

ELECTRICAL MACHINERY INDUSTRY IN INDIA-
A TECHNO-ECONOMIC STUDY

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ELECTRICAL MACHINERY INDUSTRY IN INDIA—
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P R E F A C E

This study deals with four subgroups of electrical machinery industry in India, viz. Motors, Transformers, Switchgears and Fans.

The problem of unutilised capacity of the manufacturing plants in some of these industries has been studied using linear programming technique. The analysis may bring out to the reader the multifaceted nature of the problem. It also throws out useful engineering data for further economic research.

Earlier attempts towards the analysis of the problem of unutilised capacity have been reviewed in Chapter I. This chapter also discusses in brief certain issues like the nature of the larger complex of metal working industries of which the four sectors studied in this work are part and the use of engineering & technical data for this study.

Chapter II presents certain aspects of the industry relevant to the problem. The purpose of this chapter is mainly to give a broad outline of the four industries being looked into.

Chapter III gives an account of the supply position in respect of raw materials. Inadequate supply of raw materials of the requisite quality forms a constraint on the production in the case of many industrial units. Later, in Chapter V, in the linear programming models of the firms, this constraint has been assumed away, for the limited purpose of analysis. However, the importance of this constraint in the context of some of the Indian industries is fully appreciated. A discussion of the supply position in respect of raw materials was, therefore, thought necessary.

Chapter IV gives a technical background to the analysis and data presented in Chapter V.

In Chapter V, the concept of capacity of a manufacturing plant has been developed. Measures of unutilised machine capacities under a variety of conditions are obtained and discussed.

Chapter VI summarises the important points in and the issues brought out by this study.

Much of the technical details have been relegated to the end as appendices.

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LIST OF ABBREVIATIONS AND TECHNICAL TERMSAbbreviations

MSP	Monthly Statistics of the Production of Selected Industries of India.
DGTD	Directorate General of Technical Development.
DGSD	Directorate General of Supplies and Disposal.
HEIL	Heavy Electricals India Ltd.
BHEL	Bharat Heavy Electricals Ltd.
TISCO	Tata Iron and Steel Co. Ltd. (India)
ASI	Annual Survey of Industries (India).
Rs.	Rupees

Technical Terms

HP	Horsepower
KV	Kilovolt
KVA	Kilovolt-ampere
MVA	Megavolt-ampere
TWh	Terawatt hour
KWh	Kilowatt hour
KW	Kilowatt
MW	Megawatt
AC	Alternating Current
DC	Direct Current
HT	High Tension
LT	Low Tension
CRGO Steel	Cold rolled grain oriented steel
SWG	Standard wire gauge
RPM	Revolutions per minute
Hydel	Hydro-electric
EMU	Electro magnetic units

Equivalents

1 lakh =	10^5
1 crore =	10^7
1 million =	10^6

MW (Megawatt) = 1000 KW (Kilowatts)
 TWh (Terawatt hour) = 10^9 KWh (Kilowatt hour)
 Rupees = \$ 0.133 US (approximately).

CHAPTER 1

PRELIMINARY CONSIDERATIONS

1.1 The Theme

'Capacity' figures as an important concept in economics. It is frequently used both in theoretical discussions and in economic administration. Measures of capacity, under a given set of conditions, are used as indicators of the total potential of an industry or firm. The rate of utilisation of capacity based on a concept of 'full capacity' shows how far the economy is using its resources and how far it is failing to use them. Alternative approaches towards the 'full capacity' concept can be broadly classified as those which consider it as a purely 'technological' concept and others which treat it as an 'economic' concept.

Technological capacity generally refers to the theoretical or rated capacity of a capital equipment or that of a set of equipments working together in a chain to produce a particular product. The technological concept of capacity does not take into account the various economic factors. These, however, have to be taken into consideration when the plant is to be put into operation. The economic concept of capacity is based on the consideration of these economic factors and is usually defined with reference to prices which are the indicators of these factors in a market economy.

In the case of a uniproduct, single equipment manufacturing plant, given the technique of production (which defines the capital equipment and auxiliary factors like raw materials and labour which cooperate with it), 'technological

capacity' generally means the rated capacity of the machine or the maximum rate of output with the given technique.

In a uni-product, multi-equipment case, like for instance, sugar producing plant, given the technique of production, technical capacity may be defined as the maximum technological rate of output with respect to the technical imbalances¹ in the chain of equipment through which the raw material has to pass.

In a multi-product, multi-equipment plant, a direct measure of technological capacity is more difficult. Difficulties in the measurement are introduced by the existence of several products on the production schedule or what is referred to as a 'product mix'. In the first instance, this implies a problem of aggregation requiring one to take resort to prices. This is necessary while expressing the measures of capacity and capacity utilisation, say, as a maximum achievable total output and the total output that is being achieved.

Difficulties are not confined to the problem of aggregation alone. Within a machine group in such a factory, a certain amount of transferability is possible.² A machine could be used to perform an operation for different products.

¹ This refers to the different technical (rated) capacities of the individual machines.

² For more details regarding this point, see Chapter V, and Appendix C.

Alternately, a product could be fabricated on either of the machines within a precisely defined group of them. Thus, a certain amount of change in the composition of a product mix can be met with the same set of machines. In a market economy, the composition of the product mix or the relative quantities of different products to be produced will obviously be determined by the considerations like maximisation of profit given the prices and costs of different products. Purely technical concept of capacity, therefore, loses some of its significance. Given, however, a set of prices and a product mix based on the set of prices, it is possible to obtain a measure of capacity as a maximum rate of output that is possible with the given set of capital equipment. Such a measure is not unique, because with a change in the proportions of the quantities to be produced, a different measure of capacity is possible.

In all the three cases described above, it will be seen that the technological capacity is rather an indicative concept. It indicates maximum possible rate of output of a machine or that of a set of machines for one or more products.

Though it is possible to define capacity in the case of industries producing a single homogeneous commodity as a hypothetical maximum rate of output (with respect to the capital equipment), market established costs have to be taken into account of almost all industries while defining capacity as a maximum output possible in practice. The economists

work out ideal output under various assumed conditions. From their concept of ideal output they derive an economic concept of capacity.³ In certain cases this may coincide with technological concept or full rated capacity; in others it may differ. Particularly in the multi-product case, it is the economic concept (or a central planning directive as regards the composition of the product mix) that can provide the guidance. The actual level of output of a plant has to be distinguished from both the technological maximum output or the ideal output given by the economic concept of capacity. Measures of unutilised capacity will depend on the concept of 'full capacity' that we adopt for comparison with actual level of output of firms.

Without a study of the practices in this respect, it is difficult to state how capacity in different industries is defined. It is, however, necessary to bear these points in mind from the point of view of analysis of problems in which measures of capacity are used. In many important policy problems, especially those related to planning for development, or those related to war mobilisation, the necessary capital requirements of different productive sectors is an important objective of analysis. Attempts

³ See, for instance, Chamberlin's definition of the concept of full capacity discussed on pp. 9-10 of this chapter. See also, pages 177-78 for the definition of 'full capacity' as an economic concept adopted for the purpose of analysis in this study (Chapter V).

are being made to estimate the capital required for a unit capacity (output) in a particular industry.

Input-output approach necessitates detailed studies in the capital requirements for different sectors of economic activities. Capital-output ratios or capital coefficients which describe capital requirements per unit of capacity in a particular sector form an important empirical base of such models. It is obvious that the measures of capital requirement will be subject to a considerable variation depending upon whether we assume plant operation near the maximum technological capacity or operation at some level of 'economic' capacity.

Another problem in the estimation of real capital requirements per unit capacity is posed by the fact that many reporting units in the official surveys that are generally the bases of such statistics, have unutilised capacity. The existence of excess capacity leads to a higher measure of capital requirement per unit capacity (output) than what is technically warranted. This unutilised capacity is often coupled with another problem viz., imbalance in the capital equipment of the manufacturing plants. At a particular level of output (which may be the capacity output), certain machine groups show excess capacity while the others show shortages and form bottlenecks beyond the particular level of output.

Existence of imbalance in the capital equipment vitiates

the picture of capital requirement in another sense. Thus, if we assume a brand new plant, where investment has to be made in all the sections, right from machining and stamping to assembly and despatch, we may get a certain measure. If, however, we base the measure of capital requirement on the basis of an old plant (using the same technology as in the earlier case) expanding its capacity, we may get a different measure of capital requirement for a unit capacity in the same industry. This is so, because it is a common experience that expansion of capacity in the case of plants having imbalance in the capital equipment is possible by investment on certain machine groups only.

The probable factors that lead to this type of capital structure are discussed in a later chapter.⁴ The important point to be noted here is that the analysis of capital structure itself becomes necessary along with the measure of capacity as a particular level of output.

Apart from the problems of measurement of capital requirement of different industries, the interest in the measures of capacity and the rate of utilisation of capacity results from many problems of current economic policy; some of them intended as remedial measures are -- licensing of new capacities in different industries, location of new capacity, liberalisation or tightening of imports, etc.

⁴ See Chapter V.

Unutilised capital resources imply a loss of the national product due to certain malaise in the economic structure. The problem assumes particular seriousness in a country like India that has to spend a considerable amount⁵ of foreign exchange on the import of machinery and is facing almost a foreign exchange crisis.

What is worse is the fact that precise measures of capacity and the exact magnitude of unutilised capital resources are not known in many cases. The estimates of unutilised capacity are obtained either on the basis of published statistics or on the basis of measures supplied by the firms. Glib talk of the 'failure to achieve the maximum output' or 'our unutilised capital equipment' is often not based on a clear knowledge about the situation in these two respects. It is still too early to expect official surveys to throw light on these aspects. Some experimentation with data for each industry is needed before we can bring forth different aspects of the problem in detail.

The present study proposes a methodology⁶ for this purpose. Here, the attention is drawn mainly on the twin aspects of the problem of capacity utilization, viz., the current rate of output as a proportion to the maximum possible output and the rate of utilisation of capital stock at the level of a firm, under a variety of conditions.

⁵ During 1965-66 (the last year of the Third Five Year Plan) India imported Rs. 4,89,46,77,766 worth of machinery) including electrical machinery. Source: India, Department of Commercial Intelligence and Statistics, Monthly Statistics of the Foreign Trade of India, Calcutta, March 1966, p. 14.

⁶ See, Chapter V.

The analysis is based on the case studies of firms in the electrical machinery industry. This work also follows the pattern of general industry studies in so far as it covers certain important aspects of the industry related to the main theme (Chapters II and III). An outline of the industry is presented in Chapter II, while the supply position in respect of raw materials is described in Chapter III. Chapter IV serves the purpose of giving a technical background to the analysis and data presented in Chapter V.

1.2 Earlier Attempts to define the 'capacity' concept and related empirical investigations

The earlier attempts to analyse the problem of unutilised capacity, could be broadly divided into those of a theoretical and others of an empirical nature. This distinction is only a matter of emphasis. Any attempt at theorisation has an empirical experience at the background and any empirical study takes a concept of capacity as a basis. So far as the Indian scene is concerned, attempts are mostly of the latter kind.

We may begin our survey with the concept of 'full capacity' of a firm as developed by Chamberlin.⁷ Capacity of a firm is defined as the output level associated with full competitive equilibrium. This point would occur at

⁷ Chamberlin, E.H., The Theory of Monopolistic Competition, The Oxford University Press, 1949, pp. 104ff.

the minimum point of the average cost curve of the firm. An important feature of this concept is that it brings in the economic considerations of cost in defining the capacity. Any departure from the perfect competitive nature of the market towards monopolistic competition according to this theory leads to excess capacity. As a theoretical model this concept has been regarded as an important landmark in the economic analysis of the problem.

Chamberlin's work inspired a number of essays both of critical and supplementary nature on the same subject. Thus, Cassel in an article⁸ makes a clear distinction between excess capacity of fixed factors and excess capacity of all factors. He interpretes Chamberlin's analysis as applying to all factors, and long run curves.

While Nicholas Kaldor⁹ agrees on the whole with Chamberlin's line of analysis, says, "general conclusion as to the effect of generation of excess capacity upon economic welfare is extremely difficult." "Neither excess capacity is the result of consumer's choice." -- "Consumers are never in a position to choose between the alternatives 'variety' to 'cheapness'."¹⁰

⁸ Cassel, J.M., "Excess Capacity and Monopolistic Competition," The Quarterly Journal of Economics, Vol. 51, 1937, pp. 426-43.

⁹ Kaldor, Nicholas, "Market Imperfection and Excess Capacity", Chapter IV in Essays on Value and Distribution, Gerald Duckworth and Co., Ltd., London, 1960, pp. 62-80.

¹⁰ Ibid., p. 80.

Suppose that it is decided to measure capacity as the minimal point on a firm's cost curve. The short run cost curve may very well be U-shaped with a distinct minimal point but there are serious doubts whether the long run curve will actually turn up like that. This led Klein¹¹ to explore some approaches to capacity measurement in terms of cost functions particularly as properties of what he calls 'probit' total cost functions.¹² The emphasis of the methodology given here is on aggregating the individual capacities; those of the firms to that of an industry and those of industries to that of a national economy. The attempt at the methodological exploration, however, is not combined with any empirical exercise.

In a paper entitled "Capacity Concept and Induced Investment" Bowman and Phillips¹³ discuss the concept of capacity in the light of its use in dynamic input output analysis. The capacity level for each industry sought by the input-output analysis is to be expressed in such a way that changes in the selected final bill will not call forth capital expansion in any industrial sector until it

¹¹ Klein, L.R., "Some Theoretical Issues in the Measurement of Capacity", Econometrica, Vol. 28, 2, 1960, pp.272-286.

¹²Ibid., p. 278.

¹³ Bowman, Raymond, T. and Phillips, Almarin, The Capacity Concept and Induced Investment, National Bureau of Economic Research, Inc., New York, 1953, p. 19.

reaches its capacity. In this context capacity is defined as "The rate of output which is best for the present facilities, considering the existing price and cost structure (and associated institutional arrangements such as number of shift operations etc.) as given." In an explanatory note on this definition the authors further write, "this implicitly assumes that there is a rate of output which is ideal for existing capital stocks. Such need not be the case if there are imbalances existing among the equipment of the various production processes, which make up a plant."

In a separate section on measuring the capacity of an industry authors write, "The simplest and most reliable way of measuring industry capacities is to ask the establishments involved what their capacity is ... Many plants will be found to have capacity estimates for their own use which are not very dissimilar to that being required. The measurement itself does not seem at all insuperable."¹⁴

In an appraisal of the measures of industrial capacity and rate of capacity utilisation obtained by the major research projects, Phillips¹⁵ has pointed out clearly how

¹⁴ Ibid., p. 25.

¹⁵ Phillips, Almarin, "Industrial Capacity - An Appraisal of Measures of Capacity", American Economic Review, Papers and Proceedings, Vol. LIII, Number 2, May 1963, pp. 275-292.

capacity is required to be measured separately both in terms of output rate and as the rate of utilisation of capital stock. These two measures are necessary if effect of sheer demand on capacity utilisation is to be distinguished from that due to structural changes.

The theoretical economic concept of capacity is sometimes also illustrated in terms of production instead of cost function. A recent attempt is by Klein and Preston.¹⁶ The authors have developed a measure of capacity and capacity utilisation at the industry level from production functions. The thorny problems encountered here as the authors have mentioned are: (a) to determine the real capital employed at time t and (b) to determine available man-hours at time t . Further, lacking estimates of capital utilization, authors are forced to use a proxy, viz., the rate of man-hour employment by industry.

Thus, it will be seen that quite a few able attempts have been made to define the capacity of a firm. In the case of some of the measures that have been suggested, however, the empirical application is difficult, while in some of the other cases, it has not been tried on any significant scale.

We may next look into the way, the capacity is defined (or is asked to define) at the level of a firm in some of

¹⁶ Klein, L.R., and Preston, R.S., "The Measurement of Capacity Utilization," The American Economic Review, March 1967, pp. 34-58.

the important surveys undertaken to obtain industrywise measures of capacity.

In the United States, the McGraw Hill Department of Economics¹⁷ publishes measures of capacity which are derived from their 'Annual Surveys of Business Plans for New Plants and Equipment' which are conducted since 1947. No effort is made by McGraw Hill to define capacity. Companies set their own commonsense definitions of capacity such as "maximum output under normal work schedules."

In India, the government publication called "Monthly Statistics of the Production of Selected Industries of India"¹⁸ reports monthly figures of capacity and actual production for different products. Capacities for electrical machinery industries are computed by assuming 300 working days per year and on one shift basis.

The concept of installed capacity of production is defined by the 'Annual Survey of Industries',¹⁹ which seek information on capacity from industrial units as "the production which can be achieved in a plant or a combination of plants working together in a sequence under normal

¹⁷ McGraw Hill Department of Economics, Business Plans for New Plants and Equipment, 1961-64, 14th Annual Survey, New York 1961.

¹⁸ See India, Central Statistical Organisation, Monthly Statistics of the Production of Selected Industries of India, Calcutta, Vol. 18, 1966, pp. iv-v.

¹⁹ India, Central Statistical Organisation, The Annual Survey of Industries, Calcutta, Vol. 1, 1963, pp. 164-65.

operative conditions." In the case of a uniprodukt, multiequipment manufacturing plant, the term 'normal operative conditions' refers to "the factors inherent in the imbalance of the designed capacity of individual plants in the whole chain". In the case of a multiprodukt, multi-equipment manufacturing plant the term 'normal operative conditions' refers to the actual composition of the products to be produced during the year. The capacity is "a technological maximum rate of output in the given context of fixed assets and other related factors."

Thus the questionnaire is adequately qualified by the appropriate assumptions regarding existing plant and equipment, number of shifts, product mix, and subcontracting.²⁰ However, the term "normal operative conditions" as elaborated above does not distinguish the imbalance in the capital equipment (given a product mix), which is due to technological reasons and the imbalance crept in due to other factors.²¹

Apart from the official publications mentioned above, a few noteworthy attempts that have been made are important from the point of view of better understanding the magnitude and causes of the problem of underutilization of capacity. The report²² of the Survey of Small Engineering Units in

²⁰ This has been specified in an another question. Ibid., p. 169.

²¹ Some of these factors are discussed in Chapter V.

²² Reserve Bank of India, Survey of Small Engineering Units in Howrah, Bombay, 1964, pp. 143-44.

Howrah undertaken by the Jadavpur University, under the auspices of the Reserve Bank of India contains an excellent analysis of the idle time of men and machines. In the context of the Indian industries this is perhaps the first serious effort to investigate the problem by a joint team of engineering and economic investigators. The purpose of the authors was "to obtain a broad idea of the total work content of every work hour and the process of production apart from the gain in the knowledge necessary for reducing ineffective time of machines and idle time of men where it is avoidable."²³ Issues, like for instance, the set-up time as a factor in the idle time of machines and the problem of optimum lot-size, the pattern of machine loading etc., which are significant for economic analysis but which are rather difficult to tackle by economists alone themselves, have been thrown up. It is interesting to note that idle machine time due to set-up time (17 per cent) exceeds idle time due to shortage of raw materials (10 per cent) and the shortage of work (13 per cent) in the case of these small engineering units.

Rao's²⁴ study on excess machine capacity in the

²³ Ibid., pp. 143-144.

²⁴ Rao, R.S., "Capacity Utilisation in Sugar Industry in Maharashtra". Papers presented to the Input-Output Seminar held at the Gokhale Institute of Politics and Economics, Poona-4, from 24th to 30th August, 1965.

factories belonging to the sugar industry in Maharashtra is based on the data supplied by thirteen factories regarding the capacities of different machines and the final output. Norms are set for machines as regards the minimum capacity of each required for a given final output. This is done by calculating what is called minimum capacity coefficient (this points out a machine with a minimum capacity sustaining a particular final output). Capacity of this machine is compared with those of a similar type in other factories. Excess capacity of machines is defined as that above the minimum capacity indicated by the 'norm'. Due weights are given at each stage of comparison. Such a comparison was made possible because the product (viz. sugar) is homogeneous and there were no qualitative differences in the product. In the case of processing industries in India, like sugar for instance, this is perhaps a pioneering study on the individual machine utilisation and presents a fairly workable approach.

In a brief but illuminating essay "Better Plant Utilization in India", Soloman has analysed certain causes of unutilised capacity. Maintenance imports i.e., imports of spare parts, components and tools has been mentioned as an important factor in the lesser utilisation of machine capacity in this study. To quote Soloman²⁵ -- "In an attempt to increase

²⁵ Soloman, Morris J., Better Plant Utilization in India, A Blueprint for Action, Asia Publishing House, Calcutta, 1963, p. 45.

indigenous manufacture, imports of tools have been cut off as soon as an Indian manufacturer starts supplying tool. In many cases the Indian product is far less durable than the imported products. This obliges the user of the tool to adjust in two ways. First the speeds of cutting have to be reduced. Second, time has to be taken to sharpen the tools or at least a change in the tool must take place. Both effects can drastically reduce the product that can be obtained from the fixed plant."

The emphasis of Solomon's study is more on the ways to improve the situation at the plant level. One of the important measures suggested is more intensive staffing of labour per machine in the plant. Assumption here is that labour time is cheaper and machine time dearer in India. This assumption, however, does not hold good in every situation.

