pound of cloth. If we allow 10% for the weight of size the weaving cost will be 4.4 annas per pound of yarn used in weaving.

STATEMENT 'C'

Expenses per loom in Mills.¹

In Bombay.	517 pies.
In Ahmedabad.	470 pies.

This does not include the cost of size, nor the excise duty.

The rate of production on the power-loom is 35 yards to 60 yards per day of ten hours. It depends on the nature of the weave, the kind of yarn used and the number of picks per inch. The average daily outturn is 35 yards per loom when 26s to 30s yarn is used and the pick per inch is 64. It is 60 yards when 14s yarn is used and the pick per inch is 42. It is about 50 yards per loom when 20s yarn is used and the pick per inch is 52.

¹ Report of the Indian Cotton Textile Tariff Board, 1927.

STATEMENT 'D'

COSTING FOR 24½S WARP YARN IN ANNAS PER POUND OF YARN

Arno S. Pearse in his book on the *Cotton Industry of India* gives the costing as furnished by a mill in Ahmedabad, 1929.

Spinning Department			Weaving Department		
	ANNAS.			ANNAS	
Spinning wages	... 0.87	Stores including yarn purchased	...	2.05	
Card and frame wages	... 0.36	Wages	...	1.51	
Engine wages	... 0.25	Coal	...	0.25	
Coal	... 0.36	Depreciation	...	0.28	
Stores	... 0.37	Interest charges	...	0.20	
Depreciation	... 0.35	Brokerage	...	0.17	
Interest charges	... 0.25	Agency commission	...	0.52	
Commission	... 0.04				
Ground rent	... 0.07				
Water rates	... 0.05				
Miscellaneous	... 0.07				
Total spinning charges.	3.4	Total weaving charges.	4.98		

Spinning and weaving charges per pound of yarn used in cloth is 8.02 annas.

STATEMENT 'E'

Statement showing weaving charges per piece of cloth of different sorts in Indian Mills.

(From Arno. S. Pearse: *The Cotton Industry in India*).

Description of cloth a	Dhoti b				Dyer's Cloth c			
Width of cloth	...	32"	...	...	...	46"	...	...
Speed of loom	...	205	...	...	...	190	...	...
Reed	...	48s	...	...	...	36s	...	...
Picks	...	52	...	...	...	36	...	...
Warp counts	...	{ 24s	...	...	...	24s	...	...
Weft counts	...	{ 2/32s col.	...	...	...	20s	...	...
Dimensions of cloth	...	28" x 7 yds.	...	...	...	41" x 36 yds.	...	...
Charges per piece in pies	2000	1910	1914	1928	2000	1910	1914	1928
Preparatory engine and other charges	22	29	29	57	71	95	96	232
Weaving wages	7	9	10	24	34	39	42	92
Total	29	38	39	81	105	134	138	324
Efficiency per cent	...	56.09	61.9	65.7	...	67.9	63.2	67.3
Cost of production per yard of cloth	4½	5½	5½	11½	2½	3½	3½	9

Shirting d				Dhoti e				Dhoti f			
46"	190	56s	52	46"	190	48s	52	56"	170	48s	48
24s	20s	35" x 22 yds.		24s	20s	39" x 10 yds.		24s	34s	49" x 11 yds.	
d				e				f			
1900	1910	1914	1928	1900	1910	1914	1928	1900	1910	1914	1928
65	91	74	185	...	...	44	97	...	...	53	96
33	38	40	85	...	...	18	38	...	...	23	50
98	129	134	270	...	...	62	135	...	...	76	146
-	60.1	61.2	67.05	...	...	64.3	66.3	...	...	66.7	68.4
4½	5½	6½	12½	...	...	6½	13½	...	...	6½	13½

STATEMENT 'F'

The cost of production¹ in an up-country mill in 1907 is given below for a piece of grey chaddar No. 4000, 65" wide, 6 yards long with 56s reed and 56 picks.¹

Warp 17s.	@ 0-14-2	2 lbs.	...	Rs. A. P.
Size	@ 3 as. per lb.	7½ oz.	...	1 12 4
Weft.	@ 0-12-3	1 lb. 12½ oz.	...	0 1 4.9
			...	1 5 0
Total weight of unfinished cloth 4 lbs. 4 oz.				
Winding, warping, drawing and sizing for 2 lbs.	...	...	...	0 1 4
Weaver's wages	...	...	...	0 4 6
Fixed charges on 4½ lbs.	...	...	...	0 5 4
Folding, baling, weaving stores, nett loss in waste, etc.	...	...	...	0 5 8
Railway charges	...	...	...	0 7 1
Duty	...	...	...	0 3 2½
Depreciation	...	...	...	0 1 4
Total cost	...	...	...	4 15 4
Cost of yarn	...	...	...	3 1 4
Cost of production less excise duty	...	...	...	1 14 0

¹ This costing has been furnished to the writer by his friend who was employed in Indian cotton mills.

			Rs.	A.	P.
Cost of production excluding excise duty and railway freight			1	6	6
Do.	per pound of cloth	...	0	5	3
Do.	per pound of yarn used	...	0	6	0
Do.	per yard of cloth	...	0	3	9

These rates include cost of baling, folding and other charges. Still the cost of production in the hand-loom is nothing prohibitive.

The cost of production in mills at present is twice the cost of production in 1910 according to Statement E. On this basis the cost of production at present will be 10 As. 6 Ps. per pound of cloth, 12 As. per pound of yarn used and 7 As. 6 Ps. per yard of cloth in the above case.

STATEMENT 'G'

Cost of production on the hand-loom.—Cost of producing one yard of cloth (4.75 oz.) of 20s warp and weft on the hand-loom as stated by Mr. D. M. Amalsad in his Memorandum to the Textile Conference.

Specification of cloth:—Length 1 yd; breadth 48"; ends 48; picks 52; weight of 1 yard of cloth 4.75 oz; add 10 per cent size.

			Rs.	A.	P.
Cost of yarn	...	...	0	3	6
Cost of winding, warping and sizing	...	...	0	0	6
Cost of weaving and winding	...	...	0	0	11
Total cost			0	4	11

Cost of weaving 1 lb. of cloth with size	...	4 annas 4 pies.
Cost of weaving 1 lb. of yarn	...	4 annas 9½ pies
Cost of weaving 1 yard of cloth with size	...	1 anna 5 pies.

STATEMENT 'H'

Cost of weaving in Kumaramangalam in Salem District (1928.)

Specification:

Grey Veshti with thin black border 18½s warp and weft; picks and ends per inch about 50; length of the warp 84 yds.; breadth 45".

Yarn for the warp.	228 hanks, i.e.	...	12.2 lbs.
Yarn for the weft.	228 hanks, i.e.	...	12.2 lbs.

Total yarn ... 24.4 lbs.

Add 10 per cent size; weight of cloth is ... 26.8 lbs.

			Rs.	A.	P.
Wages paid for the warp in 1923	...	...	7	0	0
Wages paid for the warp in 1928	...	...	5	0	0
			1923	1928	
Cost of production per lb. of yarn used	...	...	0	4	7
Cost of production per lb. of cloth	...	...	0	4	2½
			0	3	3½
			0	3	0

Details of cost —

			Rs.	A.	P.
Winding and warping	...	...	0	10	0
Sizing cooly	...	...	0	8	0
Cost of size	...	...	0	4	6
Total preparatory charges			1	6	6
Weaver's gain in 1928	...	...	3	9	6

CHAPTER XVII

HAND-LOOM VERSUS POWER-LOOM

In this chapter we propose to explore the possibility of resuscitating the hand-loom industry and to examine in greater detail the commercial basis for its reorganisation.

The lay opinion is that hand-woven cloths are dearer than mill cloths and it is usually attributed to the higher cost of production on the hand-loom. This may be true in some cases and in some places but the higher price of the hand-woven cloth is not mainly due to the higher labour cost. Cost of labour is not the only factor that determines the cost of production. There are other factors as well to be considered such as cost of yarn, overhead charges, cost of marketing etc. The hand-loom industry as at present organised for the purchase of raw materials, for the production of cloth and for marketing accounts for the higher price of cloth; and economy in these directions will reduce the cost of production. The yarn from the mill passes through many hands before it reaches the weaver and so does the cloth pass through a series of middlemen before it reaches the consumer. But where the weaver himself markets the cloth in the shandy the price is sometimes much lower than that of the mill cloth. Again the weaver gets his yarn from mills and his price includes (a) the profits of the spinner, (b) profits of the middleman through whom the yarn passes and (c) the duty on yarn. In a place 15 miles from Coimbatore, to cite an instance, the price of yarn per pound of 20s is 9 pies higher than the retail price in Coimbatore. The power-loom gets its yarn at a price which does not include middleman profits and duties and thus enjoys another advantage over the hand-loom. Again there is a psychological factor. There is usually less size in the hand-loom products than in many Japanese and Ahmedabad mill cloths which are neatly filled and finished; and the latter therefore compare favourably with hand-woven cloth where the weight or the appearance of the cloth is the determining factor. It must also be remembered that the hand-loom weaver, not being able to dictate the price for his labour, sells his cloth for whatever price it fetches him. Cost of production does not regulate his output

or determine the price of his cloth. He is willing to slave for hours on any terms so long as it gives him a living. On the other hand the cloth merchant for whom most of the weavers are bound to work tries to get the best price for the cloth. He knows that buyers are willing to pay more for hand-woven cloths and takes full advantage of this. Thus it is not because that the cost of production in the sense that relative cost of labour is higher on the hand-loom than in mills that the hand-woven cloth is dearer but it is due to the cost in other respects viz., in the distribution of yarn to the weaver, the marketing of cloth and the import duty on yarn. The one great advantage the power-loom enjoys is in the preparatory process. The slasher sizer is decisively cheaper than street sizing or even the Yorkshire dresser sizer. It is also asserted that the higher price of the hand-woven cloth is not too much when the quality of the cloth is considered. There is much to be said for this view. But these impressions are the results of personal prejudices and individual judgment and they are not helpful in determining whether the hand-loom or the power-loom is more commercially advantageous.

The hand-woven cloth is not standardised and therefore it does not lend itself to a comparative study of costs. Even where there are fairly standardised products, the cost of production varies from place to place and time to time according to the demand for cloth and the necessity of the weaver. We cannot therefore state with any certainty the difference between the cost of production on the hand-loom and on the power-loom.

We must pursue a different course of enquiry: 'Can cloths of stated quality be produced on the hand-loom at the same cost as on the power-loom?' To answer this question one must ascertain the kind of the cloth, its dimensions, its weight, the nature of the weave, the percentage of size in it, the count of yarn used for warp and weft, the number of ends and picks, the weight of different yarns used, the price of yarn, its quality, the nett cost of that cloth in the mill, the cost of manufacture per pound and per yard of cloth, whether at such rates cloth can be produced on the hand-loom and if so, under what conditions. These are points which must

be fully investigated. The present writer has examined some mill cloths on the lines indicated above from the data given in the report of the Indian (Cotton Textile) Tariff Board, 1927, and the evidence of the Bombay Millowners' Association and the result is appended to this chapter as Statement B. Absolute accuracy cannot be claimed for it, for the difficulty of obtaining accurate information from the mills in a fluctuating market is obvious. The selling price of the cloth is for ex-mill delivery during the last quarter of 1926. It is not stated in the report nor is it stated in the evidence at what price the cost of yarn was taken so that we can calculate the weaving cost in mills. To be on the safe side the cost of yarn is based on the top price of cotton during 1925 i.e. the year previous to that when the prices of cloth were ascertained by the Board and the Millowners' Association, though the average price of cotton in 1926 was Rs. 360 per candy of 784 lbs., i.e., $7\frac{1}{2}$ annas per pound. The following prices for different counts of yarn are adopted on the basis of 9 annas per pound of cotton and spinning rates mentioned in column 3 in the accompanying table:—

Count of yarn	Price of cotton	Spinning charges per pound ¹	Price of yarn per lb.
14s ...	9 annas	$1\frac{1}{2}$ annas	$10\frac{1}{2}$ annas
20s ...	9 "	3 "	12 "
24s ...	9 "	$3\frac{1}{2}$ "	$12\frac{1}{2}$ "
30s ...	9 "	5 "	14 "
36s ...	9 "	$6\frac{1}{2}$ "	$15\frac{1}{2}$ "
40s ...	9 "	7 "	16 "
44s ...	9 "	$8\frac{1}{2}$ "	$17\frac{1}{2}$ "

¹ The spinning rates adopted here are overestimated when compared with the rates calculated on the cost of maintaining a spindle in Bombay mills as given in the Cotton Textile Tariff Board Report. On the basis of 10·6 pies per spindle in Bombay and on the basis of the number of spindles required to produce a pound of yarn indicated in col. 2 below the probable cost of spinning different counts of yarn is given below:—

Count	Spindles per pound	Cost of spinning per lb. at 10·6 pies per spindle
10	1·25	13 pies
20	2·50	$26\frac{1}{2}$ "
30	4·30	45·6 "
40	6·66	70·7 "

When definite information is not forthcoming, many things have to be assumed. As regards the rate of production and the cost of production on the hand-loom, the ordinary weaver can furnish no reliable information as he maintains neither production sheet nor costing sheet. Mr. Chatterton observed in his book that the average rate of picking in a country-loom is about 30 per minute.¹ It is over 40 in a country-loom fitted with a flyshuttle sley. A weaver can do six to fifteen yards in a day of 10 hours, varying according to the dimen-

¹ THE AVERAGE RATE OF PICKING IN HAND-LOOM COMPETITION

	20s warp. 20s weft.	30s warp. 30s weft.	100s warp. 100s weft.
Best country loom with throw shuttle.	31	...	...
Improved pitloom with fly shuttle ...	45	...	47
Frame loom with fly shuttle ...	62½	66½	48½

The average rate of picking in the Government Textile Institute, Madras, in respect of different sorts of cloth and different kinds of looms is given below :—

Loom	Kind of cloth	Width	Warp and weft	Rate of picking
Flyshuttle	Long cloth ...	44"	20s × 20s	36
Do.	Fine dhoti ...	46"	60s × 60s	27
Do.	Plain striped shirting ...	35"	2/64 × 30s	60
Do.	Towels with dobby border ...	34"	20s × 20s	36
Do.	Twill shirting ...	38"	20s × 20s	38
Drawboy harness	Saree ...	44"	2/64 × 30s	27
Flyshuttle loom	Fancy shirting ...	45"	60s × 40s	31
Do.	Grey cloth ...	24"	2/42 × 20s	45
Hattersley's	Do. ...	24"	20s × 20s	54
Flyshuttle	Coating with different cotton weft ...	36"	2/30 × 16s	32

sions of the cloth, the count of yarn used, the number of picks per inch, the pattern woven and the kind of loom used. In Statement A, a scale of wage-rates varying in proportion to the number of picks, the width of the cloth and the count of yarn used is adopted to ascertain the probable cost of production on the hand-loom. The weaving rates are so arranged that the weaver gets at least 10 annas a day, for this is 25 per cent higher than the general level of wages. He is given 15 pies per yard when the picks to an inch are 64, 12 pies when there are 52 picks and 9 pies when 40 and below. If he increases his rate of picking, which he can easily do if he uses a frame loom with weaver's beam, he can earn more than 10 annas. Now neither do the average earnings of the most fortunate weaver, nor the daily earnings of the ordinary weaver or the agricultural worker generally work at the rate of 10 annas a day.