In a preliminary report on the subject entitled 'Capacity Utilization and Factors Affecting It in Certain Indian Industries, 1966-67', Koti²⁶ has covered 234 industrial products and obtained estimates of unutilised capacity and reasons therefor. The investigation was confined to important industries manufacturing capital goods and intermediate goods and therefore covered coal and other

²⁶ Koti, R.K., Capacity Utilization and Factors Affecting It in Certain Indian Industries, Gokhale Institute of Politics and Economics, Mimeograph Series No. 2, Poona, 1966.

mining, paper, chemicals, fertilizers, cement, metal and metal products, electrical and other machinery, transport equipment and other engineering industries. Though the number of units in each sector on which the results are based was small, this inquiry gives a glimpse of the conditions regarding the utilization of capacity for a much wider variety of products than what is available in the 'Monthly Statistics of Production'.²⁷

Koti's study tries to explore the effects and extent of the two main factors responsible for the under-utilization of capacity viz. (a) the shortage of demand and (b) shortage of raw materials. The importance of these factors in the case of each product has been assessed. It was left to the respondents to define the capacity of their plant(s) and to fill in the questionnaire accordingly, assuming a given product mix. The obvious advantage of this method is that questions relating to capacity are responded to by persons likely to know the answers. This is not an unmixed blessing, however, for there are many ways in which bias and errors can enter the results.

As Koti's and other studies show the unutilized capacity may be due to shortage of demand. The details of the demand factor, as the cause of unutilised capacity, are yet to be

²⁷ India, Central Statistical Organization, The Monthly Statistics of the Production of Selected Industries of India, Calcutta. This source reports only a part of the total number of industrial products.

investigated. A firm may be facing a shortage of demand because it is not in a position to meet the exact standards of quality. On the other hand, a firm may be facing a shortage of demand because the industries consuming its products might themselves be facing difficulties, say, a period of recession. Difficulties on the demand side may be the result of the coming up of cheaper and better substitutes. The shift from a product to its substitute may be the result of sheer price advantage, taste, or technological improvements embodied in the new product.

Another important factor which has emerged in these studies is the shortages on the supply side, especially in the case of raw materials and intermediate goods which are, in the main, the effects of non-balanced planning in an economy facing foreign exchange difficulties. In certain cases where the indigenous supply is not of requisite quality the users have to depend on imports. Supply of imported materials is always unsteady mostly due to changes in the government's import policy. Difficulties in getting timely supply of spares and tools are also mentioned as responsible factors in some studies.²⁸

This survey of the works on the concept and measurement of capacity and problems related to unutilised capacity is by no means exhaustive.²⁹ Its purpose is to take

²⁸ The Reserve Bank of India, op.cit., p. 106.

²⁹ For a comprehensive discussion of different factors responsible for the underutilisation of capacity of industrial firms in India, see, Morris Budin and Samuel Paul, 'The Utilisation of Indian Industrial Capacity (1949-1959)', The Indian Economic Journal, Vol. IX, No. 1, July 1961, pp. 19-47.

note of the aspects of the problem that have been covered already.

1.3 Approach of the Present Study towards the problem of unutilised capacity

In an industrial sector, which is a part of a mixed economy, unutilized capacity may arise due to various other reasons. It may be the result of the peculiar nature of the markets. To quote Chamberlin,³⁰ "... It is the peculiarity of monopolistic competition that it (excess capacity) may develop over long period with impunity, prices always covering costs, and may, in fact, become permanent and normal through a failure of price competition to function. The surplus capacity is never cast off, and the result is high prices and waste.... They are wastes of monopoly - of monopoly elements in monopolistic competition." It is beyond the scope of the present study to bring out elaborately the nature of competition in the electrical machinery industry. However, Chapter II may give at least a glimmering of the situation in this respect.

Complicating the above mentioned factor sometimes as also operating independently are another set of factors which are structural in character. Thus, the growth rate of a particular industry, say copper refining, may not keep pace with others which are growing faster and this may at a point of time start causing bottlenecks in the production of the industries which use copper as a raw material.

³⁰ Chamberlin, E.H., op.cit., p. 109.

These 'leads and lags which reflect mainly as bottlenecks of different kinds, also have their effect on the demand side. The operation of these factors has to be viewed in a dynamic context. A detailed input-output analysis provides a tool for grappling with such problems.

Apart from these problems, there are forces structural in character operating at the level of an individual firm. We may look at a production unit or a plant of a firm especially one in metal working industries as consisting of a set of different facilities or machine groups. The problem of unutilised capacity in such a plant may be viewed both in terms of output rate as well as the utilization of the capital stock. Unused capacity on different machines may not arise because of insufficient demand alone. It may arise from changes in the product mix due to varying relative demand, relative prices and costs. These factors have to be distinguished from inadequate aggregate demand, because they disturb the balance of different machines or facilities in a plant which also gives rise to excess capacity.

It is here viz. in separating structural effects from sheer demand effects as causes for under-utilisation of resources (capacity) of a firm that the present study attempts to fill in lacuna. As will be seen in Chapter V, the linear programming analysis helps not only to define capacity of a firm under a variety of conditions, but it enables one to probe into the pattern of utilization of the capital stock.

1.4 Use of Engineering and Technical Data

The approach of this study towards the analysis of unutilised capacity requires the use of technical data on a number of aspects. This kind of information may be obtained directly from firms or in certain respects standard technical literature could be used (when the analysis is of a generalised nature). As the interest of this study is more in the actual working of the units in the electrical machinery industry, technical data were obtained from the firms themselves. It pertains to the existing capital equipment, production pattern and the production technique adopted in the manufacturing plants of the units studied.

Technical data, either in the form of information supplied by firms or that based on standard engineering handbooks has been used for analysing quite a few important economic problems. Recent applications are found in the analysis of capital and other input requirements of industries and industry-wide capability studies.³¹

The usual problem faced in the context of input output analysis is that of instability of technical coefficients³²

³¹ Our interest in looking into these applications is more from the point of view of their experience regarding the use of this new field of information (viz. engineering and technical data) rather than the objectives of analysis per se.

³² Coefficients denoting inputs of raw materials, machinery etc. for a unit of output in different industries.

over time due to factors such as changing product mix, process mix and product multi-dimensionality.³³ Inputs of raw materials, requirements of machinery and labour, inventories of raw materials are all based on the assumption that there is a constant product-mix adopted by the manufacturing plants and that the technique of production remains unchanged. In many industries both the product-mix and the manufacturing processes are subject to frequent changes. These changes introduce an element of instability in the technical coefficients which are based on the situation prevailing at a point of time. Efforts have to be put in afresh to construct newer tables either de novo or by incorporating the known changes.

In order to circumvent the problem of coefficient instability attempts were made to use technical and engineering data mainly as a supplement to methods of calculating input coefficients based on statistical data. Attempts of an experimental nature were also made to use such data as a basis for classification and aggregation.

Chenery³⁴ for instance, has discussed from a general methodological point of view the derivation of economic

³³ For the discussion of these concepts, see, Mathilda Holzman, 'Problems of Classification and Aggregation' in Leontief et al. Studies in the Structure of American Economy, Oxford University Press, New York, 1953 *passim*.

³⁴ Chenery Holis B., 'Process and Production Functions from Engineering Data' in Leontief et al., op.cit., pp.297-325.

production functions from engineering data. Holzman,³⁵ while suggesting a new mode of classification based on processes rather than on products for the industries in which process changes are more important, attempts to construct a process input function for 'machining' based on technical data and basic engineering laws. Mrs. Carter³⁶ has studied the technological structure of the cotton textile industry from this point of view. Production function for cotton textiles was obtained in this way and further it has been compared with one based on the economic statistics. Fergusson³⁷ has tried to estimate the current and capital inputs in the production of commercial air transportation in the United States in the years 1937 and 1947.

If engineering data from standard technical handbooks are to be used to estimate the technical coefficients difficulty arises because there is not a single design law for many technical conversion processes. Different materials and processes could be used. This makes inputs based on a single

³⁵Holzman, Mathilda, op.cit., pp. 326-359.

³⁶Carter, Anne, 'The Technological Structure of the Cotton Textile Industry', op.cit., pp. 360-420.

³⁷Fergusson, Allen, R., 'Commercial Air Transportation in the United States', op.cit., pp. 421-447.

law somewhat irrelevant. This leads Furubotn³⁸ to propose a production function based on engineering data, as what he calls a 'multi-equation construct'. There is, however, no application of the theoretical formulation.

Another field which has found wide potentiality for the use of engineering source material and technical data is industry or economy-wide feasibility studies. Attempts made by Markowitz and Rowe³⁹ to estimate the requirements of machines, materials and labour for the metal working sector involves the combined use of engineering and census data. Though input coefficients for material, labour and equipment are largely based on census data, engineering estimates are suggested by the authors for the purposes of secondary corrections. The technology in the metal working industries has been described in terms of standard tasks (technical processes), standard machine classes, the breakdown of machine time for different tasks and machine availability.⁴⁰

³⁸ Furubotn, Erik, G., 'Some Questions on the Theory of Engineering Production Functions', Artha Vijnana, Vol.9, No. 2, June 1967, pp. 252-276.

³⁹ Markowitz, Harry, M. and Row^e, Alan, J., 'Metal Working Requirements Analysis', also see by the same authors, 'A Machine Tool Substitution Analysis', in Studies in Process Analysis, Economy-wide Production Capabilities by Alan S. Manne and Harry M. Markowitz, John Wiley and Sons, Inc., New York, 1961.

⁴⁰ Ibid. See especially pp. 357-363.

Investigation undertaken by the Institute for Research in Social Science of the University of North Carolina to study the Soviet Machinery Industry,⁴¹ is another instance of the use of engineering data in the field discussed above. This study was intended as a tool for estimating the economic capabilities of the Soviet Union. It was based on published Soviet engineering and industrial source material.

Without going into the details of these studies and the operational aspects of the theoretical formulations in some of these, we may highlight their important conclusions as regards the use of technical data. The experience of these studies shows that a certain amount of economic judgment is necessary in using the engineering data. The technical material is vast and available in considerable details. The level of disaggregation for the collection or compilation of the data has to be decided according to the purpose of economic analysis.

An important point emphasised by these studies is the use of the combined engineering statistical approach (rather than pure statistical one), for the analysis of requirements of various types of inputs for industries. The use of dis-

41

University of North Carolina, Institute for Research in Social Sciences, Production Coefficients and Technological Trends in Soviet Industry - An Input-Output Analysis of Machinery Construction, Soviet Planning Study No. 7, Chapel Hill, North Carolina, 1959.

aggregative technical information provides insight into the relationship of different industries. Further, it helps to point out the resource shortages or bottlenecks in the particular production programme clearly, which is also an important objective of these explorations.

In the present study, technical data have been used in a modest way. The linear programming analysis of firms⁴² is based on detailed technical data. These include Lists of Machines and their total time available for the particular period chosen for analysis, say a week or a month. Time of different machines required to fabricate each product on the production schedule, etc. The economic data are required to formulate the objective functions to be maximised. Linear programming technique, provides an excellent tool for combining engineering and economic data for the purpose of detailed analysis.

Thus, the capital structure of the firm surveyed for this study does not ^{only} mean so much Rupees worth of machinery but it also implies information listing the number of machines classified according to the groups chosen for the analysis. The optimum plans given by the linear programming analysis according to different objectives show not only the amount of maximum profit or value added that could be achieved out

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See, Chapter V.

of such plans but different machines and their time used in the production process.

The attempt is to arrive at the values of optimum production, capacity measures, etc. by direct analysis of the firms based on disaggregative engineering and economic data instead of depending on results based on Financial Statistics regarding some past performance.

1.5 Electrical Machinery Industry As a Part of the Larger Complex of Metal-working Industries

The present study pertains to four sectors in the electrical machinery industry viz. motors, transformers, switchgear and fans. Within the electrical machinery complex these products (especially the first three) are more akin to each other from the point of view of dependence on the power generation in the country for their demand, important raw materials required and the basic technical processes involved.

Most of the products of the electrical machinery industry and particularly those mentioned above can be included in the general class of metal working industries. These industries produce an array of products ranging from tractors and earth-moving machinery, electrical machinery, other industrial machinery to nuts and bolts, nails, springs etc. Despite the diversity of products, there is a high degree of overlap between the processes, skills, and equipment used by the metal-working industries. 'Hiring in' and 'hiring out' of the machine capacities is found quite common in these

industries. It is hardly a case when the manufacturer in these industries produces all the components, parts and accessories required for his final output himself.

A machine tool produced in a machine tool factory may be sold with an electric motor (which goes as an important accessory of the main capital asset) produced in an electrical motor manufacturing unit. A large number of parts are generally bought from ancillary industries who specialise in the particular processes. An ancillary unit may specialise in certain machining processes such as lathe-work, another may be efficient in the press tool work. Yet another may be best in electroplating jobs.

Efficient output of an electrical machine manufacturing plant thus depends on the growth and efficiency of several other metal-working industries including those producing minor parts.

This has lead economists to study the whole metal working complex as such from the point of view of its requirements of materials, skills and equipment.⁴³ Possibilities of transferability of machine capacities from one product to another, and further possibilities^{of} substituting machines for different 'tasks' or the basic technical processes have been studied at some depth.⁴⁴ In the United States, the outbreak

⁴³ Markowitz and Rowe, 'The Metal-working Industries', in Studies in Process Analysis, John Wiley and Sons, Inc., New York, 1963, pp. 264-284.

⁴⁴ Markowitz and Rowe, A Machine Tool Substitution Analysis, op.cit., pp. 313-351.

of Korean War in early fifties prompted surveys⁴⁵ with the object of assessing the capability of metal working industries especially to switch over from peace-time production to war time production.

The peculiar feature described above has been stressed here because some of the problems that are facing electrical machinery industry and especially the one of unutilised capacity has to be studied in the context of this gamut of relationships existing in the metal working industries.

1.6 Unutilised Capacity - Recent Statistics

In the recent years unutilised capacity has plagued most of the sectors of these metal working industries, including those products of the electrical machinery industry which are the subject of the present study. The situation has no doubt been aggravated by the conditions of recession prevailing in these sectors for the last one and a half year. It is, however, an agreed fact on all hands that many industries are running below normal at least for the last quinquennium. The study made by the National Council of Applied Economic Research⁴⁶ which is based on published statistics⁴⁷

⁴⁵Survey of Production Machinery, Factory Space and Manpower, York, Pennsylvania, 1951.

⁴⁶National Council of Applied Economic Research (N.C.A.E.R.) Under-utilisation of Industrial Capacity, New Delhi, 1966.

⁴⁷Viz., the following, India, Central Statistical Organization. Monthly Statistics of the Production of Selected Industries of India, Calcutta.

reports that the average per cent unutilised capacity for the period of four years viz. 1961-64 was 44.5 per cent for motor starters (Switchgear), 49.4 per cent in the case of electric fans, 15.3 per cent for transformer and 38.2 per cent for electric motors on the double shift basis.⁴⁸ The latest published statistics⁴⁹ for the year 1967 show that on the two shifts basis, the unutilised capacity in the four important sectors varied between 25 per cent and 57 per cent. Product-wise unutilised capacity was as follows:-

TABLE 1.1. UNUTILISED CAPACITY (ON THE TWO SHIFT BASIS) IN MOTOR, TRANSFORMER, SWITCHGEAR AND FAN INDUSTRIES DURING 1967.+

Product	Unutilised capacity
1. Motor Starters (Switchgears)	24.73
2. Fans	57.08
3. Transformers (Power)	38.65
4. Motors	26.43

+ Calculated from Monthly Statistics of the Production of Selected Industries of India.

⁴⁸This is considered to be the desirable shift working pattern for these industries in the 'N.C.A.E.R.' Study.

⁴⁹India, Central Statistical Organisation, op.cit.
The data given in the Monthly Statistics of the Production of Selected Industries of India regarding these products relate only to all assisted units featuring on the list of Directorate General of Technical Development of the Government of India (DGTD) in the whole of Indian Union. Units having fixed assets of more than Rs. 5 lakhs are generally looked after by the DGTD. Exact situation regarding the utilisation of capacity in the small scale units not covered by the DGTD is not known.

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Koti's study for the year 1966-67 shows that the unused capacity in the case of responding firms ranges from 22 per cent in switchgear, 21 per cent in the electric motors, 22 per cent in power transformers, 31 per cent in other transformers to 66 per cent in the cables and wires industry. The responding units in the electric fan industry had no idle capacity.

1.7 S u m m a r y

Four sub-groups of the electrical machinery industry in India have been studied in the present work. These are: motors, transformers, switchgears and fans. The emphasis of the study is mainly on the analysis of unutilised capacity (at the level of a firm) in these industries. The problem of unutilised capacity is being approached both as a comparison of the actual output to the capacity output and from the point of view of utilisation of capital stock. Linear programming has been used as a tool of analysis for this problem. The analysis of unutilised capacity has been facilitated by the combined use of engineering and economic data.

CHAPTER 2

THE INDUSTRY

2.1 Introduction

The last chapter gave an outline of the theme of this study. It also showed the kind of need that may be fulfilled by studies of this kind. This chapter is intended to present broadly, certain important features of the four subgroups of the electrical machinery industry, viz., motors, transformers, switchgears and fans, being considered in this study. It also gives the recent position of these four industries in respect of installed capacity, production, imports and exports. Most of the statistics relates to the period 1951-52 to 1965-66 which is the period covered by India's three Five Year Plans. This account is based mostly on published statistics, reports and other references.

Unutilised capital resources involve certain 'extra' costs. In the model of a perfect competitive market it is assumed that such a firm will be weeded out by the market forces. The nature of competition prevailing in an industry is related to the problem of unutilised capacity in this sense. The nature of competition in a modern industry in India is influenced by many factors. Only a broad outline of some of these could be given here. What strikes any keen observer of the industrial scene in India is the fact that market in the case of many sectors of industry is segmented into many distinct sections. That the operation of competitive forces in some of the modern industries in many countries is restrained by factors such as product differentiation and

selling cost is a subject already discussed at able hands.¹ Some of these factors appear to be applicable to Indian industries also. Certain facts of the Indian situation (such as, a range production being reserved for the public sector undertakings, and others as discussed in the next paragraph) probably/⁴restrict the field of effective competition in Indian industries. No conclusion, however, could be drawn here as to the effect of this situation on prices.

In the case of electrical machinery industry in India and especially the four sectors under study, it is the policy of the Indian Government² that a major part of the demand for viz. that/the heavy electricals will be met by the units in the public sector. A substantial range of production is, thus, reserved for the public sector where an entry of a private firm is difficult, unless the government makes an exception to its policy and licences a private firm to undertake the production. In each sector, a large³ amount of production is accounted for by a few big firms. Quite often, as will be seen in a subsequent section these largest firms represent foreign capital investment; sometimes with far

¹See Chamberlin, E.H., The Theory of Monopolistic Competition: Re-orientation of the Theory of Value, Oxford University Press, London, 1949, pp. 71-173.

²Government of India, Industrial Policy Resolution, New Delhi, 1956, pp. 3-4.

³ See Section 2.8 passim.

better business competence than their Indian counterparts.

Restrictive trade policies of the Indian government in respect of imports either in the form of a total ban on the import of certain items or prohibitive tariffs keep off the forces of international competition from a wide range of indigenous production.

In the subsequent sections, these aspects have only been touched upon. It is not the intention here to question the 'raison d'être' of the public policies involved.⁴ Nor is the attempt directed to answer the 'why' of the problem of the under utilisation of capacity by explaining the nature of competition in the groups of industries being studied here. The purpose is only to present certain facts in this respect which also forms a part of the objective of this chapter viz. to give a general outline of the industry.

Section 2.2 gives a description of the products: motors, transformers, switchgears and fans, along with a brief history of the electrical machinery in India. Section 2.3 describes in short, India's total hydroelectric power potential, and hydro-power put to use. The scope for the products that are being studied depends very much upon the power generating capacity in the country. Position of the electrical machinery

⁴ Thus, perhaps no private Indian firm was coming forward to invest in the production of heavy electricals which have been reserved for the public sector. Alternative to public investment would have been to invite foreign private investment.

industry in the total manufacturing sector and the size of different sectors (Large, Medium and Small) within the industry are given in Section 2.4.

Section 2.5 gives a brief description of the present position of the public sector undertakings, especially as regards the investment and the range of the products for which capacity has been installed. However, for the convenience of presentation, statistics regarding the actual production of these units has been given along with those in the private sector in Section 2.8.

Section 2.6 describes the foreign concerns participating in each sector. Present regulations regarding imports and tariffs on imported items are stated in Section 2.7. Section 2.8 puts in brief the recent position of the four sectors in respect of capacity, production, exports and imports. This has been given for the four selected years. Statistics on different aspects of industries is not available in a single source. Different sources of data had to be used. At every stage it has been shown that the sources cover major portion (that of production, capacity, etc.) of these industries.

2.2 Scope of the Industry and Its Brief History

The Electrical machinery industry consists of establishments engaged in manufacturing machinery, apparatus, and supplies for generation, storage, transmission, transformation and utilisation of electric energy.⁵ Generators and turbines,

⁵ See for instance, the definitions given in the follow-

transformers, switchgears and distribution line equipment like wires and cables and related products are required for the generation and transmission of electricity. Electric motors of various types are used to transform electrical energy into mechanical energy. The products using electrical energy are many and varied, ranging from electrical lamps, meters, radios, telephones, to household appliances working on electrical energy. Motors, transformers, switchgears and electric fans are considered in the present study. Except electrical fans, which is a durable consumer good, all the rest are important capital goods. These capital goods are the key products required in the electrification and irrigation programmes and in increasing the productivity in industry and agriculture. We may look into the nature of these four groups of products in some more details.

Electric Motors

This is a machine which converts electric energy into mechanical energy. Electric motors are produced in a broad range of sizes. Those below one horse-power are classed as fractional horse-power motors, while those with one horse power and above, ranging upto thousands, are called integral

Footnote continued from previous page

ing publications:

- (a) India, Central Statistical Organisation, Annual Survey of Industries, Vol. I, Calcutta.
- (b) U. S. Department of Commerce, The Bureau of the Census, Census of Manufactures 1947, Vol. II, Washington D. C., 1949, p. 714.

horse-power motors. An electric motor can be made with a wide variety of characteristics, such as, speed, voltage, torque, duty rating, temperature rise, etc. This makes the standardization of the product difficult as the customers demand motors with special characteristics for their applications. A large portion of fractional horse-power and integral horse-power a.c. motors, however, are made in standard frame sizes and horse-power ratings.

T r a n s f o r m e r s

Supply of electricity from a power station to distant load centres, and to consumers, necessitates transformation of voltage at various stages. Large blocks of power are stepped up to extra high tension voltage near the power station; stepped down to intermediate voltage at sub-stations near load centres, and further transformed from 33 KV, or, other secondary voltages to 400/230 volts, for distribution to smaller consumers. Transformers of various duty ratings and types are used for these applications.

The two important categories of this machine are:

- (a) Distribution and instrument transformers, and
- (b) Power transformers.

Distribution and instrument transformers are sold to the electric utility industry. They are located at the out-lying ends of the electric utility network and convert transmission voltages to the end use voltages. Instrument transformers are devices used in measurement of voltages, and currents.

As compared with the manufacture of other equipment involved in the generation, transmission, and distribution of electric power, the minimum capital investment necessary to enter this segment viz., distribution and instrument transformers industry, is lower than that required for other apparatus. The specifications for each rating of transformers of this type are clearly established. This commodity type characteristic of the market makes it possible for small size plants to specialize in the manufacture of certain range and compete successfully with the large scale units in the local markets in terms of service and price. As a result of this, many companies have entered this field.

The electric utility industry is also the primary customer for power transformers. They are used to step up voltage for long distance transmission and then to reduce it at a sub-station for local distribution. Power transformers form a major capital equipment required for electric utilities. Because of the large number of variables in designs, they are usually custom-built, to meet the requirements of each customer. Large investment is needed to enter this field, because of the large size, long production-cycle time, and extensive engineering facilities needed.

S w i t c h g e a r

The term switchgear includes all types of circuit breakers for transmission and distribution of power, control-gears for various applications, switches, relays, etc.

Broadly speaking, the products which are classed as switchgears and controlgears are devices which make, break, or change the course of an electric circuit.⁶ The term switch is usually used to denote only those devices intended to function when the circuit is operating under normal load; as contrasted with circuit breakers which also function when the circuit is carrying abnormal currents.

Switches are made in many forms ranging from micro-switches used in low voltage circuits, carrying small currents in such equipment as telephones and business machines; to disconnecting switches in power transmission circuits carrying large blocks of electric current. Most familiar switches are the wall switches used in homes and offices for turning lights and appliances on and off, and service entrance switches used to cut off power from buildings in emergencies.

Circuit breaker is a device which breaks an electric power circuit whenever excessive current develops, thereby protecting the circuit's apparatus and surroundings from the potentially disastrous consequences of sustained excessive current. Circuit breakers are used in practically all kinds of electric power transmission and distributing systems, from small isolated generating sets to large public utilities

⁶ This description is based on McGraw Hill Encyclopedia of Science and Technology, McGraw-Hill Book Company, Inc., Vol. 3, 5, 13, New York, 1960.

and industrial plants. In physical size they range from that of a small two-story house to that of a package of cigarettes. They are rated according to their ability to interrupt short circuit current: from a few amperes at less than 100 volts to over 40,000 amperes at 345,000 volts, and 150,000 amperes of 240 volts.

According to the methods used to extinguish the arc, circuit breakers are classified as (1) oil circuit breakers, in which the arc is drawn and extinguished in insulating oil, (2) air-blast, in which the arc is extinguished by a blast of compressed air, (3) magnetic air, in which the arc is forced by a magnetic field and (4) gas, in which arc extinction takes place in a dielectric gas other than air.

Relays of different types are commonly used for remote switching and control, protecting electrical devices and systems, and in digital computers. This is a device, usually electro-magnetic, that uses a variation of the current in one circuit to control conditions in another circuit.

The demand for switch-gears and motor control-gears (a section of the switchgear production) is in direct proportion to the demand for transformers and motors and has therefore relationship to the electric power generated.

Electric Fans

This is an item with which we are quite conversant because of its common domestic use. Various kinds of fans are available. They include ordinary table fans, ceiling fans,

railway carriage fans, pedestal fans, blowers, exhausters, etc

Brief History

The electrical machinery industry came into existence in India a few years after the termination of the first World War. The necessity of building this industry was felt much earlier, but lack of technical knowledge combined with restrictions on the import of capital goods and machinery during the First World War precluded the industrialist of the country from entering into the field of this industry. The industry's prospects were further narrowed by the dumping of cheap electrical goods from foreign countries like Japan and Germany.

The electrical fan industry with the establishment of a factory in Calcutta in 1921 became the pioneering electrical industry of the country. Before the Second World War, the capacity of factories established in Calcutta, Bombay, Lahore and Amritsar was in the neighbourhood of 40,000 fans per annum.⁷ During the War, with a view to meeting the very large demand of Defence Services the industry was rapidly developed. By 1946, the capacity of large units was approximately 1,50,000 fans per annum.⁸

In the thirties, electric lamp, dry battery, and storage battery industry were established. During the Second World

⁷ India, Department of Industries and Supplies, Report of the Electrical Machinery and Equipment Panel on the Development of Electrical Industries, 1947, p. 36.

⁸ Ibid.

War and after, the manufacture of electric motors, transformers, cables and wires was undertaken.

In the late thirties, factories producing electric motors were set up at Bombay, Calcutta and Kirloskarwadi. Manufacture in the pre-independence period was restricted to that of 1 to 10 h.p. motors. Factories manufacturing transformers were located in Calcutta, Bombay, Lahore and Bangalore. The range of transformers manufactured in India till 1917 was quite limited. Only a limited number of 500 KVA transformers were being manufactured and the bulk of the production, apart from the very small low voltage transformers, had been in the range of 25 K.V.A. to 100 K.V.A. and 11 K.V. on the high tension side. The capacity around 1947 was approximately 80,000 K.V.A. per annum.⁹ The manufacture of switchgears and controlgears was started around the same period as in the case of motors and transformers (during the Second World War). Factories were located at Calcutta, Bombay, and to a small extent at Lahore. The range of switchgear manufactured in India covered (1) knife switches and fuses including iron-clad, domestic and industrial switchgear of 15 to 200 amps capacity, (2) manually operated disconnecting switches suitable upto 33 K.V., (3) simple type switchboards, and (4) fabricated switchboards.¹⁰ The production of all the four types was very limited.

9 Ibid., pp. 20-21.

10 Ibid., pp. 25-26.

Private investment in the heavy electrical equipment industry was, however, conspicuously absent. This was largely due to the high standards and complicated nature of the technology and processes involving heavy capital investment and a long period of gestation lag. Except a few cases of private firms undertaking the manufacture of items like transformers of high voltage, the production of heavy electrical machinery has been in the public sector undertakings only and of very recent origin.

2.3 India's Hydro Electric Power Potential and the Electrical Machinery Industry

The demand for heavy and light electrical equipment and especially those products which are being covered in this study, closely follows the programme of power development in the country. Various conversion factors are adopted to estimate the demand for electrical equipment on the basis of power generating capacity in the country.¹¹ There are four main primary sources on which electricity supply must depend. They are: water resources, coal, oil and nuclear fuels. While India has limited resources of good coal, and so far is yet known, only meagre resources of oil, the country is relatively rich in water power resources. A detailed discussion of the country's resources of hydro, coal, oil and

¹¹ See, for instance, Samuel Paul and N.V.Rao, 'Demand for Electric Motors', Artha Vijnana, Vol. 9, No. 2, June 1967, pp. 228-251.

nuclear fuels¹² may lead us far off our track. The idea of the present level of utilisation of resources could well be obtained from the following statistics regarding the total water resources utilisable for power generation and those which have been put to use.

The economically utilisable hydro-electric power potential of the Indian Union aggregate to 41.155 Million KW. at 60% load factor (corresponding to about 216 TWh annual output).¹³ Schemes for generating electricity from the water resources which are currently in operation, under construction, and whose investigations have been completed, cover a total potential of about 11.6 million KW at 60% load factor (61 TWh annual output). The ultimate potential for hydro-electricity may, further, be compared with the total electricity production by all public utilities, hydro and thermal, of 22.4 TWh annual output in 1962-63.¹⁴

This shows that a large untapped potential of hydro-electricity itself exists for exploitation in the future.

¹² For a detailed discussion of these three resources, see, India, Report of the Energy Survey of India Committee, Government of India Press, New Delhi, 1965.

¹³ Ibid., p.192. TWh = Terawatt hour = 10^9 KWh
KWh = Killowatt hour

¹⁴ Ibid., p. 125. According to another source, the latest figure regarding the level of utilisation is 6 million KW, See, S. Swayambu (Chairman and Mangg. Dir. Heavy Electricals (India) Ltd.), "Heavy Power Equipment Industry" The Journal of Industry and Trade, Vol. XVII, No. 2, Feb. 1968, pp. 130-32.

The total power generation capacity which was 1.1 million KW at the beginning of the First Five Year Plan was expected to rise to 12 million KW by the end of the Third Plan.¹⁵ By 1970-71, it was planned to be 22.0 million KW. Side by side with the increase in power generating capacity, extensive transmission systems are also developing all over inter-connecting State grids. This has brought about the adoption of higher transmission voltages. Many power systems have commissioned 220 KV lines and it is expected that 400 KV lines would be constructed in the next few years.¹⁶

The supply of generating equipment is a necessary part of the country's power development programme. The important equipment for generating hydro-electricity are turbines of different types and ratings. The equipment for generation of power from coal are boilers, steam turbines and turbo generators. These equipments are to be manufactured by the plants manufacturing heavy electricals at Bhopal, Haradwar, and Hyderabad, in the public sector.

Increasing power generating capacity will also give a spurt to the demand for motors, transformers, switchgears and other equipment in both the higher and the lower ratings

¹⁵ S.Swayambu, 'Programmes of Manufacture of Heavy Electrical Equipment', Capital, July 1964, pp.73-75.

¹⁶ See, V.P.S.Menon, 'India's Heavy and Light Electrical Industries', The Journal of Industries and Trade, Vol. XVI, No. 9, September 1966.

and ranges. Production of lighter electrical equipment is concentrated mostly in the private sector while the output of public sector units is mostly that of heavy electrical machinery.

The subsequent sections are arranged so as to give a broad outline of the important aspects of the industry and its relevant statistics.

2.4 Relative Importance of the Electrical Machinery

Industry among the Manufacturing Industries and the Position of the Different Sectors within the Industry

If value added is taken as the basis of comparison, the electrical machinery industry stood seventh by its share in the total value added by the manufacturing industries. Its contribution in the total value added by the industrial sector stood at 3.9 per cent in 1963. Table 2.1 shows the different manufacturing industries arranged according to their respective share in the total value added

The Annual Survey of Industries¹⁷ divide the electrical machinery complex into sixteen sub-groups of industries. Table 2.2, which is based on the reports of this survey for the 'Census' part¹⁸ gives the description of these sub-

¹⁷ India, Central Statistical Organisation, Annual Survey of Industries, Vol. I, Calcutta, 1963, pp. 90-93.

¹⁸ The coverage of this survey extends to the entire factory sector. 'Factory' according to the survey means any premises including the precincts thereof
(i) whereon ten or more workers are working or were working on any day of the preceding twelve months, and in any part of which a manufacturing process is being carried on with the aid of power, or

**TABLE 2.1. INDUSTRIES ARRANGED ACCORDING TO THEIR PERCENT-
AGE SHARE OF THE TOTAL VALUE ADDED BY THE
INDUSTRIAL SECTOR ψ**

Industry	Value added percentage share
1. Spinning, weaving and finishing of textiles	24.7
2. Iron and Steel	8.9
3. Electric Light and power and gas	5.4
4. Paints and Varnishes and lacquers and miscellaneous chemical products	5.2
5. Miscellaneous food preparation and slaughtering. Preparation and preserving of meat	5.0
6. Machinery, except electrical	5.0
7. ELECTRICAL MACHINERY	3.9
8. Rail road equipment	3.5
9. Metal products	3.3
10. Basic Industrial chemicals including fertilizers	3.3
11. Sugar factories and refineries	2.7
12. Tobacco manufactures	2.1
Selected industries' share as percentage of the total	73.0

ψ Source: Reproduced from, India, Central Statistical Organisa-
tion, Annual Survey of Industries, Capital Employment
and Output Estimates for the Large, Medium and the
Small-scale Sector, 1963.

groups and their total output in the year 1963. The share of each group in the total value added has also been given in order to assess the relative importance of each according to this criterion. The units in the electrical machinery complex covered by the 'census' part of the Annual Survey of Industries formed a major part of the industry. In 1963 these accounted for 96.71 per cent of the total fixed capital, 88.28 per cent of the total employment, 91.38 per cent of the total gross output, and 93.70 per cent of the value added.¹⁹

Annual Survey of Industries also divide the units in the electrical machinery industry into large, medium and small scale sectors according to the size of the capital invested. Units having fixed capital of Rs. 5 lakhs and

Footnote continued from previous page

- (ii) whereon twenty or more workers are working or were working on any day of the preceding twelve months, and in any part of which a manufacturing process is being carried on without the aid of power.

Factories employing 50 or more workers with the aid of power or 100 or more workers without the aid of power are completely enumerated. This is called the Census part of the Survey. The remaining factories, namely, employing 10 to 49 workers with the aid of power or 20 to 99 workers without the aid of power are covered on the basis of probability sample. Table 2.2 is based on the results presented in the Census part of the survey. See, India Central Statistical Organisation, op.cit., p. xiii.

¹⁹ Calculated from, India, Central Statistical Organisation, Capital, Employment Output Estimates for Factory Sector, Calcutta, 1963, p. 44.

This annual paper published by the Central Statistical Organisation gives combined estimates of the fixed capital, employment, output and value added for the 'Census' and the 'Sample' sectors.

**TABLE 2.2. RELATIVE IMPORTANCE OF THE INDUSTRIES IN THE ELECTRICAL MACHINERY
COMPLEX (ALL STATES)**

Sl.No.	Description	Total Output	Value added	Per cent of the total value added
1.	Equipment for generation, transmission and distribution of electricity including transformers	32,18,40,894	7,36,25,214	13.61
2.	Electric Motors	15,62,82,918	5,88,65,625	10.88
3.	Electric Fans	16,45,78,684	5,19,80,296	9.61
4.	Electric lamps	7,17,71,409	2,24,35,826	4.15
5.	Manufacture of electrical furnaces	7,70,68,517	2,33,43,036	4.32
6.	X-ray equipment			
7.	Electrical machinery apparatus others			
8.	Electrical cables and wires	51,79,37,998	14,52,24,879	26.85
9.	Household appliances, irons, etc.	1,13,20,207	36,33,246	0.67
10.	Storage batteries	6,49,41,750	2,47,59,259	4.58
11.	Dry cells	7,20,80,964	2,38,64,909	4.41
12.	Telephones	12,14,37,831	5,96,89,321	11.04
13.	Telegraph equipment and	4,67,83,698	1,94,27,511	3.59
14.	Teleprinters			
15.	Wireless communication apparatus and radio receivers including amplifying and			
16.	Public address equipment	11,40,07,132	3,38,12,392	6.25
Total for all sub-groups		1,74,00,52,002	54,06,61,514	99.96

Source: Calculated from India, Central Statistical Organisation, Annual Survey of Industries, Vol. 1, Calcutta, 1963, pp.90-93.

below are defined as small-scale units. Those with fixed capital between Rs. 5 and 25 lakhs as medium and those above Rs.25 lakhs are large-scale units. Table 2.3 gives the sector-wise distribution of the fixed capital, persons employed and the value added by the manufacture in the electrical machinery industry. It shows that on the basis of size, large-scale sector is predominant in all the three aspects of this industry.

TABLE 2.3. SECTORAL (LARGE, MEDIUM AND SMALL) POSITION OF THE ELECTRICAL MACHINERY INDUSTRY (ALL STATES)

Sector	Fixed Capital Rs. Lakhs	Per cent share of each sector	Persons employed	Per cent share of each sector	Value added Rs. Lakhs	Per cent share of each sector
Large	6752.35	82.57	67,848	55.26	3656.72	64.50
Medium	866.57	10.60	22,627	18.43	1092.10	19.46
Small	558.50	6.83	32,294	26.30	920.24	16.23
Total	8177.42	100.00	1,22,769	99.99 100.00	5669.06	100.13 100.00

Source: Calculated from A.S.I., Capital, Employment and Output Estimates, 1963.

Fixed capital invested per rupee of value added, fixed capital per person employed and value added per person employed; for large, medium and small-scale sectors are given in Table 2.4. The measures are based on the aggregate

statistics given in Table 2.3 . Capital-output (value added) ratio as well as the capital required per person is the highest in the large-scale sector, so also is the value added per person employed.

TABLE 2.4. FIXED CAPITAL PER HEAD, VALUE ADDED PER HEAD, AND FIXED CAPITAL PER UNIT VALUE ADDED FOR THE LARGE, MEDIUM AND SMALL-SCALE SECTORS OF THE ELECTRICAL MACHINERY INDUSTRY

Sector	Fixed capital per unit of value added	Fixed capital per person employed	Value added per person employed
Large	1.85	9952.17	5389.57
Medium	0.79	3829.80	4826.53
Small	0.61	1729.42	2849.56

Source: Calculated from A.S.I., Capital, Employment and Output Estimates, 1963.

2.5 Public Sector Undertakings

The Government of India according to the 'Industrial Policy Resolution' has included the manufacture of heavy electrical machinery including large hydraulic and steam turbines under that category of industries, the future development of which will be the exclusive responsibility of the State.²⁰ Investment in the public sector units

²⁰ India, Industrial Policy Resolution, New Delhi, 1956, pp.3-4.

The policy, however, does not preclude the expansion of the existing privately owned units, or the possibility of the State securing the cooperation of private enterprises in the establishment of new units when the national interests so require. (see, p. 4). As mentioned at the end of this section certain units in the private sector have recently been licensed to manufacture heavy electrical equipment.

intended to produce heavy electrical machinery was first undertaken at the beginning of the Second Five Year Plan viz. in 1956-57. Heavy Electricals (India), Ltd., with its first giant plant at Bhopal was the first public sector unit set up in the electrical machinery industry. The next company to be incorporated in the public sector was Bharat Heavy Electricals Ltd., in 1964.

The following paragraphs describe different units of these two companies mainly from the point of view of the range of production for which the capacity is being created and investment in each unit.

Heavy Electricals (India) Ltd. (HEIL)

This company was incorporated in August 1956 with the objective of manufacturing heavy electrical equipment for which the country had so far been almost entirely dependent on imports. Due to the foreign exchange crisis which ensued in 1957, completion of the scheme was scheduled in three phases. The important features of the three phases are given on the next page.²¹

Till the end of March 1967, the company spent Rs. 62 crores (approx.) on Capital assets. The working capital stood at Rs. 19.62 crores,²² while the total staff employed

²¹ Reproduced from: Heavy Electricals (India), Ltd., 2nd Annual Report, Bhopal, 1957-58.

²² Heavy Electricals (India), Ltd., 11th Annual Report, Bhopal, 1966-67.

HEAVY ELECTRICALS (INDIA) LTD.

IMPORTANT FEATURES OF THE THREE PHASES

No.	Phase I	Phase 2	Phase 3
1	Production scheduled to start in the latter part of 1960 on (i) Switchgear (ii) Transformers (iii) Control gear (iv) Capacitors	Production scheduled to start in July 1963 on (i) Industrial Motors (ii) Traction Motors (iii) Heavy Electrical Rotating Plant	Production scheduled to start in July 1966 on (i) Hydraulic Turbines (ii) Rectifiers
2	Full production to be achieved by January 1965.	Full production to be achieved by January 1967.	Full production to be achieved by July 1970.
3	Annual output value Rs. 6.21 crores	Annual output value Rs. 4.16 crores	Annual output value Rs. 2.12 crores

during 1966-67 was 14,605. Recent statistics regarding production targets and actual production of this unit is given in Appendix 2.1 at the end of Section 2.8.

Bharat Heavy Electricals Ltd. (BHEL)

This new company was formed in 1964, in the public sector with factories at Ranipur (Haradwar), Ramachandrapuram (Hyderabad), and Tiruverumbur (Tiruchirapalli).²³

(1) Ranipur (Haradwar) Unit:- This will manufacture steam turbines and turbo-alternators (with a capacity of 1.5 million KW per annum). Hydro-turbines and generators (1.2 million KW per annum), electric motors A.C. and D.C. (0.515 million KW per annum). Steam turbines and turbo alternators will be in the range of 50 MW to 200 MW with a possible increase of single unit capacity upto 300 MW. Hydro-turbines and generators will be in the range of 25 MW to 100 MW A.C. and D.C. industrial electrical motors will be upto a capacity of 9000 KW in heavy A.C./D.C. type and 700 KW of A.C./D.C. in medium range.²⁴

The cost of the project is likely to be of the order of Rs. 74.00 crores. The entire supply of imported equipment amounting to Rs. 21.15 crores is to come from Russia. The plant was formally inaugurated on the 3rd January 1967.

²³ Bharat Heavy Electricals, Ltd., First Annual Report, New Delhi, 1964-65.

²⁴ Ibid.

(2) High Pressure Boiler Plant, Tiruverumbur,

(Tiruchirapalli) :- This unit will manufacture High Pressure Boilers equivalent to 750 MW generating capacity, 1800 tons boiler fittings and 10 package boiler units per annum.²⁵ This project is being set up with Czechoslovak collaboration and assistance. According to the estimates the total capital outlay on this unit including the township of 3000 quarters and the training school is likely to be Rs. 23.24 crores.