A perusal of Statement A shows that the cost of manufacturing cloth in Indian mills is 3 annas 9 pies per pound of yarn of 14s, 5 annas per pound of 20s, 7 annas per pound of 24s, 8 annas per pound of 30s, 8 to 10 annas per pound between 30s and 40s and 12 annas for 44s. It is evident from Statement A that almost all cloths of counts below 40s, not even excepting shirting and drill, (for, the prices of yarn in those cases are overestimated), can be manufactured on hand-looms at the same cost as on power-looms. But in counts above 40s the hand-loom is handicapped because of the very high price of yarn which is maintained at the level.¹ But it may be observed that the cost of production on the hand-loom does not include the cost of supervision, stores, insurance, interest and commission which amount to about 12 to 15 per cent of the cost of production of

¹ The sudden jump in prices of 40s and 50s is very suggestive in the following prices of yarns (in 1928).

Price of grey yarn in Madras in 1928 March.

40s mule	Rs. 1-2-6 per pound.
50s medio	Rs. 1-14-0 "
60s "	Rs. 2- 1-6 "
80s "	Rs. 2- 9-0 "
100s "	Rs. 2- 0-0 "
120s "	Rs. 3- 6-6 "

cloths in mills.¹ The expenses on this count may not be so much on the hand-loom but at least a portion of it will be necessary when the hand-loom is organised on the lines indicated in this book. Against this can be set off the import duty on yarn which the hand-loom pays and the mills in India do not which, at the rate of $1\frac{1}{2}$ annas per pound or 5 per cent *ad valorem* whichever is higher, works at 12 per cent when yarn sells at 12 annas per pound. The savings on account of the abolition of the import duty on yarn will be considerable i.e. $1\frac{1}{2}$ annas per pound. Again, it might be pointed out by the advocate of the power-loom that the hand-loom cloth is not finished, folded and baled as the mill cloth. The cost of production in mills includes the cost of finishing, folding and baling which must be deducted from the cost of production in mills in order to make it comparable with the cost of production on hand-looms. The cost of this ordinary finishing and baling in mills will be from 6 to 9 pies per pound of cloth. Now as against this, there are two items in favour of the hand-woven cloth: (1) the cost of production is cheaper on the hand-loom than on the power-loom by a few annas as indicated in col. 23 of Statement A, and (2) the cost of yarn is calculated on the basis of 9 annas per pound of cotton while the average price of cotton in the year 1925-26 was $7\frac{1}{2}$ annas per pound thus leaving a margin of $1\frac{1}{2}$ annas per pound. Also the price of yarn to the hand-loom weaver includes the profits of the spinners and the commissions of the agents. Though it is not possible to ascertain with any precision the extent of the difference in prices on account of profits, etc., it is not too much to assert that the cost of production on the hand-loom will not at any rate be higher than it is on the power-loom, provided the industry is organised on proper lines.

STATEMENTS

¹ PROPORTION OF MANUFACTURING AND OVERHEAD CHARGES PER LOOM.

—	In Bombay	Percentage of total cost	Up-countries	Percentage of total cost
Manufacturing charges.	453·7 ps.	88 per cent	400·3 ps.	85 per cent
Overhead charges ...	60·36 ps.	12 „	70·9 ps.	15 per cent
Total cost ...	514·16 ps.	100 per cent	471·2 ps.	100 per cent

STATE-
STATEMENT REGARDING THE COST OF PRO-

DESCRIPTION OF THE PIECE	Grey Drill	3640 Gusto Shirting	Waller Yama Mfg. Shirting	AAAA Shirting
(1) Width, length and weight of the piece.	30 × 40 × 13½	36 × 40 × 13½	36 × 40 × 12	36 × 40 × 12½
(2) Count of warp ...	14	14	24	24
(3) Count of weft ...	14	14	24	24
(4) Reed ...	3/40	40	60	2/60
(5) Picks per inch ...	42	44	64	64
(6) No. of warp ends ...	1940	1600	2380	2360
(7) Tape length in yards...	44	43½	42½	43
(8) Size per cent ...	16	28	34	40
(9)a Weight of warp yarn. lbs.	7.25	5.91	5.05	4.64
(9)b Weight of weft yarn. lbs.	4.49	5.39	4.77	4.77
(10) Total weight of yarn in the piece. lbs.	11.74	11.5	9.82	9.41
(11) Cost of yarn. Rs.	7 11 5	7 6 10	7 11 1½	7 11 1
(12)a Cost price of cloth per piece (to the mills.) Rs.	10 6 9	10 4 6	12 0 9	12 7 9
(12)b Net C. I. F. Price of Japanese goods. Rs.	11 5 9	...	...	11 5 9
(13)a Selling price ex-mill. Rs.	11 8 4	11 6 11	13 10 2	14 6 0
(13)b Selling price of Japa- nese goods. Rs.	13 0 0	...	...	13 0 0
(14) Cost of production per piece excluding pro- fits on power-loom (12a-11). Rs.	2 11 14	2 13 8	4 5 7	4 12 8
(15) Cost of production per pound of yarn used. Annas.	3.7	3.9	7.07	7.7
(16) Cost of production per yard of Cloth. Pies.	13	12½	20.8	21.75
(17) Cost of production per pound of Cloth. in mills Annas.	3.2	3.14	5.8	5.9
COST OF PRODUCTION ON HAND-LOOM				
(18) Cost of winding, warp- ing and sizing and beaming on dresser sizer. Rs.	0 14 6	0 11 9	0 15 2	0 15 2
(19) Weaving charges per yard. Rs.	0 0 9	0 0 10	0 1 3	0 1 3
(20) Weaving charges per piece. Rs.	1 14 0	2 1 4	3 2 0	3 2 0
(21) Cost of production on the hand-loom. Rs.	2 12 6	2 13 1	4 1 2	4 1 2
(22) Savings in hand-loom : (difference between Cols. 21 & 14.) Rs.	+0 1 2	+0 0 7	+0 4 5	+0 11 6

N.B.—Cols. 1 to 8, 12 and 13 are taken from the Report and Evidence includes 5% for contraction and a similar allowance is made for wastage. Cost Handloom versus Powerloom. How much of coloured yarn is used is not

MENT A
DUCTION ON POWER-LOOM AND HAND-LOOM

Ali Shirting	Toyo Shirting	3938 Gusto Shirting	9999 Cotton Japan	Toyo Shirting	44000 Shirting	36210 Shirting
36 × 40 × 12	36 × 40 × 12	38 × 38½ × 10	40 × 38½ × 10½	36 × 40 × 5½	44 × 38 × 6½	38 × 38 × 5½
24	24	30	30	36	40	36
26	26	30	36	36	44	46
2/60	2/64	64	68	2/52	2/56	2/56
64	64	60	68	42	48	56
2360	2520	2680	3290	2050	2720	2350
43	43	40½	40½	42½	40	40
42	34	40	17	11	28	12
5.03	5.38	4.31	5.02	2.88	3.24	3.11
4.42	4.42	3.68	3.67	2.10	2.27	2.20
9.45	9.80	7.99	8.69	4.98	5.51	5.31
7 8 7	7 12 9	6 15 7	8 4 8	4 13 6	5 13 6	5 7 11
12 3 9	12 8 0	10 13 0	13 4 3	7 11 6	9 10 3	9 9 0
11 5 9	12 3 9	10 14 9	13 1 8	6 1 6	...	...
14 1 6	14 5 0	12 15 6	15 2 7	8 13 6	11 1 7	11 2 6
13 0 0	14 0 0	12 8 0	15 0 0	7 0 0	...	...
4 11 2	4 11 3	3 13 5	4 15 7	2 14 0	3 12 9	4 1 1
7.9	7.6	7.7	9.2	9.25	11.0	12.2
22.5	22.5	20	25	13.75	19	17.5
6.25	6.25	6	7.6	8.36	9	11.1
0 15 3	1 0 6	0 15 0	1 1 6	0 12 11	0 15 5	0 14 0
0 1 3	0 1 3	0 1 2	0 1 4	0 0 9	0 1 0	0 1 1
3 2 0	3 2 0	2 12 11	3 5 4	1 14 0	2 6 0	2 9 2
4 1 3	4 2 6	3 11 11	4 6 8	2 10 11	3 5 5	3 7 2
+0 9 9	+0 8 9	+0 0 6	+0 8 11	+0 3 1	+0 7 4	+0 9 11

of the Indian Cotton Textile Board. In Col. 9(b) the weight of weft yarn of yarn in Col. 11 is arrived at on the basis of the prices noted in Chapter on stated in the report.

STATE-
CERTAIN FACTS RELATING TO THE PRODUCTION ON HAND-

Particulars.	Longcloth Loom No. 1.	Fine cloth with Dobby harness Loom No. 2.	Plain Striped Shirting Loom No. 3.	Towels with Dobby Border Loom No. 4.
Count of warp ...	20	60	2/64	20
Count of weft ...	20	60	30	20
Count of reed ...	44	72	72	48
Picks per inch ...	48	72	80	48
Width of warp in reed (inches) ...	44½"	46"	35½"	34½"
Width of cloth on the Counter (inches).	41½"	42½"	32½"	32½"
Weight of warp per yard of cloth (in ounce)	2 oz.	1½ oz.	1.55 oz.	1.65 oz.
Weight of weft (in ounce) ...	2½ oz.	1½ oz.	1.85 oz.	1.65 oz.
Contraction in warp ..	5%	5%	5%	5%
Contraction in weft ...	6½%	8%	7%	6%
COST OF PRODUCTION PER YARD	Rs A P	Rs A P	Rs A P	Rs A P
Cost of yarn ...	0 1 3	0 2 9	0 2 6	0 2 1
Cost of weft yarn ...	0 1 4		0 1 7	
Cost of warp preparation including sizing.	0 0 6	0 0 8	0 0 3	0 0 5
Cost of weft preparation and weaving.	0 0 11	0 2 4	0 1 0	0 1 0
Cost of bleaching and Dyeing...	...	...	0 0 3	...
Cost per yard of cloth ...	0 4 0	0 5 9	0 5 7	0 3 6
Cost of production per yard includes preparation and weaving charges only.	0 1 5	0 3 0	0 1 6	0 1 5
Production per day of 8 hrs. (actual results).	10 yds.	5 yds.	10 yds.	10 yds.
Weaver's earnings per day Rs.	0 9 2	0 11 8	0 10 0	0 10 0
Length of cloth per pound (in yard).	3½ yds.	6½ yds.	4½ yds.	4.6 yds.
Cost of production per lb. of yarn used in the cloth excluding the price of yarn and charges for bleaching and dyeing.	Re. 0 5 6	1 5 4	0 5 10½	0 6 10

MENT B.

LOOMS IN THE GOVERNMENT TEXTILE INSTITUTE, MADRAS.

Twill Shirting Loom No. 5.	Fancy Shirting Two (Shuttles) Loom No. 9.	Sari (draw boy harness). loom.	Looms 27 & 28 (two weavers) Double loom.	Salvation Army Loom No. 33.	Hattersley Domestic Loom No. 35.	Coating (multiple Shuttle) loom.
20	60	2/6	2/20	2/42	20	2/30
20	40	30	10	20	20	16
52	80	72	40	52	44	60
64	84	72	40	50	48	72
33½"	46"	4½"	48"	23½"	44"	35½"
30½"	43"	42½"	46½"	22"	40½"	32½"
1½ oz.	1.3 oz.	2½ oz.	4 oz.	1½ oz.	2 oz.	3 oz.
2.15 oz.	2 oz.	2½ oz.	4 oz.	1½ oz.	2 oz.	3.1 oz.
4½%	6%	5%	6%	4%	5%	6%
10%	7%	5%	3½%	7%	8½%	9%
Rs A P	Rs A P	Rs A P	Rs A P	Rs A P	Rs A P	Rs A P
0 2 4	0 1 6	0 3 11	0 2 10	0 1 2	0 1 3	0 2 9
0 0 6	0 1 6	0 1 7	0 1 9	0 0 8½	0 1 3	0 1 9
0 1 3	0 0 9	0 0 3	0 0 3	0 0 1½	0 0 6	0 0 0
...	0 2 6	0 2 6	0 0 8	0 0 8	0 0 9	0 1 9
...	0 1 0	...	...	...	...	0 1
0 4 1	0 7 3	0 8 3	0 5 6	0 2 8	0 3 9	0 8 0
0 1 9	0 4 3	0 2 9	0 0 11	0 0 9½	0 1 3	0 3 6
yds.	5 yds.	5 yds.	24 yds.	12 yds.	15 yds.	6 yds.
0 10 0	0 12 6	0 12 6	0 8 0	0 8 0	0 11 3	0 10 6
4 yds.	4½ yds.	3½ yds.	2 yds.	6½ yds.	3½ yds.	2½ yds.
0 7 2	0 15 9	0 9 9	0 1 10	0 5 4	0 5 0	0 5 3

CHAPTER XVIII

COTTON FABRICS

MR. PATEL, a former Director of Agriculture and Industries of Baroda, prepared an estimate of the quantity of different kinds of cloth consumed in India and the extent of supply from (1) foreign imports, (2) Indian mill production and (3) hand-loom production in India.¹

(In Million yards).

Class	Counts of warp	Counts of weft	Hand-loom supply		Indian mills	Foreign imports	Total consumption of cloth	
			Patel's	Corrected ²			Patel's	Corrected ²
Coarse ...	6-20s	6-20s	900	600	60	300	1,260	960
Coarse-medium ...	20-26s	20-40s	150	100	500	1,100	1,750	1,700
Medium ...	26-40s	30-50s	450	300	40	750	1,240	1,090
Fine ...	over 40s	over 50	150	100	...	350	500	450
Total...			1,650	1,100	600	2,500	4,750	4,200

It is not stated how he arrived at the output of hand-loom. He evidently estimated the hand-loom supply on the basis of 6 yards to a pound of yarn. The Indian Textile Tariff Board (1926) took 4 yards of cloth to a pound of yarn and on that basis the corrected figure in the above table is arrived at. The Tariff Board (1930) considered this to be an over estimate. While 3 to 10 sq. yards of cloth can be manufactured from a pound according to the count of yarn and nature of the cloth, we are safe to assume that on an average a pound of yarn is equal to 4 yards of cloth.

The above table was prepared in 1906-07. As denoting generally the relative importance of cloths of different fineness, it is fairly accurate. The bulk of the consumption of cloth i.e. 60 per cent was made of coarse and coarse-medium yarns. Medium accounted for 25 per cent. This is

¹ *Indian Review*, 1907.

² (Corrected 1 lb. = 4 yards of cloth.)

nearly so even today though the relative importance of the hand-loom, the Indian mill and foreign cloths has changed.

From the available statistics the changes in the hand-loom and in mill consumption of yarn cannot be correctly stated. But certain conclusions are possible from Mr. Patel's table. The bulk of coarse cloth i.e. over 65 per cent was prepared by the hand-loom; the shares of the Indian mills and foreign imports in coarse-medium amounted to 90 per cent; and regarding cloth of the medium and fine counts, the foreign imports accounted for nearly two-thirds of the supply while the hand-loom supplied the other third. The share of the Indian mills was insignificant, though of late it has increased considerably.