(3) Switchgear Plant, Ramachandrapuram (Hyderabad):-

This unit is being set up in technical collaboration with M/s. ASIA of Sweden for the manufacture of 132 K.V., 220 KV and 400 KV airblast circuit-breakers. Capital investment in this plant will be of the order of Rs. 2.27 crores.²⁶

General Comments

According to a recent report,²⁷ manufacture of water turbines for Obra Power House in U.P. and Bassi Power House in ^{the} Punjab had reached a very advanced stage at Bhopal. Some idea of the size of the jobs which are capable of being undertaken by the Heavy Electrical Factories can be had from the dimensions of the Obra turbine. It is a Kaplan type and its

²⁵ Ibid.

²⁶ Ibid.

²⁷ S. Swayambu (Chairman and Managing Director, Heavy Electricals (India), Ltd.), 'Heavy Power Equipment Industry', The Journal of Industry and Trade, February, 1968.

spiral casing is one of the largest in the world, having an inlet diameter of 26 feet and a height of 10 feet. The stator frame of its generator is larger than that of the machines installed at the Bhakra hydro-electric generating station. 'HEIL' and 'BHEL' can make large industrial motors upto very large ratings of 12,000 HP. Bhopal has already manufactured and delivered its first 2,000 HP motor to the cement industry.²⁸

The heavy electrical industry is by its very nature a complex one involving many materials, processes and testing procedures which call for a high standard of technology. Skills involved will have to be built up over many years. Similarly the design and manufacturing know-how will have to be acquired. This involves a long period of time.

There are stray cases of private manufacturers undertaking the production of heavy electricals. Thus transformers and Electricals Ltd., in Kerala, M/s. Crompton and Greaves in Bombay, M/s. Easun Engineering at Madras and M/s. Kirloskar Electric Co., Ltd., Bangalore, also manufacture large power transformers. The Hindustan Electric Co., Ltd. in collaboration with M/s. Brown Boveri Ltd. manufacture high tension switchgear (circuit breakers).

Statistics regarding investment in the private sector is not available in details. However, a rough comparative

28 Ibid.

picture could be obtained from the following statistics. While the total investment in the fixed assets by the Heavy Electrical (India), Ltd., Bhopal, which was the only company incorporated in the public sector by that time was Rs. 47.02 crores (Rs. 47,02,27,735) as on 31st March 1964,²⁹ value of the total fixed assets in the electrical machinery industry as a whole around the same period stood at 81.77 crores (Rs. 81,77,42,000).³⁰

2.6 Foreign Investment

Predominance of the foreign private investments is another important aspect of the electrical machinery complex. Outstanding foreign investments in business enterprises in the private sector in India amounted to Rs. 681 crores as at the end of 1961.³¹ Out of this total, share of private sources abroad was Rs. 581.7 crores, while official sources abroad accounted for Rs. 99.3 crores. 'Direct' investments (i.e. foreign investments which are accompanied by control of the undertakings in which the investments are made, for instance, equity ownership, formed a larger share, Rs. 528.4 of the total. 'Portfolio' investments (holdings of shares, securities, etc.) amounted to Rs. 152.6 crores.

²⁹ Heavy Electricals (India), Ltd., 8th Annual Report, Bhopal, 1963-64.

³⁰ India, Central Statistical Organisation, Annual Survey of Industries, Capital, Employment, Output Estimates for Factory Sector, Calcutta, 1963, p. 42. This figure relates to the period January-December, 1963.

³¹ Reserve Bank of India, Survey of India's Foreign Liabilities and Assets, 1961-Survey Report, Bombay, 1964, pp. 16, 80-82.

The figures exclude investments in insurance companies. Foreign investments in electrical goods and machinery proper amounted to Rs.14.7 crores in December 1961.³²

The exact quantification of the share of foreign investment in each sector of electrical machinery industry is not possible, for lack of information in that details. The following account, therefore, merely describes the foreign private concerns participating in each sector. These companies mainly operate through their branches or subsidiaries in India. They also operate through their collaborations with Indian firms. Important instances of such participation are given below.

Heavy Electrical equipment is to be manufactured mostly in the public sector units. The project report for the Heavy Electricals Ltd. was prepared by the Associated Electricals Industries Ltd. of U.K. who are also one of the financiers for the project. The English Electric Co. Ltd. is expected to meet a large share of the demand for heavy equipment required in generation, transmission and distribution of electricity. Even the lighter equipment made in the private sector is dominated by a few foreign firms, some of them being the giants of the industry in the U.K. and the U.S.A.

Thus, out of 21 private concerns manufacturing trans-

³² Ibid., p. 81.

formers, at least seven are foreign controlled.³³ The seven concerns are:- The Associated Electrical Industries (India), Pvt., Ltd., The British India Electric Construction Co., Pvt., Ltd., M/s. Crompton Parkinson (Works), Pvt., Ltd., The English Electric Co. of India Pvt., Ltd., The General Electric Co. of India Pvt. Ltd., M/s. Greaves Cotton and Crompton Parkinson, Pvt., Ltd., J. Stone and Co. (India), Pvt., Ltd.

In the switchgear industry (lighter equipment), Larsen and Toubro, Ltd., Bombay, are a leading manufacturer in many items of switchgears and controlgears.³⁴ Licences for high tension switchgear (a sphere reserved earlier for public sector) were granted among others to the English Electric Co., Ltd., Madras, a foreign unit. M/s. Kirloskar Asia Ltd., Bangalore are collaborating with 'ASIA', Sweden, and M/s. Mysore Electrical Industries, Ltd., Bangalore with the J.G. Statter and Co., Ltd., Amersham, Bucks, U.K.³⁵

Electric motors of 200 h.p. and above are to be manufactured in the public sector units. The lower ranges are left to the private sector, where foreign capital is well represented in many forms. Thus, M/s. Crompton

³³ Michael Kidron, Foreign Investment in India, Oxford University Press, London, 1965, p. 202.

³⁴ See India, Report of the Monopolies Inquiry Commission, Vol. I and II, New Delhi, 1965, p. 280.

³⁵ Srivastava, P.K., Foreign Collaboration in Indian Industry, Shiv Lal Agarwala and Co., Agra, 1967, pp.76-78.

Parkinson (Works) Pvt., Ltd., Bombay, is a foreign controlled firm (parent concern, M/s. Crompton Parkinsons, Ltd., London), the Kirloskar Electric Co., Ltd., Bangalore has a collaboration agreement with the Brush Electric Co., Ltd., of U.K., while Siemens of Germany are collaborating with New Government Electric Co., Ltd., Bangalore, and Bharat Bijlee, Ltd., Bombay.

The electric cable industry which is an important segment of the electrical machinery industry presents a similar picture. The largest of the four units producing power cable and the sole producer of co-axial cable in 1962 was Hindustan Cables, Ltd., a public sector unit at Rупnarainpur, West Bengal, having technical collaboration with U.S. controlled British Standard Telephones and Cables Co., Ltd. Among the three others, the Indian Cable Co., Ltd. is a British subsidiary, while West German interests are involved in the Cable Corporation of India. The fourth, the Asian Cable Corporation, an Indian controlled firm has a technical collaboration agreement with the British Enfield Corporation.

A number of other firms engaged in specialized lines have foreign know-how, while some have foreign equity or loan capital.

While the flow of foreign private capital in India is encouraged on terms which are equally advantageous to the investor and to the country,³⁶ imports of a number of

³⁶ The Reserve Bank of India, India's Foreign Liabilities and Assets 1961-Survey Report, Bombay, 1964, p. 15.

electrical goods and machinery are banned. Tariff protection has been granted to a sizeable range of production.

2.7 Tariffs and Import Controls

As in the case of many other Indian industries, certain sectors of the electrical machinery industry enjoy more or less a sheltered domestic market either due to tariffs and/or import control policies. In the case of four products covered in this study the situation stands as follows:-

(1) Motors:- The electric motor industry received protection for the first time in 1948 by conversion of the then existing revenue duty of 10 per cent ad valorem into an equivalent protective duty. The scope of protection at that time was confined to motors upto 30 horse power only. Since then, the scope of protection was extended to cover motors of higher ratings in consonance with the changes in domestic production. Till 1965, the scheme of protection covered squirrel cage and slip-ring induction motors and synchronous motors of 1 to 3000 horse power, excluding certain special purpose motors between 1 and 3 horse power range.³⁷ This protection was in force till 31st December 1965. The rate of protective duty was increased to 20 per cent ad valorem on component parts and 15 per cent ad valorem on electric motors.³⁸ The protective duties continued after

³⁷ India, Tariff Commission, Report on the Continuance of Protection to the Electric Motor Industry, Bombay, 1965, p. 1.

³⁸ Ibid.

December 1965, as they existed before.³⁹ Thus, except certain special purpose motors (like variable speed commutator motors) the industry has been granted tariff protection for almost a complete range of fractional and integral horse power motors.

There has been no quota for the import of electric motors to established importers for many years. However, imports of prohibited types of motors are allowed clearance, with machinery and equipment provided the motor shaft is directly coupled to the driving mechanism and can hence be regarded as integral part of the major capital asset being imported.⁴⁰

(2) Transformers:- Transformer industry was subjected to tariff inquiry for the first time in 1952. As a result, the import duty of 5 per cent 'ad valorem' on power and distribution transformers upto 2500 KVA and 37.5 KV on the high tension side excluding certain special purpose transformers in this range, was increased to 10 per cent 'ad valorem' exclusive of surcharge of 5 per cent on duty.⁴¹ With the subsequent tariff inquiries the scope of protection was increased. Till December 1965, the protected range covered power and distribution transformers upto 50,000 KVA and

³⁹ Ibid. p. iv (Resolution of the Ministry of Commerce, Government of India).

⁴⁰ India, Ministry of Commerce, Import Trade Control Policy. For the year April 1967 to March 1968.

⁴¹ India, Tariff Commission, Report on the Continuance of Protection to the Power and Distribution Transformer Industry, Bombay, 1965, p. 1.

220 KV. on the high tension side. There was to be 10 per cent import duty, exclusive of regulatory customs duty and surcharge of 5 per cent on the transformers in this range.

After December 1965, however, Government of India decided to discontinue the tariff protection to this industry. The regulatory customs duty was to continue at its existing rate.⁴² Import of transformers of ratings upto 5000 KVA and upto 37.5 KV on high tension side was completely banned during 1967-68. Transformers of ratings not covered in this range and components and accessories of all types of transformers are allowed to be imported.⁴³

(3) Switchgears and Controlgears:- The import of motor starters is banned both in the case of actual users as well as by the established importers.⁴⁴ Similar policy exists for metal clad switches and switch fuse units and metal clad cut-outs.

Imports of air and oil circuit breakers upto 660 volts, those above 660 volts and upto 11 KV and those above 11 KV, are allowed for actual users, though banned for established importers.⁴⁵ Imports of all other types of switchgears and

⁴² ibid., p. iii (Resolution of the Ministry of Commerce, Government of India).

⁴³ India, Ministry of Commerce, Import Trade Control Policy April 1967 - March 1968, p. 45.

⁴⁴ Ibid., pp. 45-46.

⁴⁵ Ibid., p. 46.

controlgear falling outside the range defined above are allowed only to actual users.⁴⁶ No tariff protection is given to this industry.

(4) Fans:- Import of electric fans, table and ceiling, and part thereof was completely banned during the year - 1967-68. This was true both for actual users as well as established importers.⁴⁷ However, import of fans especially certain parts and accessories like fan regulator, fan resistance units, condensers etc. was allowed against the export of complete fans to the extent of 20% of the f.o.b. value of exports.⁴⁸ No tariff protection was given to this industry.

A look into the reports of inquiries⁴⁹ undertaken by the Tariff Commission and the declarations regarding the Import Trade Control Policy⁵⁰ by the Government of India show that protection either in the form of import duties or import restrictions, has been granted to the respective products almost simultaneously as the capacity for these was available in the country.

⁴⁶ Ibid.

⁴⁷ Ibid., p. 47.

⁴⁸ Ibid., pp. 205-206.

⁴⁹ Tariff Commission Reports (such as quoted elsewhere in this chapter) for the electric motor industry are available for the years 1947, 1949, 1955, 1958, 1961, 1963 and 1965. In the case of transformer industry these are available for the years 1952, 1956, 1960, 1963 and 1965.

⁵⁰ A document annually published by the Government of India (quoted elsewhere in the Chapter).

2.8 Recent Position of the Four Industries:

Motors, Transformers, Switchgears and Fans

The following account of the recent position of the four industries is based on published data. It relates to the number of units in each industry, installed capacity and production in each of them, their exports and imports. Data regarding the number of units, capacity and production are based on the official publication, 'Monthly Statistics of the Production of Selected Industries of India'⁵¹ (MSP). Statistics furnished by this source relates to all the units in the Indian Union borne on the list of Directorate General of Technical Development (D.G.T.D.) of the Government of India. Units having fixed assets of more than Rs. 5 lakhs. are registered with the D.G.T.D. Henceforth in this chapter these units will be referred to as the 'organised sector' in the respective industries being looked into. Only one public sector unit viz. Heavy Electricals (India) Ltd., Bhopal, had commenced production during the period covered here (1950-51 to 1965-66). Statistics regarding the production in this unit has been given separately in each subsection and in the Appendix Table 2.1 at the end. Output of this unit is of a specialised nature and is not always available in the same physical units as reported in the MSP.

⁵¹ See, for instance, India, Central Statistical Organisation, Monthly Statistics of the Production of Selected Industries of India, Vol. 18, Calcutta, 1966. This source also gives the figures for installed capacity, along with the production statistics.

Units comprising the organised sector account for a major share of the total productive capacity in each of these industries. Thus, in the case of electric motor industry, units borne on the list of D.G.T.D. accounted for 69.92 per cent of the total installed capacity⁵² in the industry including that of small scale units. The situation in other sectors cannot be presented as above because of the lack of comprehensive data at a point of time. However, it could be assumed to be similar as the small-scale units (with fixed capital below Rs. 5 lakhs) in the electrical machinery industries account for a minor share of the total production capacity.⁵³ Secondly, though large capacities have been built up in the public sector units, the production on a significant scale has not commenced in any of these except in the Bhopal plant till 1965-66.

Figures for the total capacity of the units in each industry presented in MSP are on a single shift basis. However, in the case of many units, double shift working is quite possible. This fact has to be noted while looking into the tables given in the subsequent pages. Figures given in these tables sometimes show that total production has exceeded the installed capacity given in the earlier column. Wherever it was possible, information of a supplementary

52 See, Table 2.6 on page 73.

53 See, Table 2.3 given earlier.

nature has been given so as to give a fuller and better picture of installed capacity and production and to give an idea of the range of production undertaken in India.

The figures regarding exports and imports are calculated from 'Monthly Statistics of the Foreign Trade of India',⁵⁴ when these relate to the two years viz. 1960-61 and 1965-66. For the two previous years, viz. 1950-51 and 1955-56, the 'Annual Statements of the Seabourne Trade of India',⁵⁵ have been used for the purpose. The data regarding capacity and production are in terms of physical units like H.P. or K.V.A. in the case of motors and transformers, respectively, and only in numbers in the case of others. The import and export statistics on the other hand is available in terms of number of units and value. No comparison is, thus possible with the production figures given in the two tables given in the case of each industry. The tables, therefore, will serve only the limited purpose of showing the position of the industry in respect of each item as it stood at different periods of time. The figures have been given for four years. The data for the year 1950-51 shows the position right at the beginning of India's First Five Year Plan. The

⁵⁴ See, for instance, India, Department of Commercial Intelligence and Statistics, Monthly Statistics of the Foreign Trade of India, Vols. I and II, Calcutta, March 1966.

⁵⁵ India, Department of Commercial Intelligence and Statistics, Annual Statement of the Seabourne Trade of India, Calcutta.

three subsequent years, viz. 1955-56, 1960-61 and 1965-66 represent the end years of the First, the Second and the Third Five Year Plans.

Electric Motors

Capacity and Production

Manufacture of electric motors in the pre-independence period was limited mostly to the motors in the lower ranges of horse power between 1 and 10 H.P.⁵⁶ Even until recently much of the capacity was being utilised for the production of motors upto about 30 H.P. only.⁵⁷ However, the need for larger and special types of motors for different applications, such as for cement plants, rolling mills, paper mills, coal mining machinery, sugar centrifuges and other heavy industries is growing. In order to meet this demand, capacities for larger motors up to about 5500 horse power ratings and for flame-proof, variable speed and other special motors have been established.

The number of units in the organised sector, as the Table 2.5 shows, increased from 10 in 1950-51, i.e. the year before the First Five Year Plan started, to 27 in 1965-66 i.e. the last year of the Third Plan. Among the units in the private sector, Kirloskar Electric Co., Ltd., at Bangalore

⁵⁶ India, Department of Industries and Supplies, Report of the Electrical Machinery and Equipment Panel on the Development of Electrical Industries, New Delhi, 1947, pp.18-19.

⁵⁷ See, India, Tariff Commission, Report on the Continuance of Protection to the Electric Motor Industry, Bombay 1965, p. 9.

was the leading producer with 34.1 per cent of the total production in 1964.⁵⁸ This was followed by the Crompton Parkinson (Works) Pvt., Ltd., Bombay with 19.5 per cent of the total share. The next, the General Electric Co. of India Pvt. Ltd. accounted for 7.1 per cent.

TABLE 2.5. INSTALLED CAPACITY AND PRODUCTION IN THE ORGANISED SECTOR * OF THE ELECTRICITY MOTOR INDUSTRY +

Year	No. of units	Capacity in H.P. (on one shift basis)	Production	
			H.P.	Nos.
1950-51	10	1,74,654	99,004	N.A.
1955-56	12	2,00,400	2,71,500	N.A.
1960-61	20	6,02,400	7,24,800	1,37,000
1965-66	27	13,58,400	17,55,600	2,82,400

* Units borne in the list of the Directorate General of Technical Development.

+ Source: Calculated from, India, Central Statistical Organisation, Monthly Statistics of the Production of Selected Industries of India, Calcutta, 1950-51, 1955-56, 1960-61 and 1965-66.

The capacity (on one shift basis) increased from 1,74,654 H.P. in 1950-51 to 13,58,400 H.P. in 1965-66.

⁵⁸ See, India, Report of the Monopolies Enquiry Commission, Vols. I and II, New Delhi, 1965, p. 281.

The total number of units in the case of each sector considered by the Commission, are those borne on the books of the Directorate General of Technical Development of the Government of India. See pp. 11-12.

Production of these units increased from 99,004 H.P. in 1950-51 to 17,55,600 H.P. in 1965-66. As stated earlier, these figures are based on the reports of the 'Monthly Statistics of Production' and relate only to the units which report to the related organisation.⁵⁹

Reports of the Tariff Commission provide a periodical source of detailed information regarding electric motor industry. Latest report⁶⁰ of the Tariff Commission summarises the recent position of the industry as follows. By 1964-65, the installed capacity of 36 units in the organised sector (excluding HEIL) was 14,90,080 h.p. Adding the capacity of HEIL, the total installed capacity for the organised sector came to 17,15,080 h.p. The total production of the 33 reporting units during the same period was 13,37,997 h.p.⁶¹

TABLE 2.6. INSTALLED CAPACITY IN THE ELECTRIC MOTOR INDUSTRY

	No. of Units	Installed capacity H. P.	Percent share in total H. P.
(a) Units borne on the list of D.G.T.D.	36	14,90,080	69.92
(b) Heavy Electricals (India) Ltd., Bhopal	1	2,25,000	10.56
(c) Small-scale units	<u>130</u>	<u>4,16,000</u>	<u>19.52</u>
Total	167	21,31,080	100.00

Around the same period (1964) there were 130 small scale

⁵⁹ viz. Directorate General of Technical Development, Government of India.

⁶⁰ India, Tariff Commission, Report on the Continuance of Protection to the Electric Motor Industry, Bombay, 1965, pp. 7-8.

⁶¹ Ibid., p. 8.

units (having fixed capital below Rs. 5,00,000) with an installed capacity of 4,16,000 h.p. The estimated production of these units in 1963 was 1,72,000 h.p. and for 1964, 1,83,000 h.p.⁶²

Statistics regarding the production in the Heavy Electricals Ltd., Bhopal is available in terms of numbers only. This has been given separately in the Appendix Table 2.1 at the end.

Table 2.7 shows the break-up of production according to horse power ranges. It gives a cross-section of the present output pattern in the private sector in 1962 and 1964. Production of motors between 1 and 30 H.P. range accounted for 64.41 per cent of the total in 1962 and 72.31 per cent of the total in 1964.

★ TABLE 2.7. +PRODUCTION IN THE ORGANISED SECTOR OF THE ELECTRIC MOTOR INDUSTRY ACCORDING TO HORSE POWER RANGES IN 1962 AND 1963.

	1962		1964	
	H.P.	Percent of the total	H.P.	Percent of the total
Below 1 H.P.	8,637	(0.89)	9,780	(0.74)
1 to 5 H.P.	2,65,938	(27.36)	3,88,304	(29.38)
Above 5 to 10 H.P.	1,97,316	(20.30)	3,17,536	(24.03)
Above 10 to 20 H.P.	1,62,838	(16.75)	2,49,811	(18.90)
Above 20 to 30 H.P.	80,309	(8.26)	91,146	(6.90)
Above 30 to 50 H.P.	88,727	(9.13)	87,750	(6.44)
Above 50 to below 100 H.P.	1,11,053	(11.42)	91,934	(6.96)
100 to below 200 H.P.	49,215	(5.06)	62,978	(4.76)
200 H.P. and above	8,105	(0.83)	22,365	(1.69)
Total	9,72,138	(100.00)	13,21,604	(100.00)

★ Reproduced from India, Tariff Commission, op.cit., p. 9.

+ Production figures relate only to those units which have furnished the relevant data to the D.G.T.D.

⁶² Information supplied by the Development Commissioner, Small-scale Industries to the Tariff Commission. See Commission's report, Ibid., p. 8.

Exports and Imports

Exports of electric motors show a slow trend towards increase. Table 2.8 shows that the total value of exports increased from Rs. 24,073 in 1960-61 to Rs. 5,25,065 in 1965-66. There were no exports in 1950-51 and 1955-56. In 1965-66, exports of alternating current squirrel cage induction motors between 1 and 20 horse power accounted for the major part⁶³ Rs. 3,60,305 of the total exports of Rs. 5,25,065.

TABLE 2.8. RECENT STATISTICS REGARDING EXPORTS AND IMPORTS OF ELECTRIC MOTORS

Year	Exports		Imports	
	No.	Value	Nos.	Value
1950-51	-	-	N.A.	1,45,55,068
1955-56	-	-	N.A.	1,59,49,833
1960-61	70	24,073	40,358	3,19,82,466
1965-66	1963 Nos.	4,84,564	11,640	4,29,56,118
	Parts etc.	40,501	Parts etc.	1,48,78,787
	Total	5,25,065	Total	5,78,34,905

Source: Calculated from, India, Department of Commercial Intelligence and Statistics, (a) Monthly Statistics of the Foreign Trade of India, (b) Annual Statements of the Seaborne Trade of India, Calcutta.

⁶³ Basis: India, Department of Commercial Intelligence and Statistics, Monthly Statistics of the Foreign Trade of India, Calcutta, March 1966.

Imports of electric motors and parts and accessories thereof stood at Rs.1,45,55,068 in 1950-51 and Rs.5,78,34,905 in 1965-66. Import statistics show that motors of larger ratings viz. above 20 h.p. figured largely in the total imports of electric motors.⁶⁴

Transformers

Production capacity for transformers has been significantly diversified during the last two decades. Firms in the private sector are now manufacturing distribution and medium power transformers, some of them have extended their range upto 20,000 K.V.A. ratings.⁶⁵ The Heavy Electricals, Bhopal, is manufacturing only large power transformers and has covered a range of transformers upto about 100,000 K.V.A. and 220 K.V.⁶⁶

Table 2.9 which is based on the official reports (MSP) shows that the number of units in the transformer industry increased from 5 in 1950-51 to 20 in 1965-66. Capacity increased from 2,88,914 K.V.A. in 1950-51 to 21,81,600 K.V.A. in 1965-66. The production shows an increase from 1,77,975 K.V.A. in 1950-51 to 44,59,400 K.V.A. in 1965-66.

In 1964, Crompton Parkinson (Works) Pvt. Ltd. was the leading producer in the private sector accounting for 14.9

⁶⁴Ibid.

⁶⁵V.P.S. Menon (Industrial Adviser, D.G.T.D.), 'India's Heavy and Light Electrical Industries', The Journal of Industry and Trade, Vol. XVI, No. 9, September 1966, pp. 1084-1087.

⁶⁶Ibid.

per cent of the total output of the units registered with the D.G.T.D.⁶⁷ Hackbridge-Hewittic and Easun Ltd. and the National Electric Co., Ltd., Bombay, followed with 13.9 and 13.5 per cent of the total production respectively.

Tariff Commission puts the position in respect of capacity and production with some details.⁶⁸ There were 18 units effectively in operation besides Heavy Electricals (India) Ltd. (HEIL) in 1963-64. The total capacity of these 18 units was 20,73,800 K.V.A. exclusive of HEIL.

TABLE 2.9. INSTALLED CAPACITY AND PRODUCTION IN THE ORGANISED SECTOR * OF THE TRANSFORMER INDUSTRY.^Δ

Year	No. of Units	Capacity (on a single shift basis) K.V.A.	Production K.V.A.
1950-51	5	2,88,914	1,77,975
1955-56	10	4,14,000	6,25,000
1960-61	16	12,44,400	13,73,900
1965-66	20	21,81,600	44,59,400

* Units borne on the list of D.G.T.D.

Δ Source: Calculated from India, C.S.O., Monthly Statistics of the Production of Selected Industries of India, Calcutta.

⁶⁷ See, India, Report of the Monopolies Enquiry Commission, New Delhi, 1965, p. 282.

⁶⁸ India, Tariff Commission, Report on the Continuance of Protection to the Power and Distribution Transformers Industry, Bombay, 1965, pp. 6-7.

HEIL's licensed capacity of 3 million K.V.A. on double shift was to be built up progressively manufacturing transformers totalling 1.4 million K.V.A. in 1963-64, 1.9 million K.V.A. in 1964-65 and 2.6 million in 1965-66. With the implementation of licensed capacity of another two units the total capacity of the 22 units inclusive of HEIL was expected to be 73.8 lakhs K.V.A. by 1965-66.⁶⁹ Report on the Monthly Statistics of Production state 44,59,400 K.V.A. as the production of the 20 units borne on the list of the D.G.T.D. for the year 1965-66. When the production of 12,41,300 K.V.A. of power transformers in Heavy Electricals, Ltd., Bhopal⁷⁰ is added to this the total production comes to 57,00,700 K.V.A. Details regarding the production in the small scale sector are not available.

Exports and Imports

There was only a moderate rise in exports of transformers from Rs. 3,190 at the end of the Second Plan to Rs.79,306 at the end of the Third Plan. India has, however, a substantial import bill on account of transformers. Table 2.10 shows that imports of transformers increased from 1.56 crores in 1951 to 3.83 crores in 1960-61. In 1965-66 the imports stood at 9.02 crores.

⁶⁹ Ibid.

⁷⁰ See, Appendix Table 2.1.

TABLE 2.10. RECENT STATISTICS REGARDING EXPORTS AND IMPORTS OF POWER AND DISTRIBUTION TRANSFORMERS.

Year	Exports		Imports	
	No.	Value	No.	Value
1950-51	-	--	N.A.	1,55,67,754
1955-56	-	--	N.A.	1,73,40,833
1960-61	38 (Nos.)	2,793	14,274 (Nos.)	3,49,22,654
	Parts etc.	397	Parts etc.	33,84,951
	Total	3,190	Total	3,83,07,605
1965-66	40 (Nos.)	76,414	2,776	6,48,50,881
	Parts etc.	2,892	Parts etc.	2,53,62,770
	Total	79,306	Total	9,02,13,651

Source: Calculated from (a) Monthly Statistics of the Foreign Trade of India.

(b) Annual Statements of the Seaborne Trade of India.

Transformers above 66 K.V. to 132 K.V., and those above 132 K.V. (i.e. of higher ratings) figured importantly in our total imports.⁷¹ While the increase in power generating capacity, its transmission, and the rising tempo of industrialisation in the country demand transformers of higher rating and of specialised types; production of these categories of transformers has started only recently in the public sector unit at Bhopal, and stray cases of private units. This fact perhaps explains the rise in the import bill, in spite of the increase in installed capacity for transformers at home.

Switchgears and Controlgears

Among the four sub-groups of the electrical machinery industry being studied here, switchgear and controlgears was the latest to be established in India. As stated earlier, capacity has already been created in the public sector unit, Heavy Electricals (India), Ltd. at Bhopal, for the production of switchgears and controlgears especially of higher ratings. The switchgear plant of the Bharat Heavy Electricals, Ltd. at Hyderabad is coming up. Units in the private sector are manufacturing switchgears and controlgears of lower ratings and capacity. Official reports on the 'Monthly Statistics

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Basis: India, Department of Commercial Intelligence and Statistics, Monthly Statistics of Foreign Trade of India, Calcutta, March 1966.

of Production,⁷² give the installed capacity and production for only one item viz. motor starters,⁷³ in the group.

In Table 2.11 below, the figures for capacity and production relate to motor starters only. The production of switchgears and controlgears in the Heavy Electricals (India), Ltd., Bhopal has been given separately in the Appendix Table 2.1 at the end of this chapter. The major switchgear product groups are as follows:-⁷⁴

(1) 400 KV/230 KV/110 KV breakers: The demand for this category would be largely for air blast circuit breakers because of the high rupturing capacity needed. Till 1965, the two public sector units viz., Heavy Electricals (India), Ltd. and Bharat Heavy Electricals, Ltd., and Hindustan Electric Co., Ltd., in collaboration with M/s. Brown Boveri were the only three licensed manufacturers in this product range.⁷⁵ Of the three units, only two, viz. Heavy Electricals (India), Ltd. and Hindustan Electric Co. Ltd. have commenced production. Capacity of the order of 350 numbers per annum is likely to be available from these three

⁷² India, Central Statistical Organisation, Monthly Statistics of the Production of Selected Industries of India, Vol. 18, Calcutta, 1966.

⁷³ The production of the motor starters, the only product presented in this publication, appears from 1960, and onwards.

⁷⁴ Details regarding the licensed and installed capacity are not known in the case of each product group.

⁷⁵ India, Planning Commission, Fourth Plan Planning Group on Machinery Industries, Report of the Working Group on Electric Power Equipment, New Delhi, 1965.

units when the schemes that have been licensed are implemented. This covers the capacity for 240 numbers of Bharat Heavy Electricals Ltd., Hyderabad, 50 numbers of Heavy Electricals (India), Ltd., Bhopal and 60 numbers of M/s. Hindustan Electric Co., Ltd.⁷⁶

(2) 66 KV/33 KV/22 KV breakers:- There were six units licensed for the manufacture of these breakers. The details regarding the capacities of these units are not known.

(3) Switchgear - 11 KV (High and low tension):- The equipment needed in this range include: indoor draw-out type switchgear as also out-door pole-mounted rural O.C.Bs. These also include low voltage iron clad switches and switch fuse units, motor starters, relays of various types and HRC fuses. The installed capacity in the private sector, for these products (switchgear 11 KV and below) at the end of the Second Plan i.e. by 1960-61 was as under:⁷⁷

H.T. switchgear	.....	300 Nos.
L.T. switchgear	.....	1,000 Nos.
Motor controlgear	.....	81,700 Nos.
Iron clad switches and switch fuses	.....	1,36,000 Nos.

⁷⁶ India, Planning Commission, Report of the Technical (Nag) Committee to study the Requirement of Major Electrical Equipment, New Delhi, November 1965, pp. 24-26.

⁷⁷ India, Planning Commission, Programmes of Industrial Development, 1961-66, p. 293.

In the public sector, the production programme of the Heavy Electrical Plant at Bhopal also includes the manufacture of 2500 Nos. (approx.) 11 KV circuit breakers annually,⁷⁸ though this factory is intended mainly to cater for the needs of equipment in the higher ratings.

The production of various types of switchgear and controlgear in the Second Plan period covered electric motor starters, such as, contact starters, star delta starters, stator-rotor starters and other special types of starters. Recent statistics in the M.S.P. report is available for motor starters only.

TABLE 2.11. INSTALLED CAPACITY AND PRODUCTION IN THE ORGANISED PRIVATE SECTOR OF THE SWITCHGEAR AND CONTROLGEAR INDUSTRY

Year	No. of units	Installed capacity (on a single shift basis) Nos.	Production Nos.
1950-51	-	-	-
1955-56	-	-	-
1960	N.A.	1,52,400	1,10,400
1965-66	20	2,82,000	3,10,600

Source: Monthly Statistics of the Production of Selected Industries of India

⁷⁸ Ibid. See also, Appendix Table 2.1.

Table 2.11 shows that the capacity (on single shift basis) in respect of this item increased from 1,52,400 Nos. in 1960 to 2,82,000 in 1965-66. The production shows an increase from 110,400 Nos. in 1960 to 310,600 Nos. in 1965-66. Statistics regarding either the capacity or production are not available for earlier years. Perhaps the production on the regular basis started only around this period.

According to another source⁷⁹ production of the various items in the range viz., low tension and high tension switch-gear upto 11 KV, low voltage iron clad switches and switch fuse units and motor starters, Relays of various types and H.R.C. fuses was worth Rs. 16 crores in 1965-66 against only Rs. 0.4 crores in 1955.

In 1964, Larsen and Toubro Ltd. was the leading producer of motor starters among 15 reporting units and accounted for 46.6 per cent of the total production of these units. The Mysore Electrical Industries at Bangalore was the second largest producer accounting for 18.1 per cent of the total production. M/s. Jyoti Ltd., Baroda, M/s. Crompton Parkinson Ltd., Bombay, and M/s. Hindustan Klockner, Ltd., Bombay, stood next with 7.3, 6.7 and 6.7 per cent of the total production respectively.⁸⁰

⁷⁹V. P. S. Menon (Industrial Adviser, Directorate General of Technical Development), 'India's Heavy and Light Electrical Industries', The Journal of Industries and Trade, Sept. 1966.

⁸⁰India, Report of the Monopolies Inquiry Commission, Vols. I and II, New Delhi, 1965, p. 280.

There are a number of more specialised products like controls for steel mills, etc. falling within the scope of 'Industrial Electronics' for which there is demand and no progress was made in the manufacture of these items.⁸¹

Exports and Imports

Despite the increase in the production capacity in the country, the requirements of switchgears and controlgears are not being met in full and imports on a large-scale had to be arranged all through the last three Plans. As Table 2.12 shows, in 1950-51, India imported Rs. 3.71 crores worth of switchgear of different types while there were no exports of any of these items in that year.

TABLE 2.12. RECENT STATISTICS REGARDING EXPORTS AND IMPORTS OF SWITCHGEARS AND CONTROLGEARS

Year	Exports		Imports	
	Nos.	Value Rs.	Nos.	Value Rs.
1950-51	-	-	N.A.	3,70,80,434
1955-56	-	-	N.A.	6,79,64,926
1960-61	26 Nos.	437	403,141 (Nos.)	6,71,02,033
	Parts etc.	1,020	Parts etc.	4,97,67,731
	Total	1,457	Total	11,68,69,764
1965-66	7,73,089	5,04,776	6,29,997	7,64,80,025

Source: Calculated from (a) Monthly Statistics of the Foreign Trade of India and (b) Annual Statements of the Seaborne Trade of India.

⁸¹ Ibid.

From a negligible amount of Rs. 1,457 in 1960-61 exports show a rise to Rs.5,04,776 in 1965-66. Cheaper items like plastic switches and small switches and fuse units constituted large volume of exports in 1965-66. Imports of switchgears and controlgears amounted to Rs. 6.80 crores in 1955-56, 11.69 crores in 1960-61, and Rs. 7.65 crores in 1965-66.

Electric Fans

Capacity and Production

The number of units in the organised private sector of the electric fan industry, as Table 2.13 shows, increased from 20 in 1950-51 to 28 in 1965-66. Annual installed capacity of the units increased from 2,84,600 nos. to 15,20,400 nos. within the same period. Today, the industry is making a complete range of electric fans such as ceiling fans, table fans, pedestal fans, air circulators, railway carriage fans and exhaust fans.

TABLE 2.13. INSTALLED CAPACITY AND PRODUCTION IN THE ORGANISED SECTOR OF THE ELECTRIC FAN INDUSTRY

Year	No. of units	Capacity (on a single shift basis) in Nos.	Production in Nos.
1950-51	20	2,84,600	2,00,000
1955-56	17	3,03,600	2,87,400
1960-61	23	8,66,400	10,40,100
1965-66	28	15,20,400	13,58,400

Source: Calculated from 'Monthly Statistics of the Production of Selected Industries of India'.

Out of the twenty-eight units operating in 1965-66, fourteen were located in West Bengal, seven in Maharashtra, three in Punjab, two in Delhi and one each in Uttar Pradesh and Madras.⁸² Production of electric fans increased from 2,00,000 Nos. in 1950-51 to 13,58,400 Nos. in 1965-66.

In 1964, the Jay Engineering Works, Ltd. (USHA fans), Calcutta, accounted for 27.7 per cent of the total output of 24 reporting (to D.G.T.D.) units. The Orient General Industries Ltd. accounted for almost equal share, viz. 27.4 per cent. The next three concerns - the India Electric Works Ltd., Calcutta, M/s. Matchwell Electricals (India), Ltd., Poona, and Ralli Fans, Ltd. -- followed with 8.6 per cent, 8.2 per cent and 7.0 per cent of the total share of production respectively.⁸³

Production of electric fans increased substantially during the Second Five Year Plan, perhaps in response to the increase in internal demand due to rapid electrification and a boom in the building construction industry.

Exports and Imports

Exports of electric fans rose from a small amount of Rs. 18,894 to Rs. 94.43 lakhs in 1965-66.

⁸² The Indian Institute of Foreign Trade, Commodity Study Report on Electric Fans, New Delhi, 1967, p. 19.

⁸³ India, Report of the Monopolies Inquiry Commission, Volumes I and II, New Delhi, 1965, p. 280.

TABLE 2.14. RECENT STATISTICS REGARDING EXPORTS AND IMPORTS OF ELECTRIC FANS

Year	Exports		Imports	
	Nos.	Value Rs.	Nos.	Value Rs.
1950-51	-	-	N.A.	3,26,457
1955-56	100	18,894	N.A.	20,54,367
1960-61	89,764 (Nos.)	81,25,634	411 (Nos.)	3,30,287
	Parts etc.	42,812	Parts etc.	3,05,537
	Total	81,68,446	Total	6,35,824
1965-66	1,25,250 (Nos.)	85,10,156	454 (Nos.)	8,15,797
	Parts etc.	9,33,119	Parts etc.	4,60,405
	Total	94,43,275	Total	12,76,202

Source: India, Department of Commercial Intelligence and Statistics,
 (a) Monthly Statistics of the Foreign Trade of India, and
 (b) Annual Statements of the Seaborne Trade of India.

Countries in the Middle East and the South East Asia are important markets for Indian fans. In the total exports of engineering goods (excluding fabricated steel and steel items) exports of electric fans represent about 5% by value, and rank third, being next to 'Steel Pipes and Tubes' and 'Diesel Engines'.⁸⁴

Imports of electric fans appear to be fluctuating over the period covered by the three Plans. From Rs. 3.26 lakhs in 1950-51 there is a steep increase to Rs. 20.54 lakhs in 1955-56. The total imports amounted to Rs. 6.36 lakhs in 1960-61 and Rs. 12.76 lakhs in 1965-66. Parts and accessories or what are called the maintenance imports figure importantly in the total imports. Fluctuations in the size of imports, in spite of the gradual increase in the production capacity at home are difficult to be explained.

2.9 Summary

The electrical machinery industry is a class of many related industries. Though the manufacture of some product lines like fans was started in the early twenties, most of the other products and especially the heavy electrical equipment are of very recent origin. Large-scale sector is the most important in this industry on the basis of fixed capital invested, persons employed as well as by its share in the total value added in the economy by this industry.

⁸⁴ The Indian Institute of Foreign Trade, op.cit., p.2.

While the production of heavy electricals was so far limited to that in the public sector, capacity is recently being licensed in the private sector also, for the production of such equipment. Foreign investment, either direct, or in indirect form is important in all the four industries studied in this chapter. All the four more or less enjoyed a sheltered domestic market at least, for the last fifteen to twenty years. There is a significant advance in respect of installed capacity and production in all the four industries during the three Five Year Plans. It has not, however, been possible to meet the diversified demand for these products created by the process of industrialisation in the country and imports on a large scale continued in the case of all the four product groups. Electric fan industry has made a break through in the export market. Capacity, even on a single shift basis, has not always been fully utilised in these industries.

APPENDIX TABLE 2.1. PRODUCTION IN THE HEAVY ELECTRICALS (INDIA) LTD., BHOPAL, 1965-66.

Sr. No.	Product	Unit	Physical Output		Value		Value of total orders on books at the end of the year
			Target	Actual	Target	Actual	
1	2	3	4	5	6	7	8
I SWITCHGEAR AND CONTROLGEAR							(Rs. in lakhs)
1	11 kV Indoor type BVP3	Nos.	1200	1000	174.90	154.91	197.10
2	11 kV Isolaters type IB4	"	50	50	1.85	2.00	2.64
3	11 kV Outdoor type GPC	"	300	275	15.60	13.85	2.43
4	33 kV Outdoor type LG1	"	250	250	93.18	91.56	146.73
5	66 kV Outdoor type I.G3	"	80	62	42.48	32.28	82.39
6	132 kV Airblast type GAX	"	1	2	1.83	6.92	35.44
7	Control and Relay Panels	Sets	400	351	24.00	27.59	24.21
8	Industrial Controlgear	Nos.	250	250	6.37	7.71	16.67
9	Traction Controlgear AC	Sets	24	12	48.00	21.97	244.16
	DC	"	11	11	22.00	30.74	94.08
	Diesel	"	15	-	22.50	-	180.00
II TRANSFORMERS							
10	Power Transformers	MVA	1790.94	1241.30	390.70	254.18	992.39
11	Welding Transformers (Thermac)	Nos.	110	110	2.75	2.74	1.34
12	Traction Transformers (EMU)	"	9	-	7.20	3.99	119.00
13	Traction Rectifiers (EMU)	"	9	-	7.20	-	101.15
14	Traction Transformers for Freight Locomotives	"	-	-	-	-	65.28
15	Instrument Transformers	"	-	106	-	12.50	27.72

Continued.

APPENDIX TABLE 2.1 - concluded

1	2	3	4	5	6	7	8
<u>III CAPACITORS</u>		KVar	63000	80000.39	35.00	44.63	1.46
<u>IV TRACTION MOTORS</u>							
16	Type 253 BX (AC EMU)	Nos.	98	40	29.40	} 47.53	200.00
17	Type 133 AY/AZ and SH 109 ID. (DC/EMU)	"	40	46	26.24		106.11
18	Type 165 (Diesel)	"	60	2	27.60		459.52
19	Type AG-51 Generator	"	25	-	0.60		19.20
20	Type TG 5301	"	15	-	13.15		120.00
21	Type 51 BY MG Sets	"	19	5	4.95	14.00	
<u>V INDUSTRIAL MOTORS</u>		"	107	85	35.05	27.45	104.61
<u>VI HEAVY ROTATING PLANT</u>							
22	Water Turbine Generator	MW/Nos.	48(2)	-	1.70*	} 9.08	1404.00
23	Steam Turbine Generator	"	-	-	-		368.67
24	Large Electrical Machines	HP	-	-	-		24.14
25	Engine Drive Alternator	HP/Nos.	470(1)	-	-		1.90
<u>VII WATER TURBINE</u>		MW/Nos.	63(3)	-	21.00*		1907.00
<u>VIII STEAM TURBINE</u>		"	30(1)	-	4.99*		1062.23
Total					1060.24	791.63	8125.57

* Heavy Electricals share of work only.