THE NATURE OF THE SUPPLY AND CONSUMPTION OF CLOTH

Though definite statistical information is not available on this point, it is possible to state broadly the extent and nature of the supply from the three sources of (1) hand-loom, (2) Indian mills, (3) foreign imports. In 1926-27 which was a normal year and when there were no heavy protective duties nor boycott of foreign goods, the estimated Indian consumption of 5290 million yards was made up of 1758 million yards of foreign imports, 2166 million yards of Indian mill goods and 1366 million yards of hand-woven cloth.

The cloths can on the basis of the fineness of yarn used, be grouped under three heads:

- (a) coarse: below 24s
- (b) medium: 24-40s
- (c) fine: above 40s.

On a careful study of the cloth market and the literature on the subject the following points suggest themselves:—

(1) Regarding imported cotton piecegoods, the bulk of the import is of medium counts i.e. 24s to 40s. The bulk of the Japanese cloth imported is of the coarser variety. As regards the coarse and grey cloth events have shown that Lancashire has lost much ground in competition with the east. It is observed by the Committee on Industry and Trade (U.K.) that the fall in the exports of coarse grey cloth to

India was great after the war and the Indian mills captured the local market. Now the total imports of foreign piece-goods have declined, and the fall is greater in the common varieties of grey coarse goods than in finished goods. But how far this decline is made good by the Indian mills and hand-looms respectively, it is difficult to state. Lancashire is now said to be specialising in the production of non-competitive goods. It stands to reason to assume that there has been a slight increase in the import of non-competitive piecegoods, such as finer grey cloths and white and coloured piecegoods of fine counts.

(2) As for the Indian mill production, the nature of the mill consumption of yarn is determined by the progress in the spinning section of the mills. The mills were producing about 600 million yards in 1906 and today they produce nearly 3,000 million yards. An examination of the quantity of the different counts of yarn spun in Indian mills suggests that the mill production of cloth is mainly in counts from 16s to 36s. The consumption of fine counts yarn is still small.¹

PRODUCTION OF YARN IN INDIAN MILLS
(in million lbs.)

Counts	1903	1913	1926	1931	1934
1 to 10	149	131	115	114	109
11 to 20	342	362	401	400	453
21 to 30	123	167	248	259	274
31 to 40	22	20	27.5	60.7	91
above 40	2.7	2.7	11.5	27.3	42

¹ Mr. Hardy, I.C.S., in his *Report* estimates that over 90% of the goods produced in Indian mills is of counts below 30 and that the consumption of counts above 40 is less than 4%. The consumption of finer counts by hand-looms is comparatively larger. The writer is of opinion that the hand-loom has not been worsted by the power-loom in India in respect of fine cloth manufacture. But the scope for the extension of its manufacture is limited. Those who talk of hand-loom taking to the production of finer counts cloth are not evidently aware of the difficulties of the hand-loom such as (a) the limited demand for such goods, (b) the dependence for yarn supply on Lancashire which enjoys a practical monopoly of it, and (c) the more formidable opposition of foreign interests.

At present the export of yarn to other countries is almost negligible being less than 3 per cent of the total manufacture. Nearly the whole quantity is consumed by Indian mills and hand-looms. It is difficult to estimate the exact quantity of different kinds of yarn consumed by mills and by hand-looms respectively. But it is safe to assume that weaving mills which are also spinning mills mainly produce such kinds of yarn as are required for their own consumption. Foreign imports of cloths made of coarse-medium and medium count yarn and hand-loom manufactures of medium grey cloths having declined, the increase in the production of cloth in Indian mills must have been in the class of fabrics employing yarns from 16s to 36s.

(3) The hand-loom manufactures have increased from 260 million lbs. in 1907-8 to 320 million lbs. in 1926-7, and 390 million lbs. in 1932-33. But the increase is mainly in the production of cloths made of coarse and coarse-medium yarn (14s to 36s) obtained from local mills. Regarding the province of the hand weaving industry, it is well known that cloth of coarse yarn is the monopoly of hand-looms, that the bulk of very coarse cloths is woven on them from Indian mill yarn. This is made from very inferior cotton. Some of the mills in Bombay tried to produce this class of cloth but the yarn could not stand the speed of the power-loom. They had to give it up as a bad business.¹ This cloth is very thick, warm and durable and is made everywhere in the country for local sales. This may, therefore, be considered as coming within the absolute sphere of the hand-loom. Foreign cloth of this class was being once imported but with the increased local production the foreign imports have practically ceased; but before 1935 Japan was a formidable competitor.

In regard to the production on hand-looms certain conclusions are possible: (a) the coarse counts yarn is the monopoly of hand-looms; (b) hand-looms consume practically all the imported yarn, (It was estimated that of 47 million lbs. of yarn imported in 1920-21, 44 million lbs. were used by the

¹ Mukerjee's *Foundations of Indian Economics*.

hand-loom;¹ (c) that the rest of the yarn consumed by hand-loom is from Indian mills of counts 12s and above. On this assumption the following comparative table of the hand-loom production for 1908-09 and 1926-27 and 1931-32 is made out:—

Yarns available for hand-loom
(In million lbs.)

	1907-1908	1926-1927	1931-1932
I. Below 10s. Indian yarn ...	148½	108	114
II. 11s. to 40s. Do. ...	77	166	174
III. Above 40s. Do. ...	nil	4²	13*
IV. 11s. to 40s. foreign yarn. ...	26½	29	16
V. Above 40s. imported yarn ...	7½	8½	13
Total ...	259½	315½	330

The progress in the hand-loom production is mainly in the class of goods produced from the coarse-medium and medium and also fine yarns. There is a decline in the output of very coarse yarn which is used for the manufacture of jamakkalams, durries, dhupatis, carpets, and for making cotton ropes and strings. The coarse medium from 16s to 26s is employed in the manufacture of coloured goods and sarees. The medium yarn is used for lungis, kailis and sarees. Grey cloths such as towels, dhoties, bedsheets etc., are also produced from the coarse and medium counts. Grey and bleached men's wear such as dhoties and upavasthrams and laced cloths are usually manufactured from fine yarns.

THE CHANGES IN THE RANGE OF GOODS SUPPLIED BY HAND-LOOMS, INDIAN MILLS AND FOREIGN IMPORTS.

The case of the hand-loom can be dismissed with a word. There is no statistical information regarding the quantity

¹ Ainscough, *British Trade in India*, 1921, p. 34.

² It is assumed that yarns above 40s produced in Indian mills are shared equally by the hand-loom and the power-loom.

and varieties of goods manufactured on the hand-loom. The difficulty of collecting information systematically and comprehensively regarding the volume and kinds of output in this cottage industry is obvious. All that can be said is that the production has increased about 20 per cent mainly in coloured cotton fabrics and cloths with solid border, or some special weave or having a mixture of silk, artificial silk or gold lace.

To begin with *foreign imports*. Before 1910 nearly 60 per cent of the demand for cloth was met by foreign imports. In 1927 they did not exceed 30 per cent of the total consumption of cloth. In 1931 they declined to 14 per cent. A comparison of the various items of imports during 1907-08 and 1933-34 will be interesting and indicate in what lines there is either an increase or decrease. (*Vide Tables below.*) The imports are grouped under three heads: (a) grey, (b) white or bleached and (c) coloured, dyed or printed. Each group is again sub-divided according to the trade name of the cloth (a) dhoties, sarees and scarves, (b) drills and jeans, (c) T-Cloths and domestic, (d) long cloth and shirting, (e) nainsooks, (f) prints and chintz, (g) jaconets, madapolam, mulls and cambrics and others.

IMPORT OF COTTON PIECEGOODS INTO INDIA

(In million yards)

(A)

1907-8

	Grey	White	Colour	Total
1. Dhoties, sarees and scarves ...	501	79	50	630
2. Longcloth and shirtings ...	581	156	62	799
3. Jaconets including cambrics, madapolam mulls ...	139	200	73	412
4. Nainsooks ...	...	247	...	247
5. Prints and Chintz...	...	...	200	200
6. Others...	32	51	159	242
Total ...	1,253	733	544	2,530

(B)

1925-26

	Grey	White	Coloured	Total	Percent- age of 1907-1908
1. Dhoties, sarees and scarves ...	428	72	29	529	84%
2. Longcloth and shirting ...	170	94	72	336	42%
3. Jaconets, cambrics, madapolam, mulls ...	80	177	34	291	70%
4. Nainsooks ...	...	77	...	77	31%
5. Prints and Chintz...	...	...	56	56	28%
6. Others...	22	45	174	241	...
Total ...	700	465	365	1,530	60.4%

(C)

EXTENT OF THE FALL IN IMPORTS IN 1925-26 AS COMPARED
WITH THE IMPORTS IN 1907-08.
(In million yards)

	Grey	Bleached	Coloured	Total	Percent- age of decline
1. Dhoties, sarees and scarves ...	73	7	21	101	16%
2. Longcloth and shirting ...	411	62	+ 10	463	58%
3. Jaconets, cambrics, Madapolam, mulls ...	59	23	39	121	30%
4. Nainsooks etc. ...	...	170	...	170	69%
5. Prints and Chintz...	...	...	144	144	72%
6. Others...	10	6	+ 15	1	...
Total decline ...	553	268	179	1,000	39.5%
Percentage total decline ...	44.2	35.5	32.9	39.5	

The following points are well brought out:—

(1) The fall in the import is greater in the case of grey goods than in that of bleached and coloured ones. The market is now captured by Indian mills.

(2) Of the first five classes of cloths enumerated in the table which themselves represent nearly 85 to 90 per cent of the total imports, the greatest fall quantitatively, however, is in respect of long cloth and shirting and dhoties and sarees. They declined from 1429 to 865 million yards—a drop of 564 million yards. This fall is made up by an increase of 671 million yards of long cloth and shirting and dhoties produced in Indian mills. The drop is also great in respect of prints and chintz of the coloured group and nainsook of the bleached group.

Production in Indian Mills has increased from 800 million yards in 1907-8 to 2,200 million yards in 1926-27 and over 3,000 million yards in 1932-33. The production is classified under three main heads (1) grey and bleached; (2) coloured piecegoods and (3) cloths other than piecegoods i.e. hosiery, cotton mixed with silk or wool. The first group is again sub-divided into ten heads according to the trade names of fabrics. If the volume of production of grey and bleached goods is separately stated, it would enable us to note the direction in which the mill industry has advanced.

The accompanying table will indicate in what lines the mill production in India has advanced since 1907-08.

PRODUCTION OF CLOTH IN INDIAN MILLS
(In million yards or dozens or pounds)

	1907-1908	1926-1927	Increase or decrease
(1) Grey and Bleached Piece goods—			
Chaddars ... yds. ...	42.8	65.5	+ 23
Dhoties ...	237.9	585.7	+ 348
Drills and Jeans ...	21.5	79.7	+ 58
Prints ...	7.7	20.9	+ 13.2
Shirting and longcloth ...	207.2	580.0	+ 373
T. cloth, domestics, sheetings ...	120.3	93.0	- 27
Khadi, dhungri and Khaddar ...	26.1	98.7	+ 72.6
Tent cloth ...	2.5	6.7	+ 4.2
Other sorts...	14.0	42.7	+ 28.7
Total of Grey and Bleached goods...	680.0	1,577.2	897.2

	1907-1908	1926-1927	Increase or decrease
(2) Coloured piecegoods ... yds. ...	128.3	681.5	+ 553
(3) Grey and coloured goods other than piecegoods ...	0.46	dozens 1.01	+ 0.55
(4) Hosiery ...	0.27	„ 0.35	+ 0.12
(5) Miscellaneous ...	0.19	lbs. 4.29	+ 3.1
(6) Cotton goods mixed with silk or wool ...	—	„ 2.31	+ 2.31
Total ...	808.4	2,258	+ 1450

Thus it is evident that there has been an increase in the output all round except in the case of T.-Cloth, domestic and sheetings. The increase is important, however, in respect of coloured piece goods, long cloth and shirtings, dhoties and drills and jeans stated in the order of importance. Of the total increase of 1,450 million yards, coloured piecegoods, long cloth and shirting, and dhoties alone account for 1,250 million yards. The increased Indian output in coloured goods is not the result of corresponding fall in foreign imports which indicates that the imports under that head are of the non-competitive type.

Since 1926-7 there has been a further decline in foreign imports followed by an increase in the Indian mill production due mainly to the policy of protection. The following table will indicate that while total consumption of certain staple varieties remains more or less constant, Indian mill goods are rapidly replacing foreign imports:—

	1926			1934		
	Foreign imports	Indian Mills	Total	Foreign imports	Indian Mills	Total
Grey and White						
(1) Dhotis and Saris ...	619	590	1209	102	1073	1175
(2) Chaddars ...	1	65	66	...	59	59
(3) Long cloth and Shirting	336	587	923	207	827	1034
(4) Drills and Jeans ...	20	80	100	5	117	122
(5) Cambrics and lawns ...	16	3	19	6	113	119
(6) T.-cloth, Domestic and Sheetings ...	24	84	108	3	159	162
(7) Coloured, dyed or print- ed ...	429	645	1074	341	734	1075

Jaconets, madapollams, and mulls besides fine dhoties, sarees, long cloth and shirting, and coloured fabrics are the only varieties of foreign imports that have maintained themselves against Indian mills competition.

THE RANGE OF PRODUCTION ON HAND-LOOMS

The products of the hand-loom can be classified with reference to the fineness of yarn used in their manufacture, the colour of goods produced, and the arrangement of the warp and weft threads. These variations constitute the various patterns which are produced,

- by the use of different coloured yarns,
- by the use of more than a single pair of treadles,
- by both these means,
- by specially interweaving yarn on a set system as the weaving of the fabric proceeds, and
- by processes subsequent to the weaving as needle work and embroidery.

To this classification must be added patterns which are the result of printing and dyeing.

It must however be remembered that this classification is neither exhaustive nor exclusive and there is a great confusion with reference to the names of fabrics in the various districts. Again it would be tedious, uninteresting, probably out of place to mention all the details regarding ends, picks, warp, weft, weave, colour, texture etc., of all hand woven fabrics. Therefore, they would be considered under three main heads:—

I. Plain woven grey materials.

II. Plain woven coloured or printed fabrics.

III. Patterns requiring more than one pair of treadles, coloured, printed and white.

I. *Plain woven uncoloured materials.*—The typical fabrics of this kind are dhupatis, bedsheets, dhoties, thundus, chaddar, munduhs. They are usually of coarse count yarn obtained mainly from Indian spinning mills. The yarn used is usually coarse. With the increased handspinning which supplies coarse yarn plain shirtings are also now woven. The counts used vary from 8s to 24s. According to quality the

number of threads varies from 24 to 48 per inch. They are all strong thick material as closely woven as the yarn used will permit. This kind of fabrics is used generally by the poorer classes for clothing, bedsheets, blankets, and wrappings. The fabrics under this group differ only in respect of their length and width rather than of materials used. The dhoti is used as the loin cloth, the thundu or dupatta is a sort of scarf worn loosely round the neck or over the shoulders or sometimes as the head dress. The materials of which these are made vary according to taste, caste and wealth of the consumer. The plain coarse white cloth of 6 yards is usually favoured by the Vellala women in the south.