Source: Reproduced from Heavy Electricals (India) Ltd. Annual Report, 1965-66.

CHAPTER 3

RAW MATERIALS

3.1 Introduction

Raw materials form an important item in the cost of production of electrical machinery. The proportion of the raw material cost to the ex-factory cost in the case of an electric motor, for instance, varies between 71 per cent and 84 per cent¹ and indigenous content thereof accounts generally for over 90 per cent.² Adequate and steady supplies of raw material form an essential factor in the fuller utilization of capacity and growth of the industry. Study of the raw materials enables us to see what are the 'supplying industries' to the electrical machinery industries. As in the previous chapter, four major sub-groups of the electrical machinery industry viz., motor, transformer, switchgear and fan have been taken into account.

The technical description of the raw materials has been given in the following section (3.2). All the items described here are those consumed by one or the other of the four industries mentioned above. Section 3.2, therefore, gives an idea about the wide range of industries which are related with the four industries being studied here. As stated in Chapter I, production efficiency in these indus-

¹ India, Tariff Commission, The Report on the Continuance of Protection to the Electric Motor Industry, Bombay, 1963, p. 13.

² Ibid.

tries depends upon a regular supply of goods of the requisite quality from all the supplying industries that will be described in the next section. This description is followed with an account of the supply position of important items of raw materials. Supply position of some of the important ferrous and non-ferrous metals is discussed even for their primary stage. This was thought necessary as the supply of rolled products (such as billets, strips, rods, etc.) which are consumed by the electrical machinery units, their prices, and import requirements will be determined by the availability of metals in their basic form. A general discussion of the substitution possibilities in respect of important raw materials which are imported, and the development of new ones has been given in Section 3.4.

3.2 Description of the Raw Materials

M e t a l s

Some forty chemical elements of commercial importance are usually classified as metals. They are distinguished from other elements by characteristic physical properties, such as high melting temperature, good electrical and thermal conductivity, metallic lustre, hardness and the ability to be deformed permanently without fracture. Those metals widely used in the electrical machinery industry are discussed below.

Iron and Steel

Iron is the name given to pure ferrite as well as to

fused mixtures of this ferrite with large amounts (above 1.7 per cent) of carbon. These mixtures are known as pig iron and cast iron.³ Pig iron is produced from iron ore in the blast furnace. It is the basic raw material from which all cast iron, wrought iron and steel are made. Pig iron is weak and brittle and is not used for structural purposes.

Cast iron is obtained by slightly purifying the pig iron in a furnace in which the composition of iron can be varied. If no other alloying element is present, the quantity of carbon present must be 1.7 per cent. Presence of other alloying elements changes this value considerably. Thus, 2 per cent silicon lowers the possible carbon limit to 1.1 per cent. Different varieties of cast iron are: gray cast iron, white cast iron, malleable cast iron, etc. These are determined by certain manufacturing details and the proportion of carbon and other alloying elements. Cast iron is used in industry because of its low cost and good casting characteristics. Wrought iron was the first tough, ductile material used in structural work, but it is used very little today. This is because many steels are superior in almost every way to wrought iron, and are much less expensive.

³Most of the technical details in this section are based on: James F. Young, Materials and Processes, John Wiley and Sons, Inc., New York, 1954, pp. 244-245.

Steel can be manufactured in great quantity at smaller expense than wrought iron and with many varieties of desirable physical properties. Many parts formerly made of cast or wrought iron are now either cast or fabricated from steel. The molten steel coming from the refining furnaces may either be cast into the desired shape in which it will be used or it may be cast into an ingot and then rolled, forged, hammered, pressed or machined into the desired shape. Steel is generally divided into five classifications⁴ :-

- (1) Low-carbon steel (carbon content below 0.20 per cent)
- (2) Medium carbon steel (carbon content between 0.20 and 0.50 per cent)
- (3) High carbon steel (carbon content above 0.50 per cent)
- (4) Low-alloy steel (alloy content less than 8 per cent)
- (5) High-alloy steel (alloy content above 8 per cent)

All the carbon steels contain less than 1.7 per cent carbon, along with other elements, usually in the range of 0.50 to 1.00 per cent magnesium, 0.20 to 0.70 per cent silicon. Others like phosphorous and sulphur are present in very minute quantities. Steel is called 'alloy grade' when the alloying elements exceed certain limits: 1 per cent manganese, 0.70 per cent silicon, 0.50 per cent nickel, etc.⁵

⁴ Ibid., pp. 269-70.

⁵ Ibid., p. 270.

Among the carbon steels, medium-carbon grade finds the largest application in steel products. Low and high carbon steels are considered for specialised application. Between the low and the high alloy steel, the former finds the largest application while high alloy steels are used for special applications such as cutting tools, dies, etc. requiring high efficiency and corrosion resistance.

Wrought i.e. mechanically worked steel may take many forms. Thus, the sound part of the steel ingot may be rolled down to a bloom. The bloom generally has a cross sectional area greater than 36 sq. inches. The bloom may be rolled down to a billet, which has a cross sectional area between $1\frac{1}{2}$ and 36 sq. inches, or to a slab which is at least $1\frac{1}{2}$ inch thick and has a width more than twice its thickness. These various forms may then be reduced to any of the many finished shapes such as bars, rails, structural sections, etc.

Electrical machinery industry requires various types of intermediate steel products mentioned above. Types usually required for the four sectors under consideration are: skelp, plates, structurals (light and heavy), sheets, bars and rods, strips, mild steel sheets, electrical steel sheets and various alloy and special steels (other than ordinary carbon steel).

The term 'electrical sheet steel' is a trade name used for steel sheets used in the manufacture of 'stampings'.

Dynamo grade silicon steel is somewhat brittle. It is used in rotating apparatus only where low stresses are involved. It is also used in lower grade transformers. It contains 3.5 to 4.0 per cent silicon.

Stampings are thin steel sheets cut into various shapes. These are used for laminated magnetic circuits and are usually made of silicon sheet steels. The silicon steels form the most important type in the steels used in transformer, motor and relays (switchgears). The manufacture of silicon steels for electrical application has become very standardized. Names of the standard grades used in the electrical industries are: field (grade), armature, electrical, motor, dynamo, transformer and special transformer. These grades are arranged according to the successively increasing percentage of silicon in the steel. Electrical grade silicon steel contains between 1.0 and 1.5 per cent silicon. It is used in relays, fractional horsepower motors, and small railway motors. Motor grade steel (silicon 2.5 to 3.0 per cent) is used for motors of various kinds and other A.C. and D.C. machines. Transformer grade steel has high silicon content (4.5 to 6 per cent) and it is too brittle. It is used in transformers. There are several grades of transformer steel.

The number of types of steel used in industries is so large that it is beyond the scope of this work to even list them all.⁶ Only those varieties which are of special

⁶ About seventyfive varieties of steel castings of different composition are used in industrial applications. Ibid., pp. 271-272.

relevance to the electrical machinery industry have been described here.

Non-Ferrous Metals

Aluminium

The principal ore of aluminium is bauxite, $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$. Commercial aluminium contains a small quantity of iron, silicon and copper. It has about the twice the strength of that of the chemically pure grade. About twenty to twenty-five varieties of aluminium alloys are found in commercial use.

The thermal and electrical conductivities of commercially pure aluminium are about sixty per cent of those of copper. This is high enough to bring about its use as the conductor for many electric power lines. Because of its light weight the aluminium conductor would cost only half as much as the copper one. This economy cannot be fully realized because the aluminium is weaker and must be reinforced by a steel core in order to support its own weight and service loading. However, the saving in the cost involved and the more easy supply position has led to the use of aluminium in many electrical transmission application. Aluminium ingots are being used for rotor cage of squirrel cage motors when these are aluminium die cast.

Copper

The high electrical conductivity of copper (second only to silver) has led to its use in large quantities in

and
electrical wires and cables/in electrical machines.

Copper forms an important raw material in all the four classes of products being considered here. Its use may take different forms such as, strips, plates open and insulated wires, etc. Copper is also used as a material for 'electrical contacts',⁷ in apparatus and control systems carrying electrical currents.

Copper and nickel form a series of alloys which find important application in electrical industries. Starting with alloys rich in nickel (70 per cent nickel, and 30 per cent copper)⁸ successively lower resistance to electric current is obtained as the proportion of copper is increased. The alloy having 55 per cent copper and 45 per cent nickel has practically zero coefficient of resistivity.⁹ The applications of copper alloys take the form of open and insulated wires, wire coils, wire spools, strips, etc.

Magnesium

Magnesium is the lightest of the metals put to commercial use. Pure magnesium is seldom used as a structural material because of its low strength, but its alloys are stronger and many of them can be hardened by heat treatment. The uses of magnesium in alloys used for portable or high

⁷ A device for closing and opening the electrical circuit.

⁸ James F. Young, op.cit., p. 189.

⁹ Ibid.

speed machinery have increased manifold in recent years. An important instance is the use of magnesium in different varieties of carbon and alloy steels in which magnesium is present in varying proportions.

N i c k e l

Pure nickel is a tough, silver-coloured metal. The most important of the commercial nickel alloys is known as Monel metal. The resistance of Monel to steam attack at high temperatures has caused its extensive use in steam valves and turbines. Nickel alloys that have high electrical resistivity make ideal electric heater materials. Their characteristic resistance to complete oxidation and retention of strength at high temperatures recommends them for use at red heat. Typical standard electric heater materials are (a) 80 per cent nickel, 20 per cent chromium and (b) 60 per cent nickel, 15 per cent chromium and 25 per cent iron.¹⁰ Nickel has come up as an important alloying element or a base metal in nickel-chromium-iron alloys.

L e a d

This metal occurs in at least 60 minerals, but it is produced commercially from galena, the sulfide of lead. Lead is widely used for storage battery castings and cable coverings.

¹⁰ Ibid., p. 361.

Z i n c

Zinc is a fairly heavy, bluish-white metal used principally because of its low cost, corrosion resistance, and alloy properties. Galvanizing and die casting are some of the important uses for which zinc is used in industrial applications. The protection of iron and steel from corrosion is done more often with zinc than any other metal coating. The oldest and the most important methods of applying the zinc coatings are known as galvanizing. A number of other non-ferrous metals of commercial importance are required (though on a very minor scale) in the electrical machinery industry. These are: molybdenum, platinum, silicon, tungsten to instance a few.

Non-metallic Materials

While metals are divided as a class in terms of certain related and measurable properties like e.g. a definite melting point, measurable and reproducible mechanical properties such as tensile strength, thermal expansion etc.; non-metallic materials are characterised by gross departure from these and other quantitative relationships. Non-metallic materials could broadly be divided into (a) inorganic and (b) organic materials. Examples of inorganic materials of commercial use are ceramics, graphite, carbides, etc. Organic materials commonly used are rubber (natural and synthetic), paper, cellulose derivatives, synthetic resins, etc.

Electrical Insulation

One of the important use of many non-metallic materials in the electrical industries is that as insulating materials. Electrical insulating materials are those which offer a very large resistance to the flow of electric current, and for that reason they are used mainly to keep the current in its proper path along the conductor. The materials ordinarily employed in insulations include cotton, silk, paper, rubber, wax, resins, asphalts, natural resin varnishes, plastics, mica, glass, asbestos, porcelain, and pure oxides. There are liquid and gaseous materials also, which serve as insulating materials. The insulating materials are used for wire coating and cable construction, for insulating spacers and structural purposes, for coil, generator and motor winding applications.

P l a s t i c s

Plastics are a certain group of natural and synthetic resins and their compounds that can be moulded, cast, extruded or used for coatings and films. Practically all these resins are of an organic nature, composed of combinations of hydrogen, carbon, oxygen and nitrogen. The chief sources of raw materials for plastics are coal, petroleum and agricultural products. The most common classification of plastics is under thermoplastic and thermosetting materials. The thermoplastics are those which when heated begin to soften at temperatures as low as 140^oF, then can be moulded

without any change in the chemical structure. The thermosetting materials undergo a chemical change when moulded and cannot be resoftened by heating to reshape them. The mould temperatures for the thermosetting materials are usually considerably higher than for the thermoplastics and the finished product is capable of withstanding much higher temperatures without deformation.

Plastics are basic fabricating materials having a variety of properties. Standard forms in which plastics are available include moulding powders, sheets, films, rods, tubes and liquids. The choice of resins and suitable modifiers offers to the engineer plastics that are very flexible or rigid, low melting or heat resistant, electrically conductive or electrically insulating.

Plastics therefore have found many applications in the electrical machinery industry. Thermoplastics such as cellulose acetate butyrate is used for telephones and radio dials, fluorocarbons are used as insulations in high voltage and high-frequency electrical equipment, nylons and polythylenes are used as superior wire insulation materials and so on. Plastics as raw materials are not inexpensive as such, but they compete with other engineering materials because (a) their adaptability to high volume low-cost production (b) the savings effected by little or no need for machining or finishing operations and (c) the possession of a combination of inherent properties not found in any

other materials. A plastic can be found for virtually all applications except those involving high (above 500°F) temperatures and very high strength.

R u b b e r

Major groups of materials in this class are (a) natural rubber, (b) synthetic rubber, and (c) rubber like plastics. Among the important applications of this class of materials in the electrical machinery industry is that as wire and cable insulation. It is also increasingly being used as belting material for power transmission.

C e r a m i c s

Products classed as ceramics are made either chiefly or entirely from earthen materials. Of the industrial applications of ceramic products, electrical applications are perhaps the most extensive and important. The product of the ceramic industry used chiefly in the electrical apparatus is porcelain insulators. There are three general categories: low voltage insulators, high voltage insulators and high frequency insulators. Usually a mixture of raw materials is blended to form the ceramic product. Clay, flint, and feldspar are the principal raw materials used.

Other non-metallic materials used are different types of adhesives, carbon and graphite, cement, cork, felt, different types of fibres, paints and lubricants.

3.3 Supply Position in respect of Raw Materials

The following is a brief account of the supply position

of the important raw materials consumed by the four sub-groups of the electrical machinery industry under study. It is based mainly on the published literature and interviews with men in the industry. It has not been possible to deal with all the items described in the previous section for lack of detailed information in respect of each. Those covered here, however, form a major proportion of the total cost incurred on raw materials.¹¹

P i g I r o n

There is an acute shortage of foundry grade pig iron for the last ten years. Indian Iron and Steel Co., Ltd. and two public sector plants at Bhilai and Durgapur are the only producers of saleable pig iron in India.¹² A small amount of saleable pig iron (40,000 to 45,000 tonnes in 1964-65)¹³ has been produced in what are called "Small pig iron plants". This is primarily sold to foundries for the manufacture of castings. Large-scale manufacturers like M/s. Crompton Parkinson, Ltd., Bombay and the Kirloskar Electric Co., Ltd., Bangalore have got their own foundries. Others buy the castings. The shortage, according to the Ministry of Steel and Mines¹⁴ is largely due to delay in the

¹¹ See for instance, the tables showing the pattern of raw material consumption given in Section 3.5.

¹² Johnson, William A., The Steel Industry of India, Harvard University Press, Cambridge, Massachusetts, 1967, p. 218.

¹³ India, Ministry of Steel and Mines, Briefs on Some Important Aspects of Work in the Ministry, 1965-66, p. 32.

¹⁴ Ibid.

implementation of schemes licensed in the private sector. A total capacity of 296,000 tonnes licensed in the years 1960 and 1962 had to be revoked in 1963-64.

Small plants upto a capacity of 15,000 tonnes per year were licensed. As an incentive to their establishment, these small pig iron plants were exempted from price and distribution controls governing India's integrated iron and steel mills. Because it was thought too low for their erection, the upper limit which was initially fixed at 15,000 tonnes was raised to 100,000 tonnes and more recently to 300,000. With this latest approved maximum capacity the 'small pig iron plants' no longer remain small, as this is a capacity of a small-size blast furnace. In spite of this, of the twelve plants approved by March 1963, only three had been erected. A possible reason as to why the capacity didn't materialise seems to be as follows. Under the normal circumstances iron produced in small pig iron plants could not compete with iron produced in large blast furnaces located in north-eastern India. Private interest considered erecting small pig iron plants only because circumstances have not been normal. Indian demand for foundry grade pig iron was well in excess of supply, and the quality of the output of India's integrated steel mills was not satisfactory.¹⁵ Under the circumstances, only a few small

¹⁵ Johnson, William A., op.cit., pp. 226-228.

plants have been promoted by companies that are themselves consumers of iron and are willing to pay a higher price for the pig iron they need in terms of its higher production cost.

Electrical Steel Sheets (Silicon Steel)

The Tata Iron and Steel Co., Ltd. (TISCO) was the only producer of electrical steel sheets of dynamo grade for making motor stampings till 1965.¹⁶ The capacity of this firm in that year was 24,000 tonnes per annum. The bulk of the output of TISCO of this variety of steel is sold to Guest Keen Williams, Ltd. (Sanky Division), Bombay. TISCO had plans to increase the production of the electrical steel (for electrical motor stampings) from 24,000 tonnes to 42,000 tonnes. This plan was held up because its application for a loan from the World Bank for the necessary foreign exchange was pending with the Government.¹⁷

The Hindustan Steel Ltd. has plans¹⁸ to manufacture electrical sheet steel of transformer and dynamo grades to the extent of 50,000 tonnes by 1967. It has been estimated by the Indian Electrical Manufacturers Association¹⁹ that

¹⁶ India, Tariff Commission, Report on the Continuance of Protection to the Electric Motor Industry, Bombay, 1965, p.14.

¹⁷ Ibid.

¹⁸ India, Ministry of Steel and Mines, Briefs on Some Important Aspects of Works in the Ministry, p. 19.

¹⁹ Indian Electrical Manufacturers Association. Demand Survey of Electrical Equipment, 1965-66 to 1970-71, pp.43-46.

by 1970-71, the demand for electrical sheet steel would be over 100,000 tonnes. It is clear that even if the aforementioned plans of TISCO and Rourkela are implemented there is going to be a gap between supply and demand which will have to be covered by imports.

The problem of adjusting the production pattern of the steel industry to the changing pattern of demand for steel in this country, has often been discussed. Much, however, remains to be done in this direction. The transformer grade sheet steel planned for production at the Rourkela Steel Plant, for instance, is of the hot rolled variety. This will not help the transformer manufacturers to change over from the hot rolled to the cold rolled grain oriented (CRGO) variety to improve the performance of the transformers and also to effect economies in the raw materials.²⁰

Production of transformer grade electric steel of the 'cold rolled grain oriented' (CRGO) variety involves considerable further processing than that required for the hot rolled variety. However, the use of steel of the CRGO variety involves substantial economies. To quote an earlier report of the Tariff Commission:- "This (the use of CRGO steel) enables the material to be used at higher magnetic

²⁰ India, Tariff Commission, Report on the Continuance of Protection to the Power and Distribution ~~of~~ Transformers Industry, Bombay, 1965, p. 15.

density thereby reducing the quantity required and at the same time reducing loss of electric energy. The insulation used on these sheets being superior and smoother, the stacking factor is better and reduces deterioration during storage. Thus, the economy is not limited to electric sheet steel, but a similar saving is effected in the requirement of copper, transformer oil (both imported materials) and the materials for fabrication of the tank. The size and weight of the transformer is greatly reduced." ²¹

As the supply of transformer grade electrical steel from the Rourkela plant (which is the only source of supply) will be of the hot rolled variety, the change over to CRGO steel will involve continuous imports of that variety of steel.

Stampings and Laminations

The inner core of an electric motor consists, among many other parts, of circular thin steel plates lumped together. These thin plates are called stampings. Transformer cores are made of special alloy steels rolled to approximately 0.014 inch thickness. These thin sheets are called laminations. These are stacked to form the transformer core.

M/s. Guest, Keen Williams, Ltd., Bombay, and M/s. Devidayal Stainless Steel Industries Private, Ltd., Bombay,

²¹ See, India, Tariff Commission, Report on the Continuance of Protection to the Power and Distribution Transformers Industry, Bombay, 1963, p. 15 ff.

are at present the only two concerns who manufacture these parts for sale.²² The capacity of these two units for the manufacture of stampings was 13,400 tonnes per annum in 1965, while the actual production was 5,152 tonnes in 1963 and 7,747 tonnes in 1964. Capacity of the same two units for the manufacture of transformer laminations was 12,200 tonnes per annum in 1965 while actual production was 4,536 tonnes in 1963 and 6,319 tonnes in 1964. While the annealing capacity for steel of the cold rolled grain oriented (CRGO) variety was 3,150 tonnes, the actual production of laminations of CRGO steel was also negligible (11 and 24 tonnes in 1963 and 1964 respectively). Both the units are having underutilized capacity. This has been attributed²³ to acute shortage of electrical steel sheets which have to be mostly imported so far.

Cooling Tubes

The supply of cooling tubes required for the transformers is another instance of how the lack of co-ordination between the production pattern of steel industry and the demand pattern of consuming industries leads us to a prolonged dependence on imports of certain items. A substantial part of the demand for cooling tubes required in the

²² See, for instance Report on the Continuance of Protection to the Power and Distribution Transformers Industry, Bombay, 1965.

²³ See, the discussion on electrical steel sheets (silicon steel) in earlier paragraphs.

manufacture of transformers is met by three indigenous manufacturers, namely, the Indian Tube Co., Calcutta, M/s. Tube Products of India, Madras and M/s. Premier Automobiles, Ltd., Bombay. Producers of transformers are satisfied with the quality of the tubes but they complain about protracted and irregular deliveries and high prices.²⁴

The main difficulty of the fabricators of tubes is said to be inadequacy of steel strips for the manufacture of tubes. These steel strips are mostly imported at present. There is a possibility of manufacture of these strips at the Rourkela Steel plant, but it would be hot rolled strips in 14 SWG. The manufacturers of transformers are using strips in 16 SWG. (This requires further processing of the 14 SWG variety). The indigenous production of the steel strips in order to be useful to the transformer manufacturers themselves has to be in 16 SWG or the transformer manufacturers themselves have to adopt steel strips in 14 SWG for their purpose (which they are not prepared to do for certain technical reasons). Otherwise the country will have to depend on the imports of 16 SWG steel strips for an indefinite period.²⁵

Aluminium

From the point of view of its present as well as potential use and as a substitute to copper and other metals,

²⁴ India, Tariff Commission, op.cit., pp. 20-21.

²⁵ Ibid.

aluminium occupies an important place in the electrical machinery industry. The Indian Aluminium Co., Ltd., Calcutta (smelters at Hirakud, Orissa and Alupuram, Kerala), the Aluminium Corporation of India, Ltd., Asansole, Calcutta, and the Hindustan Aluminium Corporation, Ltd., Bombay (smelters at Renukoot, Uttar Pradesh), are the three producers of aluminium metal in the form of ingots.²⁶ The total ingot production of these three units stood at 54,966 tonnes in 1963. The quality of indigenous products (ingots) compares fairly well with the imported ones.²⁷ The Tariff Commission estimated the total demand for aluminium in different industries to be 170,000 tonnes in 1967, while the estimated total production stood at 114,000 tonnes.²⁸ The report stresses the need for further increase in capacity of this industry.

The policy of the Government is to sanction fabricating capacity such as for plates, sheets, circles, strips, foils, etc. to primary producers (producers of aluminium metal ingots) upto a certain proportion of their ingot capacity. The Indian Aluminium Company and the Aluminium Corporation of India have their own rolling mills. In addition, there

²⁶ India, Tariff Commission, Report on the Continuance of Protection to the Aluminium Industry, Bombay, 1964, pp.6-7.

²⁷ Ibid., p. 19.

²⁸ Ibid., pp. 14-15.

were nine units in 1965, which fabricated rolled products excluding wire rods. The total capacity of the eleven units was 27,100 tonnes per annum in 1964.²⁹

E.C.⁺ grade aluminium

E.C. grade aluminium is required for the manufacture of bare conductors, covered conductors, accessories and other purposes. The total production of E.C. grade aluminium by the three units (producing basic metal) mentioned above was 8,423 tonnes in 1962. It increased to 26,377 in 1965. This increase was inadequate for the requirements of aluminium cable and wire industry and considerable imports were necessary to make up the deficit. Taking into account the requirements of bare conductors only and excluding those for other purposes, the Tariff Commission estimated the requirement of E.C. grade aluminium as 84,590³⁰ tonnes. The supply figure based on the estimates furnished by the producers was 73,500 tonnes leaving a gap of 11,090 tonnes to be met by imports. If the requirements for all the other purposes are taken into account the shortage would be still greater.³¹

+ Electric Conductor.

²⁹ Ibid., p. 9.

³⁰ India, Tariff Commission, Report on the Continuance of Protection to the A.C.S.R. (Aluminium Conductor Steel Re-inforced) and A.A.C. (All Aluminium Conductor) Industry. Bombay, 1966, p. 17.

³¹ Ibid., pp. 20-21.

Further difficulty in respect of the existing supply of E.C. grade aluminium is that while the production of E.C. grade metal is concentrated in a few states, the bare aluminium conductor industry is spread all over the country. Thus, Uttar Pradesh and Orissa account for nearly 75 per cent of the total production of the E.C. grade metal but their capacity for bare conductors is only about 14 per cent of the total capacity.³²

The tendency all over the world is to use aluminium in preference to other non-ferrous metals. Notwithstanding some of the difficulties mentioned above, aluminium has already made a big headway in the Indian cable industry and in view of the shortage of zinc, which is now almost wholly imported in India, the case of aluminium has many interesting possibilities.

Copper

The important copper producing countries in the world are U.S.A., Canada, Chile, Congo, Northern Rhodesia, Japan and Russia. Among them, the U.S.A. ranks first and produces about one-third of the total world production. The U.S.A., Chile and Northern Rhodesia account for nearly half of the total world production.

32

Ibid., pp. 27-28.

33 India, Forward Markets Commission, Report on the Recognition of Associations in Respect of Forward Contracts in Copper, Zinc, Lead and Tin, Bombay, 1956.

Indian supply of copper falls far short of the demand which is being met largely by imports, as will be seen from Table 3.1 below.³⁴

TABLE 3.1 INDIGENOUS SUPPLY AND IMPORTS OF COPPER (REFINED METAL)

Year	Indigen- ous pro- duction	Imports		Total (3 + 4)
		Ingots billets	Electrolytic copper wire bars	
1	2	3	4	5
1962	9,781	33,314	34,743	68,057
1963	9,582	39,208	32,702	71,910
1964	9,474	28,562	32,488	61,050

The Indian Copper Corporation, Ltd. with its factory at Ghatsila (Bihar) continues to be the only unit manufacturing fire refined copper (a variety of pure metal).³⁵ Its annual installed capacity for fire refined copper is 9,600 tonnes per annum. The statistics presented in Table 3.1 give the supply position in respect of copper in the

Reproduced from

³⁴ India, Tariff Commission, Report on the Continuance of Protection to the Non-Ferrous Metals Industry, Bombay, 1965.

³⁵ In order to draw a line between marketed grades of copper and copper alloys, the American Society for Testing Materials, for instance, has adopted specifications in which metal containing not more than 0.5% of an element or elements other than Cu is designated as copper. These specifications cover three main commercial varieties as determined by the method of refining, viz., electrolytic, fire refined and Lake copper; also, as determined by the method of processing, tough-pitch, oxygen-free and deoxidised copper. See McGraw Hill Encyclopedia of Science and Technology, Vol.3, p.467.

form of refined metal.

Copper is usually imported in wrought or unwrought form. In the wrought form it includes rods, sheets, strips, tubes, pipes, wires and braziers while in the unwrought form, it includes ingots and wire bars, tiles, cakes, bricks, and slabs and scrap. The latter forms a major proportion of our imports of copper. Unwrought copper is imported from U.K., Congo, Mozambique and U.S.A. while wrought copper is usually imported from U.K. and U.S.A. and Sweden. The quantum of imports of copper into India is dependent upon the industrial situation in the producing countries, the availability of supplies and the price prevailing in the foreign markets. Copper is a strategic metal and it assumes importance in the stock piling programmes of countries like the U.S.A.

Insulated Enamelled Copper Wires and Strips

In 1965, there were ten units manufacturing enamelled copper wires required for electric motors, transformers and fans. There were nine units manufacturing paper and cotton covered copper strips and wires. Indigenous manufacturing capacity in this respect is reported to be adequately planned to meet the demand. The actual production, however, is short of requirements, being limited by the allocation of copper to the cable and wire industry. The allocation of copper to the electrical industries has been reduced due to the increase in the prices of copper in the international

market. In this connection a suggestion³⁶ made by the Indian Electrical Manufacturers Association viz., that the Government may enter into an agreement with the (copper) producer countries directly on the long term basis, so that we need not have to depend on the vagaries of the London Metal Exchange,³⁷ seems to be very important.

Z i n c

The important zinc producing countries in the world are U.S.A., Canada, Mexico, Peru, Australia, Germany and the U.S.S.R.; the U.S.A. ranks first and accounts for about 20 per cent of the total world production.

Zinc occurs as lead-zinc ore in the Jawar mines in Rajasthan. An estimate regarding the reserves in these mines puts them at 700,000 tonnes of high grade ore containing 12.5 per cent of combined metal (5.25 per cent lead and 7.25 per cent zinc). However, this is quite inadequate to undertake the production of virgin zinc on a commercial scale in India, as the quantity of zinc concentrates having

³⁶India, Tariff Commission, Report on the Continuance of Protection to the Power and Distribution Transformers Industry, Bombay, 1965, p. 18.

³⁷The London Metal Exchange was founded in 1882. It has developed and maintained a position at the centre of the world's metal trade. The Exchange is the only continuous market where copper, tin, lead and zinc can be freely bought and sold, in large or small quantities. As it is the only efficient and competitive mechanism for establishing world values for non-ferrous metals, its official prices form the basis of dealings in ores in the countries throughout the world.

See, The Economist Intelligence Unit, Limited. The London Metal Exchange, The Whitefriars Press Limited, Tonbridge, England, 1958.

a zinc content of about 55 per cent is only 5,000 tonnes. At present, the Metal Corporation of India, Ltd., produces zinc concentrates (an intermediate product to virgin metal) and gets them smelted into zinc in Japan on toll basis. The production of zinc concentrates in India, zinc concentrates shipped to Japan and the metal obtained therefrom during the past three years are indicated below.

TABLE 3.2. THE SUPPLY OF ZINC CONCENTRATES AND ZINC METAL:
1961-62, 1962-63, AND 1963-64

Year	Zinc concentrates produced	Zinc concentrates shipped to Japan for treatment	Zinc Metal Received after Treatment
1961-62	9,008	10,895	4,327
1962-63	11,031	10,919	3,875
1963-64	9,900	9,922	4,826

Source: Reproduced from, India, Tariff Commission, Report on the Continuance of Protection to the Non-Ferrous Metals Industry, Bombay, 1965, p. 16.

The Corporation is setting up a zinc smelter at Debari near Udaipur in Rajasthan with an annual capacity of 18,000 tonnes. The raw material viz. zinc concentrates will have to be imported.

In respect of non-ferrous metals other than aluminium, in spite of the increased production planned in the next few years there will be a wide gap between demand and pro-

duction which will have to be met by imports.³⁸ Aluminium is the only non-ferrous metal for which adequate raw material resources are available in the country. The raw material resources in respect of all other metals like copper, lead and zinc are very limited. The possibilities of importing concentrates of these ores from other countries and processing them in the smelters within the country will have to be urgently explored.

Porcelain Bushings

These are required mostly for the transformer industry. The demand for these parts is met both from imports and from indigenous sources. The indigenous manufacturers are: M/s. Hindustan Potteries, Calcutta, M/s. Bengal Potteries, Ltd., Calcutta, The Bengal Porcelain Co., Calcutta, the Government Porcelain Factory, Bangalore, and the Bihar Government High Tension Insulator Factory, Ranchi. There is at present no standardization in respect of sizes and designs of the bushings ordered by the transformer manufacturers. This leads to a long delivery period, since every order has to be taken as a special order. The quality of the indigenous production is quite satisfactory.

Insulating Materials

The supply of insulating materials such as leatheroid, empire cloth, cotton tape cotton sleeving, empire sleeving,

³⁸ See, India, Ministry of Steel and Mines, op.cit., p. 46.

etc. required in the manufacture of electric motors and transformers is adequate to meet the quantity needed in the organized sector. Though the quality of the indigenous production is satisfactory, the prices are relatively high. M/s. Senapathy Whitely, Ltd., Bangalore, and M/s. Rohtas Industries, Dalmianagar, are manufacturers of some of these items. Insulating materials required for slot insulation in 'E' class motors such as polyester paper laminates, varnished tereylene cloth and sleeving, micanite with polyester film bond etc. are fully imported.

Transformer Oil

Transformer oil is a product of petro-chemical complex. Almost all the requirement is at present being met by imports. The demand for this product was estimated by the Directorate General of Technical Development of the Government of India to be 1.55 crores of litres in 1968. The Ministry of Petroleum and Chemicals is making efforts to set up indigenous production of transformer oil.³⁹

PF (Phenol formaldehyde) Moulding Powder

Phenol Formaldehyde moulding powder of various grades is used for the manufacture of telephones, radio cabinets, switchgear parts, etc. There were six manufacturers in India with a total capacity⁴⁰ of 2,195 tonnes on single shift

³⁹ India, Tariff Commission, Report on the Continuance of Protection to the Power and Distribution Transformers Industry, Bombay, 1965, p. 21.

⁴⁰ India, Tariff Commission, Report on the Continuance of Protection to the Plastics (Phenol Formaldehyde Moulding Powder) Industry, Bombay, 1962, p. 6.

basis in 1962. Production in 1961 was 2,244 tonnes.⁴¹ Production in 1966 was stated⁴² to be 3,823 tonnes. The Industrial Plastics Corporation, Ltd. and the Indian Plastics, Ltd. are two large scale producers in Bombay. According to the Tariff Commission's Report⁴³ the capacity of this industry if worked on multiple shifts basis is adequate to meet the demand for P.F. moulding powder in the next few years.

R u b b e r

The figures regarding the production and consumption of different varieties of rubber in 1966 are as follows:⁴⁴

TABLE 3.3. PRODUCTION AND CONSUMPTION OF RUBBER
DURING 1966

Type	Indigenous Production	Consumption
Natural Rubber	53,196	66,693
Synthetic Rubber	15,604	21,947
Reclaimed Rubber	10,832	10,578
Total	79,632	99,218

The shortfall in the indigenous supply is accounted

⁴¹Ibid., p. 7.

⁴²Narasimhan, N.S., Promising Prospects for Plastics Industry, Foreign Trade of India, Vol. 52, February, 1968.

⁴³India, Tariff Commission, op.cit., p. 9.

⁴⁴Dr. Modak, K.N., Indian Rubber Goods Industry, Foreign Trade of India, Vol. 49, September, 1967.

for by imports. There is only one factory, viz., Messrs. Synthetics and Chemicals, Ltd. at Bareilly in Uttar Pradesh manufacturing synthetic rubber with a capacity of 30,000 tonnes per annum.

As far as the rubber goods industry is concerned the present capacity meets all the Indian demand and has an export surplus. There are at present 200 large and medium sized units in addition to over 400-500 small-scale units. The total production was estimated to be Rs. 200 crores while the exports amounted to Rs. 5 crores.⁴⁵

Except such items as electrical steel, copper and other specific items discussed above the supply position of raw materials for the organized sector is fairly satisfactory. However, small-scale manufacturers in electrical machinery industry are experiencing considerable difficulties in procuring the basic raw materials. Whereas the manufacturers of stampings, laminations, copper wires and strips, steel sheets and plastics etc. have some sort of a regular arrangement with the large scale manufacturers of electrical machinery in terms of regular quotas etc. there appears to be no such arrangement as far as small scale producers are concerned. As a result a small-scale producer of electrical machinery has to purchase his requirements of copper-wires and strips and many other materials in the open market by paying

⁴⁵ Ibid.

exorbitant prices. In many cases the requirements of the small-scale producers are not large enough to place an indent on the producers of the basic raw materials.

3.4 Substituting Imports and the Use of Improved Varieties of Raw Materials

The account of the supply position of raw materials consumed by the electrical machinery industry given in the earlier section points out among other things, to the urgent need for the substitution of certain raw materials which are being imported at present. A few instances of the substitution possibilities in respect of raw materials have been given in the following paragraphs.

The Use of Aluminium Die Cast Parts

Rotors (the rotating inside part of an electric motor) as they are manufactured today involve the use of quite a substantial amount of copper. The use of aluminium die cast rotor has an important consideration of reducing foreign exchange on imports of copper through its replacement by aluminium, which is indigenously available. Though the initial capital cost in terms of die cast machines, dies, etc. is high, it has a special significance for reducing the cost of production in terms of lower labour costs, compared to rotors with copper strips and rings. Despite such significant economies, with a few exceptions, even the producers in the organised sector have not taken steps for a change over to aluminium die cast rotors.⁴⁶

⁴⁶ India, Tariff Commission, Report on the Continuance of Protection to the Electric Motor Industry, Bombay, 1963, p.23.

The use of aluminium die cast bodies is also possible in the stator (outer cover) part of an electric motors. While a one horse power motor (with the stator casting in pig iron) of the Kirloskar Electric Co., Ltd., Bangalore weighs 73 lbs., the motor of the same horse power manufactured by ASEA (Sweden) with the use of aluminium die cast body for its stator, weighs only 19.8 lbs.⁴⁷ For frame sizes whose production is possible on mass scale such a substitution may help to bring down the costs particularly for the export market.

New Insulating Materials

In the case of insulation material for electric motor, the producers in the countries like U.S.A., West Germany, U.K. have switched over to class 'E' insulation⁴⁸ as against class 'A' insulation. This has resulted in economies in the quantities of materials and reduction in cost. Though some manufacturers in India like Bharat Bijlee Ltd. of Bombay, Jyoti Electric Motors Ltd. of Baroda and Kirloskars at Bangalore have started using this variety on an experimental basis, the use has not been widespread so far. The reason is mainly the lack of supply of good quality materials used in the class 'E' insulation materials. These materials are mostly of synthetic, thermoplastic variety.

The use of class 'E' type insulation has a wider impact on savings other than merely that reflected in the reduction of the material cost proper. Its use results in the increase

⁴⁷ India, Tariff Commission, op.cit., p.

⁴⁸ This is a mode of classification of the insulation material used for an electric machine. The alphabetical order does not indicate the quality gradation.

in horse power output for the same framesize⁴⁹ (representing a certain quantum of material and manufacturing cost). This implies a saving in all the raw materials which are critically in short supply, viz., dynamo grade sheet steel, copper wires, pig iron and shaft steel (steel used for the shaft of the electric motors).

Aluminium Conductors instead of Copper Ones

Copper conductors in transformers say upto 2000 KVA ratings and in motors upto 15 h.p., bus bars and connectors in switchgear, earthing conductors in sub-stations, could all be replaced by those made of aluminium. Here, there are two difficulties, viz., (a) the methods of jointing of aluminium to copper and aluminium to aluminium have not yet been established properly and (b) aluminium conductors are not available in suitable forms and alloy combinations.⁵⁰

Electrical Grade Papers

Numerous grades of treated and untreated kraft, tissue and other types of papers are used in the manufacture of

⁴⁹This ranges from 100 per cent rise of output in the case of a 1.5 h.p. class 'A' motor to 20 to 25 per cent increase for a 25 h.p. class 'A' motor. Alternatively, saving can be gauged from the reduction in size which will involve less material cost, for a motor of given horse power. This reduction in the size and the resulting economy in the material cost averages about 30 per cent.

See, India, Tariff Commission, op.cit., p.

⁵⁰Ajwani, M.B., 'Import Substitution in Electrical Industry - Problems and Prospects', Electrical India, Vol.VIII, No. 5, Bombay, May 1968, p. 25.

capacitors, condenser bushings, coils, composite insulation etc. At present papers of all grades are imported. Major tasks in the production of these papers are the attainment of requisite degree of purity and dielectric strength.⁵¹

Suitable pulps from indigenous woods and other scrap materials have to be developed, as a first step in an attempt to substitute import of these materials.

3.5 Pattern of Consumption of Raw Materials

The data presented in the tables in this section show the raw materials consumed by the four industries under consideration.⁵² Apart from showing the consumption pattern of raw materials some of these tables may prove useful for certain analytical purposes as indicated below.

Input output flow tables that are constructed at present are based on the data regarding the consumption of raw materials by industries as it appears in the published sources of statistics. These figures are based on aggregate data usually for units in an industry as a whole or for a sector in an industry. In the process of aggregation important information is lost or has to be reported under such titles as 'others'.⁵³ Cases are not rare when the value of items

⁵¹ A loose definition of a 'dielectric' is a substance which does not show metallic conduction. Most organic substances, for instance, are dielectric. It is common to classify insulating materials according to their dielectric strength. This characteristic is simply defined as the maximum A-C or D-C voltage that can be applied to the material before dielectric breakdown occurs.

⁵² In respect of switchgears, detailed statistics regarding raw material consumption was not readily available. Only important items have been given here.

bracketed under the title 'others' exceeds even the most important single item in the list. The data presented in the two subsequent tables, therefore, may ~~also~~ provide a check or an alternative reference while using the statistics of an aggregative nature.

Table 3.4 gives the list of raw materials consumed in the production of electric motors. It also shows the purchases of indigenous materials and imported ones separately. The data pertain to an individual firm and to the year 1961-62. Raw materials worth Rs. 1,11,85,553 were consumed in the production of electric motors worth Rs. 2,51,14,607. Stampings, electrical steel sheets, ball bearings, enamelled copper wires and strips are the most important items in the total cost of raw materials consumed. Imported items of the raw materials formed 15.09 per cent of the total value of materials purchased during the year. The concerned plant producing electric motors is a large scale production unit. Its production of electric motors includes those in the fractional horse power range as well as those in the integral horse power category upto 250 h.p. in the usual production schedule. Motors above this range are also manufactured as per special order.

⁵³ See, for instance, India, Central Statistical Organisation, Annual Survey of Industries, Vol. IX, Calcutta, 1961, p. 8.