Fine upavasthras, and veshties and turban cloths are also woven in various parts of the country. The yarns used vary from 40s to 200s. The ends and picks vary from 60 to 80 per inch. Plain muslins and white sarees are also woven with nice coloured borders or with gold lace and silk borders.

II. *Plain woven Coloured Fabrics.*—Under this head come the coloured checks and stripes used by men and women for apparel, such as sarees, pyjamas, urumals, turban cloths, carpets, bedsheets, Madras handkerchiefs, lungis and shirtings with stripes and check effect. The carpets are specially made of very coarse yarn. The lungis generally have 32s warp and 36s weft. The Madras handkerchiefs have 40s and 50s warp and 60s weft. The texture and the number of ends and picks per inch vary in respect of each cloth. But on an average 42 to 64 picks are put in per inch, though in the case of lungis and handkerchiefs, the picks and ends are twice as many. But the bulk of the production under this group consists of sarees made of coarse count yarn with or without figured borders, and they are worn generally by the poor agricultural and the lower middle class women.

III. *Patterns requiring more than one pair of treadles.*—Twills, drills, satins and figured cloths fall under this group. They are produced in hand-loom factories in the West Coast, Madura, and Salem Districts. Sateens are still produced in Ayyampet in Tanjore District.

Another classification of the hand-loom products is based

on the nature of the border: (1) solid bordered cloth, and (2) cloth with ordinary border. The former requires more than one shuttle and one weaver, as the weft yarns for the border and the body of the cloth are different e.g. Bangalore sarees.

ANALYSIS OF MILL CLOTHS

We shall now examine the reeds and picks, the counts of warp and weft yarns, the nature of the weave and the finish of the chief classes of mill goods, both foreign and Indian, with a view to see the extent to which they can be produced on hand-looms; for the future of the hand-loom industry depends on its regaining its lost ground.

Long cloth and Shirting. The total consumption under this head is more than 1,000 million yards: 200 million yds. from other countries and 820 million yds. from Indian mills. *Long cloth and shirting* are plain woven cloth, grey bleached or coloured, manufactured in various widths. 36s for warp and 38s for weft for imported long cloth and 32s for warp and 40s to 50s for weft for imported shirtings are used. There are different qualities both in long cloth and shirting, the reeds and picks varying from 42 to 46 per inch.¹ The Indian long cloth and shirting are coarser and more heavily sized.

Dhoties, Sarees, and Scarves total 1,150 million yards, 90 per cent being from Indian mills. All of them are plain-weave, while in the case of dhoties and sarees the border is also 'crammed' and coloured. The imported dhoties and sarees are made of 30s/40s for warp and 36s/46s for weft and have from 56 to 66 ends and picks per inch. Imported dhoties are of three kinds: (1) shirting dhoti where the warp is less than 40s, (2) jaconet dhoti where the warp is from 40s to 48s, (3) mull dhoti of finer warps.² The sarees are of similar texture and pattern but the border design and the

¹ The term '*shirting*' is often used with reference to quality. In the sizes given above very little cloth woven from finer yarns than 40 to 44s is shipped to India and shirting quality is therefore used to indicate a cloth not exceeding this limit of fineness. However white shirting is often made from the finer counts yarn and is normally 40 yards in length.

² Hardy's *Report*.

length of the piece are different from those of dhoties. The scarves are most loosely woven with 44 to 60 ends and 36 to 60 picks; and from 28s to 34s for warp and from 32s to 40s for weft are employed.

Next in importance come the *Jaconets*, *Mulls*, *Nainsooks*, *Madapollams* and *Cambrics*. *Jaconets* are plain grey cloths with 64 ends and 52 picks, woven with 38s for warp and 40s for weft. They are made of all widths but generally from 18 to 22 yards in length. *Mulls* are plain woven cloths, mainly bleached with 64 to 80 ends and picks woven with different kinds of yarn from 60s to 100s, both for warp and weft. *Nainsooks* are also plain bleached cloths made in various qualities from the fineness of cambrics downwards. *Cambrics* are fine woven plain cloths with 60s warp and 50s weft. *Madapollams* are bleached plain cloths used by ladies for underwear. They have from 72 to 80 picks and 84 to 96 ends and are woven with yarns from 50s to 60s for warp and weft. *Domestics* are plain heavy grey cloths; the warp is finer than the weft and the length is from 20 to 66 yards with various widths.

T.-Cloth, *Domestics* and *Sheetings*. They are heavy piece-goods. *T.-Cloth* is a plain heavy grey cloth. The warp and weft are usually of the same count and the length is 24 yards with different widths. *Domestics* have a finer warp than weft. *Grey sheeting*, as known in the Indian trade, is a plain heavy grey cloth and has the warp coarser than the weft, the usual dimensions being 35 ins. by 40 yards weighing from 14 to 17 lbs. per piece. *Voile* is an open mesh wiry fabric of a plain weave and hard twist cotton. *Printers* constitute a class of coarse grey cloths of special dimensions and specially surfaced to receive a printed pattern. The machine-printing industry has always been very small but there is a considerable output in the Indian mills which is used for hand-printed quilt covers. *Prints and chintz* form a particular class of coarse printed goods of special dimensions. In the 'dyed' print goods printing is done on dyed cloth, while in 'printed' this is done on grey or white pieces. The *lungi* is a coloured garment generally with a pronounced check and is worn in Burma with the two ends stitched together. The length is from 2 to 2½ yards. The *sarong* is the Malay equivalent of

the *lungi* and like the latter is a nether garment. The cotton *lungi* or *sarong* is worn by the poorer classes of Burma, men and women alike, and by certain classes of men in East Bengal, Ceylon, and the Muslims in South India. *Dungri*, *khaddar* and *khadi* are coarse cloths woven from the lowest counts of yarn. They are sold in competition with the hand-loom cloth from hand-spun yarn. *Coatings* and *trouserings* are terms applied to a variety of heavy coarse fancy cloths, sometimes loaded almost to the consistency of serge or felt; tweeds and checks are similar to coatings and trouserings. *Checks*, *spots* and *stripes*, as applied to white goods, imply self-coloured patterns woven by the use of different kinds of white yarn or by modification of the weave in different parts of the cloth.¹

The nature of the weave is also an important point for investigation. It is well known that the texture of a cloth is largely dependent on the manner in which the warp and weft threads are interwoven. The 'plain' weave which is adopted for the majority of cloths is that in which each thread in either direction runs alternately under and over another in the opposite direction. Another common weave is the 'twill' in which the method of interlacing warp with weft describes a uniform diagonal line on its surface. There are some special weaves as *bird's eye pattern* (produced on four shafts), *sateen* and *Italian* (generally of five shafts or more), *honey comb* and *mat weave*.

Cotton fabrics can again be classified into three kinds according to their finish (a) grey, (b) bleached or white, and (c) coloured. Cloth can be finished in different ways by (i) filling and finishing with starch and additional weight, (ii) calendering, (iii) mercerising, (iv) bleaching, (v) printing, and (vi) dyeing. Cotton fabrics can also be classified into (i) garment units and (ii) piecegoods. The former is distinguished from the latter by 'borders' and 'headings'. At present the hand-loom produces more garment units than piecegoods.

¹ W. Hough, *Cotton Fabrics*. Hardy's Report and Industry Year Book, Calcutta.

We can now divide the cotton fabrics according to their weave, finish and tradenames as follows:—

Plain weave		Special weave	
Garment units	Piecegoods	Garment units	Piecegoods
GREY— Chaddars, dhoties, sarees and scarves	Jaconet, mull, madapollam, cambric, longcloth shirting, printers sheeting, T. cloth and domestics	...	Drills and jeans.
WHITE— Chaddars, dhoties, sarees and scarves	Mulls, jaconets, madapollam, cambrics, muslins, lawns, nainsooks, longcloth and shirting	...	Checks, spots and stripes; drills and jeans and twills.
COLOURED— Chaddars, dhoties, sarees and scarves, lungis, sarong	Cambrics, madapollam, muslins, mulls, jaconets, shirting	...	Checks, spots and stripes, drills and jeans twills.
PRINTED GOODS— Printed dhoties, sarees, etc.	Prints and chintz	...	...

Regarding the manufactures in Indian mills more than 95 per cent relate to the fabrics woven out of coarse and medium count yarn i.e. from 14s to 32s and nearly 80 per cent of them are plain weave.

Now we shall make a comparative table of the relative importance of the foreign imports, the Indian mill production and the hand-loom manufactures in the Indian market in 1926 and in 1934, the former representing the post-war protection period and the latter representing the present day of discriminate protection and Imperial preference:—

SUPPLY OF CLOTH

(In million yards)

Cloths of	1926					1934				
	Imports	Indian mills	Hand-loom	Total	Percentage of total consumption	Imports	Indian Mills	Hand-loom	Total	Percentage of total consumption
Coarse counts : 1s-25s	250	1675	985	2910	53.4	...	1950	1000	2950	53.9
Medium counts : 26s-40s	850	500	215	1565	29.8	375	1025	275	1675	30.6
Fine counts : Above 40s	650	25	100	775	14.8	500	225	125	850	15.5
Total ...	1750	2200	1300	5250	100	875	3200	1400	5475	100

[N.B.—It is assumed that 4 yards of cloth can be manufactured from one pound of coarse yarn, 4½ yards from medium counts and 6 yards from fine yarn.]

It is evident from the above table that

- (1) the total consumption of cloth has increased under all three heads: coarse, medium and fine;
- (2) the imports of coarse cloth have practically ceased and of medium and fine qualities have declined 56 per cent and 23 per cent respectively;
- (3) the fall in the imports is made up by increased Indian production; but the benefit to the hand-loom is very insignificant;
- (4) there is a tendency for greater preference for cloths of medium and fine yarns due partly to the system of protection; but there is no marked change in their percentage of total consumption. This suggests unmistakably that the scope for fine goods which the well-wishers of hand-loom weavers desire them to produce is limited, for the demand for the fine goods at their prices is almost inelastic. It is also doubtful whether fine goods can be produced on hand-looms as economically as they are produced on power-looms. Further

this will drive them into a hopeless competition with the powerfully organised mill industries both at home and abroad. Therefore much cannot be hoped for by inducing hand-loom weavers to use more of fine yarns. They must capture, if they are to prosper, the other vast spheres of the power-loom.

Now our enquiry regarding the weave and the counts of warps and wefts etc., of imported and Indian mill fabrics reveals that:—

- (a) about 1,750 million yards produced in Indian mills are of plain weave with warps below 25s;
- (b) about 500 million yards produced in Indian mills are of plain weave with warps above 25s but below 32s;
- (c) about 250 million yards of Indian mill manufacture and 300 million yards of foreign imports are of plain weave with warps above 32s but below 40s;
- (d) about 450 million yards of foreign goods and about 200 million yards of Indian mill goods are of plain weave with warps above 40s and
- (e) about 500 million yards of Indian mill goods and 150 million yards of foreign goods are of special weave.

For special weaves hand-looms are less suited than power-looms as the automatic device in the latter makes the manipulation of the shafts much easier than the treadles in hand-looms.¹ Advantages in respect of finishing, large scale production, etc., can be secured for hand-looms by establishing central finishing and dyeing factories and co-operative centralisation of the business.² Limitations imposed by mechanical devices are the only limitations to the development of the hand-loom industry. In the production

of plain woven cloths, especially of yarns below 40s, hand-looms seem to have the same advantage as power-looms. The extent of this class of goods now produced in mills in India and imported from abroad is nearly 3,000 million yards, a part of which, if produced on hand-looms, can employ over two more million persons. If this were done along with the development of the present lines of hand-loom production the lot of the hand-weavers can be infinitely improved.

¹ It is interesting to note that in the Government Textile Institute, Madras, cotton voiles are now manufactured on handlooms at almost the same cost as in mills.

² The cost of finishing (which relates to filling, bleaching, dyeing, printing, folding, baling etc.,) varies from one anna to twenty annas per pound of cloth according to the nature of the finish. *Balfour Committee Report* and Anro Pearse: 'Indian Cotton Mills.'

TABLE A

DETAILS OF COTTON PIECEGOODS IMPORTED FROM OTHER
COUNTRIES AND PRODUCED IN INDIAN MILLS IN
1927-28 (IN MILLION YDS.)

Names of cloths	Imported from other countries						Indian mills		Grand Total
	Grey	White	Coloured				Grey and bleached goods	Coloured goods	
			Printed	Dyed	Woven	Total			
Dhuti, Sari, Scarves and Chadder ...	528	72	23	24	3	50	66 (Chadder)	...	716
Saris and Scarves ...	...	...	30	3	5	38	616 (Dhuti)	...	654
Jaconets, mulls, madapollams, cambrics, muslins ...	80	16	...	...	...	...	...	...	304
Mulls ...	...	208	...	...	...	...	...	...	
Cambrics and lawns ...	...	8	...	...	...	...	5½	...	13½
Long cloth and shirting ...	223	112	...	...	...	...	...	...	
Sheeting ...	...	...	29	39	20	88	620	...	1,053
T.-cloth and Domestic sheetings ...	23	...	...	...	...	...	39	...	
Drills and Jeans ...	11	7	31	10	23	64	92	...	62
Checks, spots, stripes. ...	...	14	2	10	7	19	...	...	174
Nainsooks ...	...	93	...	...	...	...	...	...	33
Twills ...	...	15	15	13	12	40	...	...	93
Flannels and Flannel ...	...	...	12	4	4	20	...	...	55
Sarong and Lungis ...	...	...	11	...	9	20	...	...	20
Prints and Chintz ...	...	...	68	2	...	70	...	...	20
Sateens and Italians ...	...	...	5	25	...	30	...	...	70
Velvet and Velveteen ...	...	...	...	...	2	2	...	...	30
Coating and Trousering ...	...	...	...	...	9	9	...	...	2
Printers ...	...	...	...	...	...	...	20	...	9
Tent cloth ...	...	...	...	...	...	...	6	...	20
Khadi, Dungri and Khaddar ...	...	...	...	...	...	...	116	...	6
Unspecified ...	1	11	9	28	17	54	41	681	116
Total ...	876	556	235	158	111	504	1 621½	681	4238½

TABLE B

DETAILS OF COTTON PIECEGOODS IMPORTED FROM OTHER
COUNTRIES AND PRODUCED IN INDIAN MILLS IN
1934 (IN MILLION YDS.)

Names of cloths	Imported from other countries				Indian mills		Total of all goods
	Grey	White	Colour- ed	Total	Grey & bleach- ed goods	Colour- ed goods	
Dhoties, Saries and Scarves ...	92.9	8.9	...	101.8	1073	...	1174.8
Saries and scarves ...	...	...	22.6	22.6	...	...	22.6
Sarongs and lungis ...	...	...	14.0	14.0	...	...	14.0
Chaddar ...	0.7	...	...	0.7	59.1	...	59.8
Khadi, Dungri and Khaddar ...	...	...	...	...	101.6	...	101.6
Cambrics ...	...	...	44.2	44.2	112.7	...	162.9
Lawns ...	...	6.0	...	6.0			
Jaconets, Madapollems, Muslins and Mulls ...	23.2	23.3	...	46.5	...	...	177.8
Mulls ...	...	131.3	...	131.3	...	...	
Long cloth ...	134.5	...	...	134.5	827.3	...	1116.0
Shirting ...	...	...	81.5	81.5			
Long cloth and Shirting ...	...	72.7	...	72.7	...	...	25.0
Twills ...	...	6.4	18.6	25.0			
Nainsooks ...	...	14.1	...	14.1	...	...	14.1
Drills and Jeans ...	0.8	4.1	52.2	57.1	117.0	...	174.1
T.-cloth, Domestic, and Sheetting ...	2.5	0.1	...	2.6	158.6	...	161.2
Checks, Spots, and Stripes ...	...	4.2	14.4	18.6	...	...	18.6
Flannels and Flannets. ...	...	0.1	9.4	9.5	...	...	9.5
Printers ...	...	...	...	...	18.9	...	18.9
Prints and Chintz ...	...	...	28.4	28.4	...	...	28.4
Sateens and Italians ...	...	...	23.2	23.2	...	...	23.2
Velvet and Velveteens...	...	...	6.3	6.3	...	...	6.3
Coating and Trouserings ...	...	...	3.4	3.4	...	...	3.4
Embroidered ...	4.1	...	2.7	6.8	...	...	6.8
Tent cloth ...	...	...	...	...	5.7	...	5.7
Unspecified ...	1.0	2.1	19.7	22.8	...	734.4	757.2

TABLE C

THE COUNT OF YARN IN THE WARP AND WEFT, THE NUMBER OF PICKS AND ENDS PER INCH AND THE NATURE OF THE WEAVE OF CERTAIN CLOTHS USUALLY IMPORTED INTO INDIA.

Name of cloth	Warp	Weft	Ends	Picks	Nature of weave	Size used	Remarks
1. Dhoti ...	30s-40s	36s-46s	56-66	56-66	Plain weave with coloured borders.	...	Mainly grey.
2. Saris ...	Do.	Do.	Do.	Do.	Do.	...	Colour-ed.
3. Scarves ...	28s-34s	32s-40s	40-60	36-60	Plain weave.	...	...
4. Longcloth	36s	38s	72	72	Do.	...	Cockle finish.
5. Twill ...	36s	38s	64-76	76-108	Twill weave.	10% Size.	...
6. Shirtings.	32s	40s-50s	64-76	60-76	Plain weave	Heavily sized 25-100%	striped
7. Printers ...	36s	42s	...	...	Plain grey cloth.	...	27", 28" and 31" width. grey.
8. Domestics.	18s-24s	36s-40s	56-64	56-64	Plain weave	...	Fine.
9. Cambrics.	60s	50s	90-100	90-110	Plain weave.	...	...
10. Jaconets.	38s	40s	64	52	Do.	...	Grey 18-22 yds.
11. Mulls ...	60s-100s	60s-100s	64-80	64-80	Do.	...	Bleach-ed.
12. Nainsooks.	40s-60s	36s-50s	...	...	Do.	...	18 yds. piece.
13. Madapol-lams ...	50s-60s	50s-60s	72-80	84-96	Do.	...	Bleach-ed.
14. Muslin ...	80s-100s	80s-100s	48-96	48-84	Do.	...	Bleach-ed Printed and Dyed.
15. Voils ...	2/100s	2/100s	58	68	...	...	...
16. Drills ...	32s-36s	36s-42s	112-128	60-80	Five shaft weave.	...	...
17. Lungis ...	32s	32s-40s	60	60	Plain.	...	Poor quality.
18. Kerchief.	32s	46s	96	80-100	Plain.	...	Good quality.
19. Jeans ...	16s-20s	20s-32s	80-90	52-60	Three shaft twill weave.	...	...

[From W. Hough : *Cotton Fabrics.*]

CHAPTER XIX

THE RE-ORGANISATION OF THE HAND-LOOM INDUSTRY

'If the cottage industry is to survive as a means of livelihood the hereditary craftsman, the artistic patron, the philanthropic helper—all these uneconomical elements of the present systems must be modified in conformity with modern industrial ideas or else be eliminated. But if the inherent obstinacy and conservatism of individuals in the cottage industry prove to retain economic vitality, it must be so modified as to bring about the salvation of the worker.'

'The improvement of the hand-loom industry if undertaken at all must be done on a comprehensive scale and by tackling the problem from all sides'—DAVIES, I.C.S., *Formerly Director of Industries, Madras.*

'Any method by which the hand-loom weaving can be preserved deserves a prolonged trial and it may be pointed out that there are no justifiable grounds for any undue pessimism regarding its future.'—*Maclean Committee on Co-operation.*

THE PROBLEM

The problem of the hand-loom and of the hand-weaver is only a part of the larger problem of poverty and unemployment in India. It is a sad feature of the present industrial system that everywhere factory workers have to face a very severe competition from poor-paid workers in handicrafts and unorganised industries. Sir Alfred Chatterton noted the significance of this.¹

The consequences of the development of industries with the aid of imported machinery are many. Unemployment has increased. There is no appreciable improvement in the economic conditions of the Indian working classes. If there is any betterment, it is more the result of world forces than the consequence of internal development. And what is gained by the few is nothing compared to the sufferings of the many. It is now becoming increasingly clear that merely mechanising production cannot solve our problems. It is on this consideration that the revival of the handicrafts in general, and of the hand-loom in particular, is here advocated.

We may now proceed to state our objectives. Firstly, in view of the peculiar economic condition in India we have

¹ 'Industrial Evolution', p. 22,

to evolve an industrial system whose chief aim should be 'to employ human power to the greatest extent possible and in the way more advantageous to the individual.' This end cannot be realised by the mere development of large scale industries without a radical change of the present social, economic and political system. But one cannot deny the necessity for providing employment. Every power-loom and every mill hand displaced, it must be noted, can provide employment to at least four persons. The extent of the increased employment depends on the extent to which the hand-loom can capture the province of the power-loom. The defence of the machinery by the Classical Economists fails in this case, as no new avenues of employment as indicated by them have so far been opened to absorb displaced labour. In India the introduction of foreign machinery has created permanent unemployment. This ugly feature cannot be found if the hand-loom is developed. It is a simple machine which can be made in India and does not displace labour.

Secondly, we must increase the national income by all possible means and secure its proper distribution. The benefit of increased production to be permanent must be shared by the whole community. This is what is meant by the co-ordination of production and distribution. Economic progress consists not merely in the increased earnings of workers individually, but in the number of workers sharing this prosperity. If the present mill outturn in India is made on the hand-loom the aggregate earnings of workers will be about Rs. 12 to 15 crores i.e., an increase of 50 per cent of the purchasing power of the working class. This is not negligible. The extent to which new purchasing power of the community is created depends on the extent of the replacement of the power-loom by the hand-loom.

Thirdly, we should bring about the much desired co-ordination between agriculture and industry. The development of the handicrafts, particularly the hand-loom, will benefit agriculture by creating a larger demand within the country for the products of Indian agriculture, will increase the purchasing power of the rural population by providing

additional means of livelihood and will enrich the Indian rural life by establishing rural factories.

The organisation of the hand-loom industry has its limitations. It is not advocated here that all capital and organisation should be wiped out immediately. The transformation must take place gradually. Further, this preference for the hand-power is not for eternity. It is a necessary intermediate phase. Other limitations are also noted. Having in view all these considerations the following suggestions on the reconstruction of the hand-loom are made.

Before we proceed to sketch out the lines of reorganisation and the revival of the industry, we shall recapitulate the following facts which bear on the re-organisation of the industry: (a) The scope for weaving special patterns of cloths and for encouraging hand-loom to use more of finer counts is limited, and the market for very fine cloth cannot expand to any appreciable extent unless there is a great increase in the purchasing power of the agricultural population. And so long as very fine count spinning is a practical monopoly of Lancashire, Indian hand-loom cannot compete with Lancashire in the production of such fine varieties as mulls, muslins etc.¹ (b) The prosperity of the hand-loom cannot be looked for by devoting attention to the artistic aspect of weaving alone; the industry cannot prosper unless it regains much of its lost ground in common varieties; and the weaver will continue to sink in poverty if the industry does not expand. (c) Lastly, the expansion of the hand-loom industry is determined by the nature of the demand for cloth, the nature and extent of the imports and Indian mill production and the possibility of manufacturing them at the same cost, if not lower, on hand-loom. Now more than 80 per cent of cloths consumed in India, it is estimated, have warps with counts below 40s. A large portion of it is plain weave. Taking the grey plain cloths alone produced in Indian mills,

¹ Machinery for fine count spinning, it is said, is a British monopoly. The cost of erecting a spindle is nearly twice in India as it is in England. Hence the very high cost of production of fine counts in India. In this connection it must be noted that Japan successfully competes with Lancashire and India in the manufacture of many kinds of cloth, because Japan manufactures her own looms and spindles and this, besides other advantages, reduces its cost of production. (Refer Arno Pearse, 'Cotton Industry in Japan and China').

the annual consumption is not less than 2,000 million yards. Add to this 500 yards of grey cloth imported. The bleached and coloured, printed or dyed piecegoods differ from grey ones in their finish. There is not much difference in weaving which would render the manufacture of such cloths on hand-loom impossible or unprofitable. The bulk of the manufactures of the Indian mills is of coarse-medium counts varying from 14s to 32s and that of the imports, of medium counts from 24s to 50s. Only when the hand-loom is organised to produce these types of cloths without increasing the cost of production, can we look forward to the amelioration in the conditions of the weavers and the solution of the problem of unemployment and misery of the rural population.

It must also be noted that the immediate objects in organising the hand-loom industry are: (1) to increase the earnings of the weaver and his family by giving him a continuity of employment and by substituting the more remunerative work of weaving for preparatory operations; (2) to standardise hand-loom products, which does not mean a creation of monotony of patterns or absence of varieties, but the introduction of that principle of business which makes the product answer to the sample and, in general, the improvement of the trading and manufacturing systems; and (3) to standardise wages by eliminating exploitation of all kinds, and lastly (4) to realise the other objectives mentioned in the beginning of this chapter.

LINES OF ORGANISATION

I. LINKING OF THE WEAVERS AND HAND-LOOM FACTORY WITH SPINNING MILLS

The future of hand-loom weaving depends on the improvement of the loom, the preparatory processes, the business organisation and the system of education and industrial training. Leadership, organisation, co-operation, technical and general education, technical assistance, better business arrangements for producing and marketing are obvious necessities.

The first step in the reorganisation of the industry is to

ensure a steady supply of yarns of reputed count and quality to hand-loom weavers at reasonable prices. At present the weaver depends on the mills for the supply of yarn. In spite of the semblance of competition the price of yarn to the weaver is higher than it need be. Due to the presence of import duties on yarn, its price to the hand-loom weaver is further enhanced. In the case of mulls, muslins, etc., the difference between the price of cloth and the price of yarn at market rates is so low that it raises the reasonable suspicion whether it is sufficient to cover the cost of preparation, weaving and finishing in mills and whether the price of yarn is not artificially maintained at a high rate.¹ While the price of raw cotton lags behind the general level of prices and the level of wages the rise in the price of yarn is higher than that of

¹ 'I find it strange that the cost of yarn we import is greater than the imported cloth of the same weight. It is not possible to produce mulls of the well known 1703 type even at the cost they are sold in the bazaars though we use the same yarn and weave at the lowest possible cost. My experience tells me that the price of imported yarn is specially raised by some combination of foreign spinners and cloth manufacturers'.—*Mr. Churchill of Ahmednagar at the Industrial Conference, 1908.*

The writer has examined some foreign cloths in 1928 in the manner given below and the examination substantiates the view expressed above, viz., that the price of fine yarn is artificially maintained.

Specifications.	9000 Glasgow mull.	1703 Bleached mull.	'Lady' grey mull.
Length ...	20 yds.	20 yds.	20 yds.
Width ...	52"	52"	49"
Weight of the piece ...	1.9 lbs.	2.9 lbs.	2.9 lbs.
Ends ...	84	84	80
Picks ...	84	90	80
Warp (apparent count) ...	116s	80s	66s
Weft (do.) ...	114s	80s	64s
Percentage of size ...	1.5	2.5	3.5
Weight of yarn ...	{ 0.90 lbs. 0.93 lbs.	{ 1.3 lbs. 1.4 lbs.	{ 2.6 lbs.
Price of yarn excluding yarn duty 5 per cent ...	Rs. 6- 3-0	6-10-0	5-10-0
Price of the piece excluding cloth duty of 15 per cent ...	Rs. 11- 0-0	10-12-0	7-5-0
Difference * being the cost of production ...	Rs. 4-13-0*	4- 2-0*	1-11-0*
Cost of production per yard ...	Re. 0- 3-10	0- 3-4	0- 1-4

* This includes the cost of preparation, weaving, finishing, baling, transport to India, and other incidental charges. In the case of the grey mull the cost of production works out at the rate of one anna and four pies per yard and this cannot cover even the cost of preparation and weaving of even medium cloths in India. Refer appendix XII.

cloth and of raw cotton.¹ It means either that greater economies have been secured in the production of cloth than in the production of yarn or that the price of yarn is artificially maintained at a high level. The latter seems to be more probable. Taking the index number quoted in the *Indian Trade Journal* since July 1914, the rise in the American yarn in the Manchester market is 65 per cent while the rise in the price of cloth is only 52 per cent in 1928. The difference between the rise in the prices of Egyptian yarn and cloth is still greater. Regarding the supply of Indian mill yarn and cloth, the same tendency is observed. Taking again 1914 prices as 100, the index numbers of the prices of raw cotton, yarn and cloth are 136, 225, 170 respectively in July 1928. The conclusion is irresistible that in the absence of any radical inventions or changes in business practice which can reduce the cost of weaving in mills, the high level of prices of yarn is maintained artificially.

There is no regularity or steadiness in the supply of yarn to weavers; when the price of cloth tends to fall, more yarn is sold to them; and when the price of cloth is rising more yarn is used in mills and the weaver cannot have his quantity of yarn unless he is willing to pay a premium for the yarn. The fluctuations in the price of yarn due to causes other than the fluctuations in the price of raw cotton or in the cost of spinning, make the position of the weaver depending on the mills for the supply of yarn absolutely insecure.

As regards the quality of the yarn sold to the weaver, it is distinctly inferior. It was observed by Mr. Churchill in 1908 that the spinning mills prepared two qualities of

¹ *The movement of the prices of raw cotton, yarn and cloth:*

'The price of yarn may be regarded broadly as the price of cotton plus the spinning margin and the price of cloth as the price of yarn plus the weaving margin. When the index number of yarn is above the index number of raw cotton, the implication is that the spinning margin has risen in greater proportion than the price of raw cotton and where the index number for yarn is below the index number of raw cotton the implication is that the spinning margin has risen in smaller proportion than the price of raw cotton. A similar statement is made *mutatis mutandis* regarding the relation of yarn and cloth prices as bearing upon the weaving margin.

The figures suggest that the spinning margin in the case of American cotton has been consistently higher relatively to 1913 than the price of raw American cotton. This holds good of Egyptian yarn too.

The weaving margin rose on the whole less proportionately than the price of yarn upto 1925 but lately when yarn prices were reduced the weaving margin did not fall in proportion.'

yarn, one for their own use and the other for the market. Besides, the cotton yarns supplied by many Indian mills are badly reeled, contain many knots, do not possess the tensile strength necessary for warp and are often not of the declared count. It is suggested that false labelling and short reeling should be penalised.¹ The system of double numbering practised by certain Ahmedabad mills to pass off low count yarn as superior one is a great defect of which special mention was made by the Indian Textile Tariff Board.² The method of bundling and packing, the weight of the bundle, the number of knots in a bundle and the number of hanks in a knot, the method of stamping the count of yarn and its quality must be standardised.

In order to ensure a regular supply of specified qualities of yarn in the required form it may be necessary for the State to impose certain conditions on spinning mills regarding hall-marking of yarn. But these conditions may prove vexatious and it may be difficult to enforce them. It is necessary in that case to organise weavers' societies to arrange with spinning mills for the supply of yarn and where that is not possible, to start spinning mills in suitable centres for the supply of yarn to weavers through co-operative societies or other suitable agencies. Spinning mills as adjunct to weavers' societies will be the ideal condition for the steady supply of good quality of yarn at reasonable and competitive prices.

II. ESTABLISHMENT OF WARP DISTRIBUTING CENTRES.

The second step in the reorganisation of the industry is the reduction in the cost of the preparatory processes as

¹ Amalsad, *Cotton Cloth impasse*.

² 'There is reason to believe that in Indian mills generally efforts are made to spin a finer count of yarn than the quality of the cotton justifies, the result of which is inferior yarn. Instances were given of 18s yarn being supplied as 20s with the consequence that the length was reduced to make up for coarser counts. This practice appears to have led to the stamping of double numbers. It was, for example, stated that yarn from Ahmedabad stamped as 28s x 40 was being placed on the market. The representative of the Ahmedabad Millowners' Association admitted that in some instances, 28s yarn had been placed in the market in bundles of 40 knots but explained that this was done at the request of the merchants and that although the yarn was marked 28s x 40 the price realized was that for 28s only. They considered that marking in this manner made it perfectly clear what the count actually was but we are told that the supply of 28s yarn in bundles of 40 knots facilitates its being passed off as 40s. The practice is obviously undesirable and should, in our view, be discontinued.'—*Report of the Textile Tariff Board, 1927.*

practised in the country system and the distribution of ready warps to weavers which is most essential for the standardisation of cloth. The economics of the dresser sizer and Amalsad sizing plant have been considered in an earlier chapter. They have not reduced the cost of preparation as much as it is desirable for enabling the hand-loom to have the same advantage that the power-loom enjoys from slasher-sizer.¹ Therefore the problem of reducing the cost of preparation in hand-loom weaving remains still unsolved. But both the dresser sizer and the various hand-driven sizing plant can eliminate the waste of time and labour involved in country sizing, and enable the weaver's family to take to more remunerative occupations than winding, warping and sizing. Still, however, the improved hand-driven sizing machines have not become common nor has the dresser sizer under the Department of Industries or under private management in Ganjam District proved a success. The weaver who is to find out the market for his manufactures prefers to have small warps in ball form to long beamed warps so that he can change the designs, textures and weaves as easily as possible. The warp distributing centre which saves to the weaver the time lost and trouble involved in the country method of warp

¹ The following table will show that the introduction of the dresser sizer reduces slightly the cost of preparation which now obtains in some centres :—

The count of Warp	Cost per pound of warp of specified count											
	Under the indigenous processes									Under the Dresser-sizer		
	Madura			Rasipuram			N. Circars					
	RS	A	P	RS	A	P	RS	A	P	RS	A	P
20s	0	5	4	...			0	3	6	0	2	9
30s	0	6	11	0	3	9	...			0	3	6
40s	0	8	0	0	5	6	0	5	3	0	4	9
60s	1	0	0	...			1	0	3	0	7	3

The cost of preparation on the slasher-sizer is considerably low ; even two pies in some cases.

preparation and which gives him long warps and thereby saves the time lost in piecing the warps cannot become a practical proposition unless it provides the finance required by weavers and undertakes the marketing of cloth, and has the regular custom of 200 weavers. At present it is not difficult to find centres with 200 weavers producing the same kind of cloth. But the real problem is to find a regular market for the increased outturn. The weavers, poor, ignorant and unaided, cannot be expected to explore the possibilities for extending the market. The warp distributing centres can become a success only when they undertake the marketing of hand-loom manufactures and also introduce the second loom or more looms in the weaver's family.

There are other advantages of the central warping mill. Yarn can be tested regarding its count, strength, colour, finish and suitability for the purpose required. The length of the warp and the number of ends supplied can be guaranteed to the weaver. The fraudulent practices of the mills and the merchants may be prevented, thus improving the quality of the cloth.

The case for the central warp distributing agencies rests on one more ground. The economy of mechanical power is greater in preparatory processes than weaving. Secondly the spinning mill, the warp distributing centre and the finishing and dyeing house around which can flourish the hand-loom weavers working in their cottages will lead to the establishment of rural factories which, while rationalising production, would correct the evils of excessive industrialism and extreme ruralisation.¹ In the woollen industries in Wales, hand-loom cottage weavers flourish in the neighbourhood of small spinning mills driven by water-power. The merits of rural factories cannot be exaggerated. They avoid the evils of urban factory life but still adopt mechanical

¹ The weaving industry seems to me eminently suited to the Indian craftsman working in his own village, if his circumstances can be bettered and if I am correctly informed, the success achieved by Japan has been due largely to a splendid organisation of cottage weaving centred round factories which only collect and finish the fabrics. Whether we achieve a similar result by the individual weaver, the group of weavers, or the hand-loom factory is a matter of local circumstances purely but it cannot ordinarily be by any development of mills.—Maxwell-Lefoy, *Silk Industry*.

power within necessary and desirable limits. They possess the advantages of handicrafts without foregoing the essential economies of large-scale production. Also, these rural factories are the essence of the linked system' which is said to be adopted in Switzerland. 'There are a number of hand-loom linked to a factory which does all preliminary work of spinning, warping and beaming and the weaver begins his work direct with weaving. By this, the weaver saves a lot of time which he used to spend upon the processes uneconomically and is thus able to produce more cloth than before'.² It will of course take a long time to make the weaver adapt himself but yet a beginning in this direction must be made to facilitate his work and thus make his production more rapid and perfect. The keynote of the Swiss system of cottage industries is expert control and a constant market and also a reasonable intelligence on the part of the working population. The difficulties in introducing the linked system in India are many. The hand-loom weavers are scattered over the whole presidency and there are difficulties in having the combination to the same extent as in a small country like Switzerland. But the scheme is not an extravagant imagination impossible of realisation if it is given a fair trial.³

III. INTRODUCTION OF MORE LOOMS IN THE FAMILY

The third step would be the introduction of the two-loom system. The object of it is to increase the earnings of the weaver's family by substituting weaving for the unremunerative preparatory processes now done by the members which take more time and labour than weaving without any corresponding advantage. But still these preparatory

¹ *Indian Fiscal Commission* : Evidence Vol. III, pp. 596-604.

² There are many mills in India to which the weavers can be linked ; especially with the growth of new mills in the upcountry the growth of the linked system can greatly be facilitated.

³ By 'linking' is not meant that there should be a factory system of labour at all. The weaver will take the product to his own home and weave it there. He will be supplied with yarn by the mill. Economies of power and large scale production in some respects are secured without the attendant evils of overcrowding, and other industrial problems.

processes are done by the members of his family because some income is better than none at all. The weaver himself cannot be persuaded to give up the preparatory work unless there is scope for increased production and income and there is an organisation which can prepare the warp for him at the same, if not lower, cost. The tendency to increase the looms in the family is evident even now in a number of centres where special warping and sizing agents exist. But that is possible only when there is an increased demand for the hand-loom product. But in the general scheme of re-organisation we cannot hope for the weaver to take the initiative. To be more effective and for the results to be permanent, an external organisation for production and marketing, preferably on co-operative lines, is necessary.

The two-loom system is nothing radical and strange in industrial rationalisation. We find this principle adopted in spinning and weaving mills. Where speeding up the machinery is not possible, the usual step towards economy is by increasing the outturn per worker by increasing the number of looms or spindles he will have to attend to or by a more intensive use of capital equipment by increasing the shifts of employment. It is also based on the modern idea of increasing the efficiency of the worker, which aims not so much at obtaining a higher efficiency per machine as per operative. In the hand-loom organisation the efficiency or the income of the worker's family as a whole rather than of the weaver alone is to be aimed at.

At present where there is one loom in the family and winding and warping are not done by its members, and the adult male works the hand-loom, the daily earnings of the family according to the statement on the next page are from 9 to 13 annas. If the warp is prepared by the family, its earnings will be from 13 annas to a rupee. But where the two looms are introduced the family earnings are from 15 to 20 annas though the cost of production falls by about 25 per cent. Add to this the advantage of a greater regularity of employment.

The difficulties in the introduction of more looms in the family are many. Firstly, while the weaver with his one loom cannot find a market for his product, how can he sell

his increased outturn? This difficulty can be obviated by the marketing organisation proposed herein and also there will be an increased demand for the hand-loom product as its price can be lowered and its quality improved. Secondly women in India, it is stated, cannot stand the strain involved in weaving. This is not quite true. Women are found to work silk looms and also cotton looms in certain centres. In Japan women and young girls are mostly employed in hand-loom sheds.¹ There will be no difficulty in inducing women in India to take to weaving. Thirdly, there is the financial difficulty. This can be overcome by the system of State-aid and co-operative finance outlined below.

Details of the cost of production per yard of cotton cloth made on hand-looms (1927).

	a	b	c	d	e
Cloth	Coarse dhoties	Women's sarees	Fine dhoties	Turban cloth	Angavasthram
Count of yarn ...	20s	40s	60s	80s	100s
Length ...	1 yd.	1 yd.	1 yd.	1 yd.	1 yd.
Width ...	48"	48"	48"	48"	48"
Weight ...	4.75 oz.	3 oz.	2.3 oz.	2 oz.	1.8 oz.
Ends per inch ...	48	60	72	80	90
Picks per inch ...	52	64	72	80	90

(A) Under the single loom system where winding and warping are done on indigenous lines.

	a	b	c	d	e
	RS A P	RS A P	RS A P	RS A P	RS A P
Yarns ...	0 3 6	0 3 9	0 3 9	0 5 4	0 5 6
Sizing ...	0 0 6	0 0 7	0 0 8	0 0 10	0 0 10
Weaving ...	0 0 11	0 1 9	0 2 4	0 3 4	0 4 5
Cost of production ...	0 1 5	0 2 4	0 3 0	0 4 2	0 5 3
Output per day in the family ...	10 yds.	6 yds.	5 yds.	4 yds.	3 yds.
(a) Earnings per day of the family where warp preparation is not done by the weaver.	0 9 2	0 10 6	0 11 8	0 13 4	0 13 3
(b) Daily family earnings if warp preparation is done by the family.	0 13 3	0 13 6	0 14 6	1 0 0	1 0 0

¹ Freda Utley. *Lancashire and the Far East*.

(B) Under the double loom system where Dresser sized warps are supplied.

	a	b	c	d	e
	RS A P	RS A P	RS A P	RS A P	RS A P
Yarn ...	0 3 6	0 3 9	0 3 9	0 5 4	0 5 6
Power preparation ...	0 0 4.5	0 0 6	0 0 7	0 0 8	0 0 9
Weaving ...	0 0 9	0 1 4	0 1 6	0 2 3	0 3 3
Cost of production ...	0 4 1.5	0 1 10	0 2 4	0 2 11	0 4 0
Output per day in the family ...	20 yds.	12 yds.	10 yds.	8 yds.	6 yds.
Daily family earnings.	0 15 0	1 0 0	1 1 6	1 2 0	1 4 6
Reduction in the cost of production ...	0 0 4½	0 0 6	0 0 8	0 1 3	0 1 3
Percentage of reduction in the list of production ...	26	21	22	30	22
Percentage of increase in the daily earnings of the family ...	13	18	21	12	25

IV. ESTABLISHMENT OF A CENTRAL CLOTH EXAMINING BOARD

The fourth step in the organisation of the hand-loom industry is the introduction of a device for uniform picking in weaving and the establishment of a central cloth board for examining and passing the cloth manufactured.¹ It is said, and it is true to some extent, that uniform weaving can be obtained if weavers are trained and paid by results and if the product is closely examined as it was done in the Itchapur Weavers' Co-operative Society and as it is now done in the case of Madras hand-kerchief and Salem Weavers' Co-operative Society. However, the possibility of introducing in the ordinary loom a simple mechanical device for uniform wefting, as it obtains in Hattersley's hand-loom, is worth investigation.

V. ESTABLISHMENT OF CENTRAL PRINTING, DYEING, AND FINISHING FACTORIES

Since our object is to substitute the hand-loom product for the mill cloth, it is necessary to finish the former and

¹ The establishment of a cloth examining board attached to the Co-operative Society or other marketing organisation for examining the picks and ends of the cloth and stamping it as of specified length, width and picks and ends cannot be a costly one. It is estimated that it will be less than 0.5 pie per yard.

make it answerable in all respects to the latter. It must be bleached, printed, dyed or finished in the same manner as the mill cloth and for this purpose small cottage plant for printing, dyeing, bleaching and finishing may be attached to the warp distributing factories. Thus it is the warp distributing centres with small cottage finishing plant that will constitute the real rural factories round which can flourish hand-loom weavers. The weavers with no knowledge of modern methods of finishing cannot be expected to manufacture those finished products made in mills. Central factories for this purpose in suitable centres can alone help them to get the upper hand in mill competition.' Thus it is necessary to link the hand-loom with the spinning mill and the warp distributing centre on the one end and the finishing factory on the other. Then it would be possible to work co-operation in all spheres successfully and effect various other measures of improvement in the quality of the product, in the conditions of the industry and the position of the weaver.

VI. THE ESTABLISHMENT OF (a) A CENTRAL RESEARCH INSTITUTE, (b) A MUSEUM OF DESIGNS AND PATTERNS AND (c) A RURAL INDUSTRIES INTELLIGENCE BOARD

The future of the hand-loom industry depends on the improvement of the designs, patterns and quality of its output, as dyeing and calico printing play an important part in the development of the industry. The Bihar and Orissa Government made a good beginning in 1926-27 by appointing a staff consisting of a dyeing demonstrator and four maistries to conduct dyeing demonstration and to teach the weavers dyeing fast colours. The Madras Government Textile School has introduced autograph printing. Further progress in this respect depends on the establishment of a museum where different designs and patterns are collected. At a conference held in Simla of the Directors of Industries, 1920, Sir Alfred

¹ The economics of the cottage finishing plant have not been fully investigated by the writer. But so far as he can see the practices in Switzerland and Italy encourage him to believe that they are not unsuitable to India. Switzerland and Italy import cloths from the United Kingdom, finish them in their small factories and export them to other countries.

Chatterton, pleading for the establishment of central experimental workshop for hand-loom weaving, stated: 'What we now want in India is a Central Research Institute intimately connected with some of the larger schools in the country, so that the results of experimental work, on what may be termed a laboratory scale, may be given a more extended trial on what will be generally semi-commercial conditions'.

After enumerating the work of the research institute in the direction of improving the preparatory processes combining the advantages of indigenous methods with the productive capacity of the machine used in factories and of evolving suitable cottage plant, he emphasised the need for the establishment of a museum of designs and patterns. 'Even more important than the improvement of appliances is the provision of patterns and designs to meet the demand for change and variety if new markets are to be opened out both in India and abroad'.¹ While the research institute will make new designs, a museum for the collection of patterns and designs must be established with a view to educate the weavers and to enable them to produce for foreign and home markets.

Besides, each province must have an institution like the Rural Industries Intelligence Board, London, to offer advice on designs, to maintain a workshop for experiments, to run a library, to collect samples and to publish tracts and journals. The Department of Industries has done much work in this direction. But it can probably be more effectively done by an independent non-official body. Organising weaving competitions and textile exhibitions in important weaving centres will give a great impetus to the industry. The publication of magazines in vernacular will be highly educative.

VII. The next problem is the avoidance of mill imitation of hand-loom products for which there is a great demand. Buyers are often deceived by unscrupulous dealers in mill goods. Legislation on the lines of the Irish Hand-loom Weavers' Act² will give the hand-loom the necessary security against mill imitation and competition. By legislation it is

¹ *Proceedings of the Conference of the Directors of Industries, Simla, 1920.*

² The Irish Hand-loom Weavers' Act of 1909 compels the term 'handwoven' to be stamped in all goods manufactured on hand-looms, and prohibits such a description of cloth woven in mills.

not sought to prevent the mills from producing the kinds of cloth that are usually woven on hand-loom but to prevent the possibility of palming off mill goods as hand-woven ones. The existing laws of copy-right and trade marks are inadequate and the weavers are too ignorant and poor to take full advantage of the same.

VIII. Then the further possibility of the export trade in hand-loom products must be explored. There is even now a great demand in other countries for many kinds of cloth made on Indian hand-loom. Handkerchiefs to the extent of several millions of rupees in value are exported from Madras every year; and lungis and kailis and other coloured goods are usually in demand in places where Indians have settled. But during the last few years we witness a decline in the export trade, especially in the Madras handkerchiefs. It must be noted that the expanding market will not come to us; it will have to be made. A Trade Commissioner must be appointed to create a market for hand-loom products in other parts of the world who will educate the manufacturer and acquaint him with the requirements and the changing tastes of the distant consumer. The establishment of a central co-operative wholesale depot will be a great source of help especially to weavers manufacturing for distant markets.¹

IX. There are two other important lines in which the industry needs re-organisation, viz. (1) business and (2) finance. In regard to both of them the industry has very little organisation to speak of. The primitive character of his trade places the weaver at a disadvantage. What can be achieved in this direction is indicated by the experience of Japan. 'Not a little of the industrial success of Japan is due to the attention that has been paid not only to the educational and technical training of cottage workers but to the building of business organisations which take over the products of the industry and dispose them all over the world.' Therefore the urgent and immediate step in the permanent amelioration of the conditions of the weaver is to provide him with an agency for marketing his goods on fair commercial terms. The maximum benefit from the

¹ Cf. Export Development Society for cotton goods, Japan.

introduction of improved working processes can be derived only when the business organisation relating to the purchase of raw materials and to the sale of finished products is systematised.¹ The appointment of a marketing officer by the Government of Madras in 1931-32 was a successful experiment. The sales of hand-loom products developed greatly but the experiment was given up too soon. The present wasteful methods of middlemen and the primitive and crude indigenous system of marketing must give place to a more economic and effective method of distribution. The organisation of the trade depends on a proper survey of production, the demand for the products, advertisement, experimental production and so on. All these cannot be done by the individual weaver. The hand-loom factory or any other central organisation with some governmental assistance can do much for extending the market. Mr. Davies, a former Director of Industries, Madras, said that the only hope of the weaver was in the hand-loom factory. But it is often supposed that the hand-loom factories are unsuited to the habits of the weaver and the failure of the Salem hand-loom factory is often cited in support of that opinion. But the prosperity and growth of hand-loom factories in South India and elsewhere indicates that future business organisation of the hand-loom industry lies in some sort of co-ordination and not in the present independent, wasteful and uncoordinated system of cottage production.

The market for the hand-loom product can expand only with proper transport facilities. Reduction in the railway rates, lowering the rates for yarn,² special concessions in regard to hand-loom products and yarns required for hand-

¹ Prince Kropotkin says in respect of small industries: 'In the immense number of trades it is not the superiority of the technical organisation of the trade in a factory nor the economies realised in the prime motor which militate against the small industry in favour of the factories but the more advantageous conditions for selling the product and for buying raw materials which are at the disposal of the big firms. Whenever the difficulty has been overcome either by means of associations or in consequence of a market being secured for the sale of the produce it has always been found first that the condition of the worker has immediately improved and next that a rapid progress was realized in the technical aspects of the respective industries.'—*Field, factory and workshop*.

² 'At present both yarn and cloth are charged the same freight with the result that foreign countries and mills in India prefer to trade in cloth rather than in yarn as the finished cloth is of less freight than the yarn.'—*Travancore Industrial Bulletins*, No. 15.

looms, abolition of the import duty on yarn and gold and silver lace and abolition of professional and other local taxes on looms are some other ways of bettering the industry.

In respect of financial assistance to the hand-loom industry the establishment of yarn bank which can purchase yarns, advance loans to weavers against yarn and cloth pledged to it or the organisation of a bank on the lines of the Home Manufacturers Bank in China will be of great help to the weaver. Certain facilities must be given to the bank. Capital should be provided by the State with necessary safeguards. The bank should purchase and sell yarn to recognised co-operative societies of weavers. Concession rates in railway transport and exemption from duties on yarn imported by the bank and provision of free audit by Government are some directions in which the State can assist the bank and the weaver. The present State-Aid to Industries Act must be so amended that weavers can be adequately supplied with funds without undue insistence on the furnishing of real securities. Co-operative organisation for credit, purchase, and sale and production must be strengthened, for there can be no more powerful lever for the uplift of a community steeped in poverty, ignorance and vice than co-operation.

The finance required by the state for the establishment of central warping and finishing factories, and the museum of patterns and designs and for making the present work of the Department of Industries more effective and all-embracing can be obtained by imposing a small duty on yarn for the special purpose of assisting the hand-loom industry. At present the amount spent on education, propaganda, and research connected with the hand-loom industry in different provinces cannot be definitely ascertained; but it is negligible. If a tax of one pie per pound of yarn consumed in mills is levied it will yield more than Rs. 30 lakhs. This tax cannot be exorbitant, for even on the basis of the present prices of yarn it is hardly $1\frac{1}{2}$ per cent. The opposition of the mill owners to this excise duty can be changed into active co-operation if the duty so collected is not used for general purposes by Government but is earmarked for the development of the hand-loom industry. The Department

of Industries can extend its activities in different directions without being as at present unduly handicapped in its work for want of funds.

X. The mere organisation of the industry which does not improve ultimately the conditions of weavers nor modernise them is not commendable. Their economic and social conditions must be bettered.¹ The home-workers are at a special disadvantage in regard to bargaining; they cannot easily be reached by organised effort to better their wages; thus they do not benefit by the gains which trade union organisation has secured for the factory worker. How to create and work an organisation if home-workers on trade union lines is the problem. The influence of the trade union on home-workers has been slight except in Soviet Russia, in the cigar trade in Germany and to a small extent in the clothing industry of France.²

Legislation in the interest of industrial home-workers began in England with the factory laws but it was inoperative as they could not be reached and effectively regulated by inspectors. The Trade Boards Act of 1908 introduced the minimum wage and it achieved some measure of success. In the U.S.A. the system of licensing was introduced, especially in respect of cigar-making in tenement houses. The object of the legislation was to improve the sanitation of the work-place. Another law provided that the tenement where industrial home-work was carried on was to be inspected every six months. But it was not possible to carry out inspection thoroughly. In Germany the law provides that employers should register all their home-workers and the social legislation relating to home-work concerns itself with sanitary conditions and wages of the home-workers. It determines piece rates and fixes the hourly minimum rates. Industrial home-workers in Russia are now brought under Producers' Co-operation and Governmental Agencies.

There is very little legislation in India in the interest of

¹ The isolated weavers require an organisation to protect their interest against those of manufacturers and merchants who provide the yarns and have performed the necessary preparatory processes. Otherwise they would, by under-cutting, destroy their own standard of living.' Forrester: *History of the French Cotton Industry*, p. 62.

² *Social Science Encyclopaedia*.

home-workers. Recently some effort was made to safeguard the interests of workers in the beedi industry in Madras and the Central Provinces. It is obviously difficult to deal with the entire organisation of cottage industries which is built of the merchant, the contractor, the entrepreneurial home-worker and the home-workers who are members of the family and the hired home-workers.¹ Nevertheless some attempt must be made to improve their lot and strengthen their bargaining power and improve their sense of self-respect and thus educate them to better their standard of living. The present system of remuneration of labour and the payment of wages based, not on the needs of labour but determined by supply and demand, ignores the human claims of labour, especially so in regard to cottage workers. Mr. Hobson says: 'To accept the view that to buy labour power, like other commodities at a price determined purely by relations of supply and demand is a policy dangerous to the life and well-being of the individual whose labour power is thus bought and sold, to those of his family and society. . . . The private human needs of a working family should be regularly and securely met out of their weekly and fortnightly pay. The life and health of the family and the sense of security which is essential to sound character and regular habits, to the exercise of reasonable foresight and the formation and execution of reasonable plans, all hinge on their central demand for a sufficiency and regularity of weekly income based upon the human needs of the family'. Though this is not possible of realisation fully all at once something can be done by the constitution of the Trade Boards.

Boards consisting of employers and workers and representatives of the Government must be constituted in different areas for the regulation of wages and hours of

¹ The problem of protecting the home-worker from the evils of sweat shop conditions is not solved. Licensing home-workers or the place of home-work will not destroy child labour which is easily concealed. Registration is desirable but useless without effective inspection. Indirect control of home-work through general social legislation is equally faulty. Hours cannot be regulated when the work is performed during leisure time or on 'rush' orders. If the fixing of wage rates by the Trade Board is effective it would probably destroy the entire home-work and leave without means of support many persons unable to secure work in the factory. The problem is full of difficulties.

work, conditions of employment and welfare. More than that there must be an organisation on the lines of All India Spinners' Association which will give the worker the full reward of his labour, prevent sweating and exploitation, develop the technique of the industry and the morale of the worker and organise production, purchase raw materials and sell finished products. But to wait for such an organisation to appear spontaneously would be to miss the opportunity not only of the very immediate remedial action but also of acquiring accurate information with regard to the hand-loom and other valuable handicrafts.

The education of the weaver is equally important in the regeneration of the industry. At present the education given in the industrial school is not of the nature which will ultimately enable the children of the weaver to take their place in the organisation of the industry. The majority of the schools are in practice not regular schools but small hand-loom factories and the training offered does not help the people to earn an independent livelihood. The weaving schools should not be mere charitable institutions but effective centres where better types of artisans and captains of industry from among the community are reared up. More vocational schools at suitable centres for the education of weavers' children must be established under the control of the Department of Industries. A technological institute for the study of problems in connection with dyeing and textile technology should also be started. A weaving institute under a weaving expert for the improvement of processes and mechanism of hand-loom weaving and a large increase in the number of peripatetic parties to control and assist in the economic regeneration, specialised education and the improvement of manipulated processes are desired.¹

¹ The question of practical importance is how the great changes stated herein are to be brought about; how a new generation of weavers is to be created, who will at any rate ply their trade on terms of equality with other artisans. Education alone can do this and that to be effective it must be begun at an early stage. Besides provision for the training of the rank and file adequate arrangements must be made for the education of those who will be leaders in the trade and the masters of the future associated groups of weavers. For them a high grade technical school is required where the art may be studied in all its varied branches and experimental work can be carried on.—Sir A. Chatterton: *Industrial Evolution*.

In the absence of a sound organisation, technical instruction and state patronage will prove futile. A practical spirit is wanted. It is because of the insuperable difficulty of modernising the independent weaver who, as long as he remains the entrepreneur, will not move out of the deep rut in which his ancestors have travelled, that those who believe in the future of the hand-loom industry advocate the erection of the hand-loom factory. In such a case, a private capitalist, preferably educated, would install a certain number of improved looms in his own premises, engage weavers on a monthly salary, and set them to work upon the kind of fabric for which he has discovered there is a market. Thus the organisation of the industry on a factory basis will facilitate an early regeneration of the industry. The moral and material conditions of workers would further improve if the factory is organised on co-operative lines. But this factory organisation of the hand-loom would be useful, though not as indispensable as the warp distributing factory, for the revival of the industry. Nor need it be feared that the establishment of the factory will result in the recrudescence of all those evils of large-scale industries which we are anxious to avoid.

Another way by which the industry can greatly be advanced lies in the perfection of the tool the weaver uses and of the methods he adopts. The possibility of introducing a mechanism for automatic and uniform wefting, must be explored. The strain involved in weaving must be minimised. But such improvements must be simple and cheap and within the reach of the weaver. When the use of power is considered desirable and when electric power becomes cheap and easily available, the weavers must be encouraged to use it.¹

In this connection it must, however, be noted that the mere adoption of labour-saving appliances will not do.

¹ The prospect of rapid development of electrical power raises the question of the advisability of applying that power to the hand-loom. (There is no standing prejudice to the use of mechanical power if it does not take one's bread out of his mouth.) Weaving in that case will cease to be hand-done but may continue to be a cottage industry. When power becomes so cheap as to be of universal application and work becomes so properly distributed as causing no extremes of poverty and opulence, employment for a few and unemployment for many, the introduction of machinery and the application of electrical or other mechanical power will be to the great advantage of all workers.

Saving of labour is not always a matter of importance; for, it is often gained by the introduction of absolutely automatic plant driven by mechanical power. But the invention of tools which do not eliminate man-power to the same extent as machines, and which do not reduce the weaver to a mere automaton, is what is desired in countries like India.

Finally, the attempt made in the past in this Presidency having been confined mainly to certain technical aspects of the industry, the economic condition of the weaver did not materially improve; for, the improvement in the technique resulted not in actually increasing the production of the weaver but in cutting short his hours of work owing to the absence of marketing facilities for him. Further, the other aspects, finishing and baling of hand-woven cloths and placing them on a marketable basis as in the case of mill goods so that regular and extensive business may result, were not considered; and they remain still unsolved.

The organisation of the industry in all its economic and commercial aspects requires the co-operation of officials and non-officials. All Government departments must act together. The textile expert, the research engineer, the co-operator and the business organiser must combine their efforts. The development of the hand-loom industry, if undertaken at all, must, be carried on a comprehensive scale by tackling the problem from all sides. There are difficulties; of course the improvement of the status and conditions of a million people who are indifferent to their own improvement is not an easy task. But if we approach the rising generation on a basis of enthusiasm tempered by knowledge, we need not despair of success. What is now wanted is concentration of efforts along definite lines.

CHAPTER XX

CONCLUSION

'There can be no true progress in industry unless that progress is reflected in the conditions of the masses and workers who make industry possible, an advance in which they do not share would be a transient advantage. Healthy and permanent progress are bound up with a steady improvement of the human and the economic status of the rank and file of the industrial army. It is the well-being of all the persons engaged in the industry which constitutes the contribution that industry makes to national wealth.'—THE RT. HON'BLE J. H. WHITLEY.

'The world's most pressing problem has come to be not a further increase of power to produce but the devising of means for the full use of the productive resources already at hand.'—G. D. H. COLE.

'Whatever be true of "labour as a whole in the long run" here is enough, in my judgment, to make it likely that in the next half-century the march of science and the growth of capital will continue to reduce large groups of work people to a state bordering on economic worthlessness for long periods of time; and will thus subject a society based on the correspondence of reward with economic worth to greater strains than it has ever previously known.' D. H. ROBERTSON: 'Is Mechanisation a Danger?'—*Times of India*, December 1933.

In preceding chapters the case for the resuscitation of the hand-loom industry has been stated. It is to be preferred to the power-loom as it causes less unemployment, as it suits the peculiar economic conditions prevailing in India, as it distributes work and welfare with greater justice and equality. The plea for the revival of hand-loom weaving—all other small industries as well—raises certain important questions of policy and ideology which deserve a fuller treatment in this chapter.

The first question is: in the natural selection in industrial evolution is it not an inexorable law that smaller industries wear out and larger organisations take their place? Is it not inevitable that human power is replaced by mechanical power? Is it not true that small industries lack the basis of permanence and stability and that their protection, is therefore, unwise and unnatural? The answer to the last question has been given. Reference has been made to an exhaustive enquiry into small scale organisations in the countries of the world, a summary of which was published in the *International Labour Review*, June 1928. Even the Council of the People's Commissaries and the Minister of

National Economy of the Reich have recognised the importance of small scale industries. In a decree of May 1927 the Soviet Council declared: 'For a long time to come large scale industries will not be able to produce sufficient for the needs of the country, *nor will it be able to absorb all the surplus labour*. Small scale handicraft industries will use this surplus labour especially among the poorer strata of the peasantry, and will to a great extent satisfy the needs of the rural and urban markets. This explains the enormous importance of the small industries for the national economy of the Socialist Soviet Republic'. The Reich Minister declared himself in favour of the handicrafts in no less unequivocal terms. 'The handicrafts-man has held his own in production and has even succeeded in gaining some contested ground but he is no longer the handicraftsman of old historic times with methods of working handed down from bygone centuries'.

The answer to the first question is given by Richard Gregg and Theodore Morison. The latter, while recognising the place of machinery in the progress of civilisation, states: 'It is not a law of nature that steam power should supersede hand-power. It has been the consequence of the special conditions of Europe. . . . When the power required is not in excess of that which can be supplied by human body, it is a calculation of the relative cost which decides whether steam power or hand power shall be applied to manufactures'. Hand-power is expensive in the west of Europe; hence the attempt to substitute steam-power but in India at the present day hand-power is cheap and to the employer, generally, more economical than steam power. This consideration of comparative costs will be dominant and cannot be eliminated at least so long as the society is organised on a capitalistic basis and production is for profit and not for consumption; and so long as that consideration prevails the substitution of mechanical power for human power cannot always be effected. It must also be remembered that as the human skill, intelligence and dexterity cannot be replaced by machines completely, however perfect they may be, there is always a place assured for handicrafts employing human power in the industrial scheme. The proposition that in the

industrial evolution small scale industries are mercilessly and invariably wiped out by large scale organisations stand discredited. 'The more one examines', says Dr. Radhakamal Mukerjee, 'the present state of the small industries in this country, the more one is inclined to think that they have been steadily developing and conquering new fields for the last fifty years. The petty trades are not killed and cannot be killed. Like Proteus they change their aspects. It is a fallacy to suppose that natural selection in industrial evolution is only a process of larger organisations surviving and wearing out the smaller. . . . There is always a place for the smaller industries in the course of industrial development—a place which can never be abolished, but will always grow simply because it cannot be filled by large industries'. Leading industrialists and economists of the world have declared that small industries and handicrafts are not mere relics of the past but form an integral part of the future industrial order.

Another question of practical importance arises out of the advocacy of protection of the hand-loom against the power-loom. One may ask, 'Is it a wise policy to pit the low paid homeworkers against the better paid factory labourers?' 'Will not such a policy lead to the lowering of the standard of living?' 'Is it not a novel method of economic reconstruction which seeks to depress the elevated classes rather than to elevate the depressed classes?' Generally speaking, it is true that it is not wisdom to promote an unhealthy competition between a well paid worker and a low paid one. The State must allow the process of natural selection to have its course. But the special circumstances prevailing in India demand, however, such an action. It is a truism that competition tends to level down wages in different areas and industries.¹ The high wages now obtaining in Indian factories cannot for long remain far above the average level of wages that the actual resources of the country and the stage of economic

¹ 'Modern power-driven machinery and large-scale industries will mean a rapid advance in material prosperity but only upto a point. The existence of backward communities and countries and the possibilities of cheap labour working on modern automatic machinery will worsen the situation by increasing unemployment and imperil the relatively high wages which the workers in those industries and countries at present receive.'—G. D. H. COLE, *The Intelligent Man's Guide through World Chaos*, p. 176.

development of the country can warrant. Also a difference in the nominal wages does not necessarily reflect a difference in the relative efficiency of the workers concerned; nor even a difference in their conditions of living. A high nominal wage is not always indicative of a better living or cultural advancement of the person receiving it. Further the present higher wages in urban areas, in industries, or in even highly advanced industrial countries cannot be maintained by any amount of trade unionism and governmental buttresses if there is a large working population living on lower wages with no legal or political obstacles in their way to compete with better paid workers. When such extremes of poverty exist, it is not just to invoke the argument that the State interference with the natural selection in industrial development of mechanised industries and cottage industries is unwise as it results in the lowering down of the standard of living of workers in the former. One cannot afford to make a cult of the standard of living especially when that standard of living is not shared by all. While it is desirable to increase material comforts and maintain a high standard of comfort, it cannot be arbitrary, much less exclusive. It is conditioned and dependent on a number of factors such as the resources of a country, its population, its productive powers, the degree of its productive efficiency, and others. But the existence of the extremes of poverty and riches, of luxury and want, the presence of a large population remaining unemployed and under-employed are in themselves the manifestation of an unstable economic order and can promote nothing but economic insecurity which slowly increases with the widening of the gulf between the groups of workers in the society. It is folly to maintain—even to tolerate—great disparities in wages, as it is folly to maintain disparities in wealth and income. For, it can lead to only one end which every one fears and none has the strength and vision to avert—*Revolution*. Apart from the fear of anarchy it might create, it is heartlessness to suggest that the State should not interfere in the natural ordering of the economic system—however hideous its manifestations may be—as evolved by the forces of competition and economic freedom while a large section of the people live for

ever on the verge of starvation and a fraction thereof enjoy the extremes of opulence. The State would fail in its duty if it does not eradicate such preventible economic and social diseases as threaten the stability of society and the advance of civilization and if it does not regulate the economic progress in a manner that its blessings are shared equally by all individuals and classes. That the State exists for all and not for the few is not a meaningless truism. It is a hard reality which every civilised Government is seeking to realise. Its function is not merely to maintain political order but to secure economic and social stability; and it is now realised that the State is not an instrument of exploitation, much less a partisan organisation but a creative institution, the highest expression of social justice and harmony.

In these days of rationalisation and mechanisation of industries, one often hears a wholesale denunciation of all industries which cannot pay a decent wage making a decent life possible for workers. 'No civilised society' it is said, 'can tolerate the existence of such industries as cannot permit enough leisure for men employed in them for their cultural development and as cannot afford enough returns to workers for their comfortable standard of life'. Home industries are specially covered by this sweeping condemnation, for it is the home workers that are as a class poorly paid, are weak in bargaining, are not easily reached by trade unionism or state protection, live in squalid surroundings and slave for long hours. As an ideal to be realised in the future economic order, it is excellent that sweated industries are weeded out. But as an immediate practical proposition in India—perhaps, in all countries of the world—the desire to suppress all home industries is nothing but an empty aspiration. Cottage industries and small scale organisations, however uninviting their conditions of work may be, have not been wiped out and they cannot be wiped out by all the wondrous mechanical inventions and scientific progress. There is a permanent utility, an inexhaustible vitality, in them. True, they produce certain monstrosities in the life of the workers and in the conditions of employment under the stress of competitive production for capitalist profit which aims at cheap production. Cheap

production is not an ultimate good. It is good only if it leads to a right distribution and if it is limited by the demand of the workers for tolerable human conditions of labour'.¹ The remedy does not lie in the total suppression of the homecrafts, cottage workshops or rural industries, as it is often contemplated, but in placing human values above economic values and in guaranteeing sufficient returns to workers and tolerable human conditions of labour in all economic activities which are essential to sustain the life of the society.

This plea of the writer for the revival of the hand-loom, his love for homecrafts and small industries, his argument for the cautious introduction of machines and his half-concealed admiration for the socio-economic experiment now carried on in Russia—all this makes a hotch-potch of economic ideals. What is the place he gives to machine in the industrial order? What is the economic creed that he would wish India to possess? An attempt will be made here to answer these questions and avoid possible misunderstanding. While he has no hesitation in equating economics with human welfare, in accepting the liberal and social doctrine of 'maximum of production with minimum of effort' and the socialist theory of just distribution and the province of Government, and while he does not deny the material basis of civilisation and the need for increased production, he has his own difficulties in accepting the methods by which the end is realised; he has his own misgivings in adopting the machine as the medium by which the economic salvation is to be attained. The working out of the economic ideal in practice must vary according to the circumstances in which each country is placed. The blind imitation of the methods and the indiscriminate absorption of the ideas of the West

¹ G. D. H. Cole, observes : 'There are serious obstacles in the way of introducing mechanical power in its most developed forms in countries like China and India. It is hard enough for Soviet Russia, to abstract at the expense of the low standard of life of the great mass of her people, enough capital to finance her ambitious schemes of industrial reorganisation. But Russia as a country is thinly populated in relation to the countries of the Far East and in their case the density of population, the very small size of their crowded peasant holdings, and their extreme poverty, put even greater difficulties in the way of any comprehensive plan of economic development.' *The Intelligent Man's Guide Through World Chaos*, p. 139.

and their haphazard, or even unflinching, application to India will spell disaster. The philosophy of machinery which has transformed Western Europe and increased its material wealth is sound theoretically; and it has also achieved a great measure of success in practice. But it must be recognised that even in those countries it has prospered on the ruins of humanity, on the miseries of millions and it has left its permanent marks of devastation on mankind. It must also be recognised that the philosophy of machinery has its own limitations. It cannot be realised in all countries and at all times in the same manner as it is done in Russia today or as it has been done in any other industrial country of the world. Though India and China may require a thorough-going reconstruction of their entire economic systems on lines of large scale collective organisation based on the use of mechanical power in its most developed forms, and though they may stand in need of a thorough-going communism, these ideas require a great deal of adaptation before they are applied to the different economic circumstances of these countries.¹ There is ample scope for increasing the total production, even of necessities and comforts of life in India; there is a crying need for shortening the hours of work and reducing the physical strain of labour and increasing the wages of workers; all this seems possible only by the mechanisation of industries and large scale organisation on the collectivist principle. But, still, 'the doubt persists if all the mechanical inventions yet made have lightened the day's toil of any human being'.² 'The direct evidence drawn from the most highly evolved machine industry', writes J. A. Hobson in his *Evolution of Modern Capitalism*, 'seems to justify the general opinion expressed by Prof. Nicholson "it is clear the use of machines, though apparently labour saving, often leads to an increase in the quantity of labour, negatively, by not developing the mind, positively by doing harm to the body"'.³ Even granting that mechanisation of industries increases the leisure for the working

¹ G. D. H. Cole, *World Chaos*.

² J. S. Mill, *Principles of Political Economy*.

³ Pp. 338-40. Mr. Hobson cites certain instances of machinery increasing the intensity of labour. 'The general opinion seems to be that in spinning mills, roughly speaking, 75 per cent. of the increased output per operative

classes and decreases their physical strain, it often leads to the degradation of human personality and sows the seeds of social disintegration, especially when such production is unaccompanied by a just system of distribution. For there is the danger of ignoring the human problem in the enthusiasm for the development of the technique of industries. 'The technician', as observed by G. D. H. Cole, 'tends to regard industry merely as a technical problem; whereas it is fundamentally a human problem as well, and its object is not merely to create the maximum of goods, but to create them with the minimum of human suffering and inconvenience and in such a way as to promote the best distribution of wealth'. This danger may be avoided in a perfectly controlled economic and social order. The difficulties in transforming the present society to such a highly communistic state as contemplated are many. Perhaps they should not deter us. 'To do great things a man must live as though he had never to die.' But this unshakable faith in the cause and optimism in the rectitude of our own conduct must not at the same time blind us to certain realities, certain difficulties which can be tackled only by patience, knowledge and intelligence. It must be understood that even in a communistic society it is hard to realise the principle of justice in distribution. That principle to be a fact and not a dream must base distribution not merely, subjectively, on individual needs but also, objectively, on his capacity and opportunity for work; and there can be no divorce of work from remuneration, of responsibility from privilege; and such a close relation which is absolutely essential for the permanence and stability of the social order, would be very difficult to realise, and even if realised, difficult to maintain, in such a vast country, with such a vast population living in abysmal ignorance and stark poverty as India when it is rapidly industrialised and transformed with the help of machines. For, apart from the danger arising from the

may be imputed to improved machinery and 25 per cent. to increased intensity of labour in regard to quantity of spindles or speeding up.' 'The driving system in looms by which the overworkers are paid a bonus on the product of the looms under their charge has admittedly induced, as it was obviously intended to do, an increased intensity of labour'.

limitations of the human vision, rectitude and intelligence, it undermines the basis of distribution. It is possible, though it seems extremely unlikely, there may not be enough work for all. If, as it were by the wave of a magic wand the whole world in all its economic activities is transformed with automatic machines which can be manipulated by a couple of millions of men and if they can produce by working for a couple of hours all that the community needs, distribution of work and wealth will become extremely difficult. This is not an impossibility, a mere figment of the imagination; for, as we see it today, the recent phase in the development of mechanical invention and scientific progress has been in the direction of transferring human intelligence to machines.¹ If this is carried far enough and proves a success the place of man in industry will be lost and the cupidity of the few who have the control over the economic machinery will result not merely in shattering to pieces the fabrics of a socialised State but it will cause all evils of unemployment, poverty and miseries. The theme of this book is not to dwell upon these political and economic scares, nor to deal with these highly improbable nightmares which might frighten us to inaction, but to stress on the limitations of the capacity of the machine in realising human happiness; to emphasise the importance of work to human development as also to the realisation of distributive justice; to emphasise the necessity of advancing cautiously the progress of economic development with the sole assistance of mechanical power so that human sufferings may be reduced to the minimum; to compel recognition of the rightful place of small industries and handicrafts in the industrial scheme; and at the same time to urge the need for appreciating human values likely to be lost in the craze for industrial progress which seeks unfortunately to substitute the cult of the machine for the love of humanity.

¹ Cf. G. D. H. Cole, *The Intelligent Man's Guide Through World Chaos*, Chapter on 'Machinery and Men', pp. 139-149.

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