TABLE 3.4. CONSUMPTION OF RAW MATERIALS FOR THE MANUFACTURE OF ELECTRIC MOTORS

DURING 1961-62

Particulars	Unit	Imported		Indigenous		Consumption		***
		Quantity	Value	Quantity	Value	Quantity	Value	
1. M. S. Rounds	M. T.	-	-	178.50	1,28,942	145.40	1,07,836	0.96
2. IV D Steel	M. T.	484.65	4,27,854	24.18	18,305	435.00	4,13,231	3.69
3. Electrical Steel Sheets	M. T.	120.57	2,05,803	843.00	11,98,304	1,004.00	14,42,786	12.90
4. Stampings	M. T.	-	-	816.44	31,10,034	743.58	30,16,363	26.97
5. Ball Bearings	No.	22,259.00	5,24,296	41,637.00	4,46,639	75,362.00	10,95,797	9.80
6. Pig Iron	M. T.	-	-	2,343.00	6,07,949	2,238.00	5,83,221	5.21
7. Hoop Iron	M. T.	-	-	5.00	8,824	3.75	6,449	0.06
8. Enamelled Copper Wires	M. T.	-	-	264.18	18,69,835	320.20	20,58,195	18.40
9. Copper Strips	M. T.	-	-	56.15	4,19,921	94.00	4,65,446	4.16
10. Copper Fans	No.	-	-	8,231.00	45,121	10,359.00	56,525	0.50
11. Copper rings	No.	-	-	1,566.00	5,531	2,254.00	8,256	0.07
12. P. B. Sliprings	No.	-	-	4,158.00	57,159	5,509.00	57,661	0.51
13. V. I. R. and P. V. C. wires	MR	-	-	92,698.00	87,726	1,56,433.00	1,28,156	1.15
14. Aluminium Fans	No.	-	-	22,225.00	2,79,926	22,960.00	2,93,224	2.62
15. Bakelite Terminal Boards	No.	-	-	25,845.00	75,091	25,388.00	71,395	0.64
16. Bakelite Insulation Rings	No.	-	-	6,109.00	21,597	3,890.00	13,831	0.12
17. Empire Cloth	CM	640.00	6,394	6,799.00	61,842	5,956.00	56,669	0.51
18. Empire Tape	No.	-	-	1,800.00	21,066	1,340.00	20,225	0.18
19. Carbon Brushes	No.	-	-	14,150.00	65,533	11,761.00	52,830	0.47
20. Brush Holders	No.	5,074.00	71,422	-	-	4,702.00	83,563	0.75
21. Leatheroid	Kg	22,750.00	2,12,616	450.00	3,831	10,168.00	1,43,478	1.28
22. Empire Sleeves	No.	5,757.00	4,115	1,91,777.00	47,517	1,37,372.00	58,811	0.53
23. Varnishes	LR	-	-	60,502.00	1,94,679	71,697.00	2,44,355	2.18
24. Paints	LR	-	-	17,505.00	1,13,686	11,425.00	95,396	0.85
25. Planks	CM	-	-	1,863.00	3,62,597	1,863.00	3,62,597	3.24
26. Packing cases	No.	-	-	16,441.00	1,43,771	16,441.00	1,43,771	1.28
27. Packing paper	Rl	-	-	350.00	8,599	450.00	10,486	0.09
28. Cotton Tape	No.	-	-	41,171.00	2,18,090	19,000.00	95,000	0.85
Total			14,52,500		96,22,115		1,11,85,553	99.97

*** Percent Share of each item in the total cost of raw materials consumed.

Source: Case Study Data.

The data regarding the purchase and consumption of raw materials for the production of transformers (year 1961-62) are presented in Table 3.5 next. Raw materials worth Rs. 58,17,611 were consumed in the production of transformers worth Rs. 84,76,691. Transformer laminations, copper strips and wires, transformer oil, are some of the important items in the total cost of raw materials consumed. Imported items of raw materials in this case, accounted for 20.11 per cent of the total value of materials purchased during the year 1961-62.

Table 3.6 gives the consumption pattern of raw materials for fans. The table has been based on published aggregate statistics, viz. the Annual Survey of Industries, as detailed information was not available from the case studies undertaken for this work. Data relate to the year 1961 and show the aggregate consumption of raw materials for 23 factories. Raw materials worth Rs. 7,29,03,234 were required for a total output of Rs. 12,13,20,481 of the 23 units. Electrical sheet steel (stampings), winding wire, bearings, aluminium sheets and strips are some of the important items in the cost from the point of view of their share in the total cost of raw materials.

The 'Annual Survey of Industries' do not report the product group 'switchgears and controlgears' separately. This is grouped in the 'equipment for generation, transmission and distribution of electricity' including transformers. Raw

TABLE 3.5. THE PURCHASE AND CONSUMPTION OF RAW MATERIALS FOR THE MANUFACTURE OF TRANSFORMERS DURING THE YEAR 1961-62

Particulars	Unit	Imported		Indigenous		Consumption		Percentage share of each item in the total cost of raw materials consumed
		Quantity	Value	Quantity	Value	Quantity	Value	
1. (a) DCC Wires	M.T.	-	-	26.42	2,04,827	29.83	2,24,142	3.85
(b) DPC Wires	M.T.	-	-	110.48	7,82,907	77.43	6,56,495	11.28
(c) TPC Wires	M.T.	9	1,69,447	15.60	1,22,671	18.80	1,73,957	2.99
2. DPC and TPC Strips (Copper)	M.T.	-	-	134.19	9,45,142	111.16	8,55,468	14.70
3. Paints	LR	-	-	17,505.00	1,13,686	3,583.00	21,589	0.37
4. Varnishes	LR	-	-	21,780.00	45,420	19,684.00	36,142	0.62
5. Empire Sleeves	No.	5,757	4,115	1,91,777.00	47,517	66,365.00	14,680	0.25
6. Cotton Tapes	Rls.	-	-	41,171.00	2,18,090	10,482.00	58,556	1.01
7. Elephantide and Press pan sheets	Kg	10,524	68,792	-	-	30,591.00	2,85,151	4.90
	Kg	12,698+	1,19,125	-	-			
8. Trans.Oil	LR	2,17,433	2,17,147	-	-	5,97,966.00	6,57,763	11.31
	LR	1,94,370	2,14,871	-	-			
9. Cooling Tubes	MR	-	-	48,472.00	2,02,680	63,310.00	2,53,049	4.35
10. Porcelain Bushings	No.	1,349	1,27,880	9,224.00	78,854	9,925.00	1,82,163	3.13
11. Dial Thermometers	No.	50	6,296	-	-	221.00	12,938	0.22
12. Bucholz Relays	No.	60	23,530	-	-	33.0	13,742	0.24
13. Transformer Laminations	M.T.	-	-	581.62	17,43,492	613.61	18,30,231	31.46
14. M.S.Channels	M.T.	-	-	29.50	25,385	88.75	66,562	1.14
15. M.S. Plates	M.T.	-	-	143.00	1,09,666	263.00	1,79,346	3.08
16. M.S.Sheets	M.T.	-	-	170.35	1,38,468	212.40	1,61,055	2.77
17. G.M.Wheel valves	No.	-	-	4,958.00	94,724	3,537.00	79,711	1.37
18. Bakelite Sheets	Kg.	-	-	7,635.00	69,890	2,522.00	22,383	0.38
19. Bakelite and Fibre Tubes	MR	12,392+	97,656	7,317.00	24,034	6,243.00	32,488	0.56
Total			10,48,859		49,67,453		58,17,611	99.98

Source: Case Study Data.

+ Imported, but locally obtained.

TABLE 3.6. RAW MATERIALS CONSUMED IN THE PRODUCTION OF ELECTRIC FANS DURING THE YEAR 1961

Sr. No.	Item	Unit	Quantity	Value Rs.	Percent share of each item in the total value of Raw Materials consumed
<u>Basic Materials</u>					
1	Pig iron	M. tonne	1,404	3,44,624	0.47
2	M.S. bars, rods, strips	"	2,427	23,51,149	3.22
3	Electrical sheet steel/ stampings	"	5,200	1,04,81,940	14.38
4	Casting steel/stamping	"	4,239	33,09,762	4.54
5	Pipes and Tubes	Metre	2,73,253	3,77,336	0.52
6	Other iron and steel materials	M. tonne	959	7,92,396	1.09
7	Copper bars, rods, tubes, and sheets	"	46	3,49,338	0.48
8	Copper wire	"	228	11,96,407	1.64
9	Brass bars, rods, tubes and sheets	"	136	7,41,482	1.02
10	Brass wire	"	13	82,585	0.11
11	Aluminium sheets and strips	"	780	41,37,453	5.67
12	Phosphor bronze wire	"	-	4,401	0.01
13	Other non-ferrous metals	"	922	35,72,831	4.90
14	Winding wire	"	741	72,48,263	9.94
15	Bearings	No	16,78,296	46,26,443	6.35
16	Condensers	No	8,99,014	20,55,506	2.82
17	Regulator components	Rs.	-	2,94,900	0.40
18	Others	Rs.	-	1,91,55,787	26.27
<u>Chemicals and auxiliary materials</u>					
19	Paints and varnishes	M. tonne	839	28,30,317	3.88
20	Others	Rs.	-	3,25,951	0.45
<u>Packing materials</u>					
21	Paper, all kinds	M. tonne	377	2,53,031	0.35
22	Wooden cases	No.	8,35,949	22,54,597	3.09
23	Others	Rs.	-	10,08,692	1.38
24	Consumable Stores	Rs.	-	46,69,552	6.40
25	Materials consumed for re- pairs and maintenance	Rs.	-	4,38,491	0.60
TOTAL				7,29,03,234	99.98

Source: Calculated from, India, Central Statistical Organisation, Annual Survey of Industries

Vol. IX, Calcutta, 1961, p. 11.

materials consumed for 'switchgears and controlgears' are not therefore, separately available in this publication. Another source⁵⁴ mentions the following important items of raw materials required for switchgears and controlgears:-

- (1) Iron and Steel (castings, strips, etc.)
- (2) Electrical Steel Sheets
- (3) Brass
- (4) Copper
- (5) Phosphor-Bronze
- (6) Aluminium
- (7) Winding Wires
- (8) Bimetal and resistance wires
- (9) Special contact materials
- (10) Insulating materials
- (11) Insulating oil
- (12) Moulding powder

3.6 Summary

The electrical machinery industry consumes raw materials ranging from products of iron and steel to modern plastics. Electrical steel, copper, aluminium, and various insulating materials remain by far the most important among them. Supply position in respect of many items is not satisfactory. This is especially true for the small-scale sector. Fuller utilization of the capacity in the electrical

⁵⁴Indian Electrical Manufacturers Association, Demand Survey of Electrical Equipment, 1965-66 - 1970-71, Calcutta, 1965, p. 45.

machinery industry that has been created in the last fifteen years implies a simultaneous development of all the industries supplying the wide range of raw materials to this industry. Development of industries which are comparatively new, like for instance, aluminium and plastics and the switch over to the use of their products is vital both from the point of view of reduction of costs and minimizing the import component in the electrical machinery industry. Dovetailing the production programme of the steel mills to the specific requirements of the metal working industries will also help to save the foreign exchange to a large extent.

CHAPTER 4

TECHNICAL PROCESSES AND SOURCES OF DATA

4.1 Introduction

The need to resort to the technological information for the kind of analysis undertaken in the present study was pointed out in Chapter I. There, it was also pointed out how engineering and technical data are being used in this study. The purpose of devoting a separate chapter in this study to the technical processes involved in the manufacture of electrical machinery, is mainly, to give a technical background for the analysis undertaken through case studies of two firms in the electrical machinery industry, which is reported in the following chapter. The description of the technical processes also brings out to the reader the fact that the basic processes¹ of manufacture in this industry are more or less similar to those prevalent in the whole metal-working complex. Section 4.4 of this chapter gives an account of the different sources of engineering and technical information in an electrical machinery manufacturing plant. These sources and modes of organizing data are, again, common to many modern plants in the different sectors of the metal-working complex. The treatment of the processes, manufacturing equipment and

¹ Many variations will be found in the process details (such as given in the Appendix A at the end). Here, we are emphasizing only the broad groups.

the sources of data given here is by no means exhaustive and for a more detailed information sources quoted may have to be referred to.

4.2 Technical Processes

The metal working industries each include the following broad groups of processes:-

- (A) Change in the form of the metal e.g. casting, forging,
- (B) Cutting and shaping of the forms e.g. machining, stamping,
- (C) Joining of the forms e.g. rivetting, welding,
- (D) Heat treating,
- (E) Cleaning, Plating and Finishing,
- (F) Assembly, and
- (G) Testing.

In the following analysis, a typical electric motor is taken as an example of electrical machine and the processes involved in its manufacture are given in greater detail. All those are covered by the seven broad categories mentioned above.

The general characteristics or the level of the technical process chosen is dictated both by engineering considerations and by the nature of the economic investigation. The production organization of a plant producing electric machinery suggests a stagewise subdivision of the technical relationships within the industry. The final

product of a metal working industry consists of many components. Each of the components requires some or all of the seven broad processes mentioned above. These components are finally assembled to form the final product. A plant is divided into departments corresponding to successive operations or steps in the processing of different parts. Each stage is associated with a major type of processing equipment.

Before we go over to discuss the basic technical processes involved it is necessary to see what are the basic parts of a typical electric motor and what are the processes that they go through.

The basic parts of an electric motor and the processes: ²

Parts

- | | |
|--------------------|----------------------------|
| (1) Stator shell | (6) Fan |
| (2) Two end covers | (7) Sheet metal components |
| (3) Shaft | (8) Rotor winding |
| (4) Bearing Caps | (9) Stator Winding |
| (5) Stampings | |

Stator Shell

- (1) Casting, Cleaning, deburring, etc.
- (2) Turning
- (3) Base Milling
- (4) Drilling and Tapping

² See, Anderson, Edwin. P., Audels Electric Motor Guide Construction, Control and Maintenance, Taraporewalla and Sons and Co., Pvt., Ltd., Bombay 1, 1964.

End Covers

- (1) Casting, Cleaning, etc.
- (2) Turning
- (3) Fine boring operations
- (4) Drilling and Tapping

Shaft

- (1) Cutting to size
- (2) Facing and centering of ends
- (3) Turning on copying lathe
- (4) Cylindrical grinding of specified steps
- (5) Keyway cutting - Milling

Bearing Caps

- (1) Pressure die casting
- (2) Turning and grooving

Stampings

Stamping

Fan

Pressure die casting

Sheet metal components

Various machining processes mentioned above

Rotor Windings

- (1) Rotor stamping block (Manual operation)
- (2) Pressure die casting
- (3) Insertion of shaft
- (4) Turning or grinding of rotor block
- (5) Dynamic balancing of rotor

Final Assembly

Assembly

Testing

Painting

Packing and Despatch

As pointed out above, the concept of an industrial process can be defined at various levels. It can be defined at the level of production of an electric motor itself or preparing a shaft out of a barstock, or, disaggregating still further, it may be defined as facing the two ends of the shaft. Disaggregation is generally required to increase the ability of an analysis to detect bottlenecks under a variety of conditions. As we disaggregate, however, the importance of (machine) substitution possibilities increases. Without going into the details of this point,³ it may be stated here that the main consideration followed in the description of the processes that follows was availability of data and the nature of the investigation undertaken in the case studies. The principle processes are:-

(A) Change in the form of the metal

(1) The production of castings

Castings are made by pouring molten metal into moulds and allowing it to solidify. In some processes the mould

³ For the elaboration of this point, see Alan S. Manne and Harry M. Markowitz, Studies in Process Analysis, John Wiley and Sons, Inc., New York, 1963, p. 313.

can be used once only and a new one must be made for every casting, while in other processes the same mould may suffice for the production of a large number (sometimes over 100,000) of castings. The latter process may be called casting in permanent moulds. Thus we have two main divisions of foundry work:-

- (1) Casting in non permanent moulds
- (2) Casting in permanent moulds
- (2) Forging process

Forging may be described briefly as the art of manipulating metals that have been heated until they are more or less plastic, by means of hammering, squeezing, and bending. Most forgings are made in steel but other metals can be forged, for example some of the brasses and many of the aluminium alloys. A forged material nearly always has better mechanical properties than a cast one; the difference being usually marked as regards toughness and impact strength.

(B) Cutting and Shaping of the forms

(1) Press tool work

This phrase is used to describe a wide variety of processes by means of which articles are made from sheet materials by cutting, bending, drawing and stretching operations all of which are performed cold. A certain amount of cold pressing and bending is done in forges but such work is not regarded as coming under the heading of press-tool work. The material operated on in press tools is

usually fairly thin, seldom exceeding 10 S.W.G. in thickness, and the operations performed may be roughly classified as:-

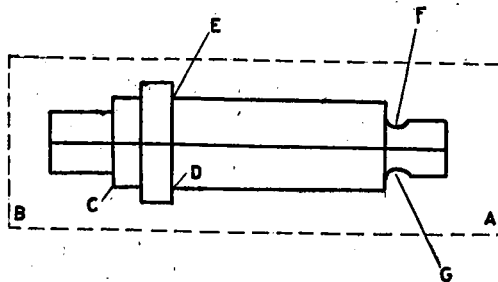
- (i) Piercing, blanking and trimming
- (ii) Bending and Forming
- (iii) Cupping and drawing

Frequently all of these operations may be performed by a single stroke of the press used to produce an article.

(2) Lathe work

Lathe is a machine in which work is held so that it can be rotated about an axis while the cutting tool is traversed past the work from one end to the other thereby forming it to the required shape. Various tasks can be performed on an ordinary lathe with the help of different attachments and cutting tools.

Suppose for instance, the piece shown in full line in Fig. 1 has to be machined all over from bar stock (shown in dotted line) the operations will be as follows:⁴



⁴ See, W. Steeds, Engineering Materials, Machine Tools and Processes, Longmans, 1962, pp. 208-9.

<u>Operation</u>	<u>Tool</u>
1. <u>Cut off</u> piece or bar	Hacksaw or circular saw
2. <u>Centre</u> ends	Centre drill
3. <u>Rough turn</u> one end A	R.H. front roughing tool
4. <u>Turn</u> bar end for end	-
5. <u>Rough turn</u> other end B	R.H. front roughing tool
6. <u>Square out</u> corners C	90° front roughing tool or knife tool
7. <u>Square out</u> corners D	As for 6
8. <u>Turn</u> bar end for end	-
9. <u>Turn</u> semi-circular groove G, F.	Round nosed parting tool
10. <u>Finish turn</u> end A	90° finishing tool
11. <u>Turn</u> bar end for end	-
12. <u>Finish turn</u> end B	As for '10'

All these operations are performed on the same machine.

(3) Machining of holes

Machining of holes may be divided into two types according as to whether the hole has to be produced in solid metal or whether it already exists because of coring in casting or punching in forgings and merely has to be brought to size. Depending on the nature of the drilling process, different types of drilling machines are used such as sensitive, pillar, radial, multiple spindle, etc.

(4) The Milling Process

The milling process is very widely used and is second in importance only to the lathe. Essentially it consists of the use of a rotating cutter against which the work is

fed. The work of the milling machines in general is to face surfaces of any size within the limitations of the machine: to cut grooves, including keyways and splines; to mill keyseats; to do a limited amount of boring; to mill radii; either convex or concave, to cut angles, levels and dovetails; in short to machine any surface that can be reached by a milling cutter.

(5) The Grinding Process

This is a method of machining articles by means of abrasive wheels. It is similar in one respect to the milling process in that it uses a rotating cutter having numerous cutting angles. An abrasive method is composed of a large number of abrasive particles held together by a bonding material.

The abrasive particles must obviously be harder than the materials they are going to cut and they must have sufficient strength to resist fracture under the suddenly applied force of cuts taken.

Grinders are used when a good finish is required or where very close tolerances⁵ are to be met. Grinding machines fall into three main classes: External, internal and surface. The work produced is of many types -- plain stepped, form, concave and convex radii, taper, etc.

(C) Joining of the Forms

Welding, brazing and soldering.

⁵The greatest variation in the dimensions of parts made that can be tolerated.

(1) Welding process may be divided into two groups

- (i) Pressure welds
- (ii) Fusion welds

The characteristic of a pressure weld is that the metal being joined is never brought to a molten state, it is heated upto a welding temperature and the actual union is then brought about by the application of pressure. In this group are forge welds and resistance electric welding. The characteristic of fusion weld is that the metal being joined is actually melted and the union is produced on subsequent solidification. Gas welding and electric arc welding fall in this group.

(2) Brazing

This is a method of joining two or more pieces of metal by means of a very thin film of suitable spelter which is fused and run into the space between the pieces. It differs from welding in that the metal surfaces being joined are not fused.

(3) Soldering

This is similar to brazing but uses a low melting point alloy solder instead of spelter.⁶ The heat necessary for

⁶ Solders and Spelters: - Solders are divisible into two groups - (a) Soft solders and (b) hard solders. The principal soft solders are lead-tin alloys, thus tinsmiths solder ranges from about 40 per cent to 76 per cent tin as an alloying element. The hard soldering are sometimes called spelters, a common composition for spelter is copper 50 per cent and zinc 50 per cent. See Young, James F., Materials and Processes. John Wiley and Sons, Inc., New York, 1954.

fusion is usually supplied by warming the articles being joined by means of a flame.

(D) Heat Treatment

A heat treating process includes, broadly speaking, any operation or combination of operations involving heating above room temperature and cooling to room temperature and below for the purpose of obtaining desired properties in a metallic material. Usually a finished part is given a heat treatment to produce some desired change in structure. The change obtained may be in nature of the structural constituents, in their size, form or distribution, of either ferrous or non-ferrous metals. The processing schedule depends on the goal to be attained. The operations involving structural changes typically include heating, holding at some temperature and cooling at a desired rate. Temperatures and rates of heating and cooling depend on the specific metal or alloy and the purposes of the treatment.

(D) Cleaning, Plating and Finishing

Coatings are used on almost all metal products today, either for protective purposes or for both protection and decoration. Most often coatings are applied to finished components, which are then assembled to form the final product. The various processes involved in preparing work for coating and in applying the coating are closely inter-related. In smaller manufacturing plants the methods

available are often performed in the same department.

(1) Cleaning Methods

Three general methods for cleaning metals contaminated with oil, grease, etc. are: (a) vapour degreasing, (b) emulsifiable solvent cleaning and (c) aqueous alkaline cleaning. Cleaning previous to plating, for example, should be complete, and the work should show no 'water break' (on removal from water, the work should be covered by a continuous water film).

(2) Electroplating

Electroplating may be described as a process in which metals are deposited or plated from solutions containing metallic ions by means of electrolysis. The main purposes of depositing one metal on another by electroplating methods are: (a) to afford protection against corrosion of the base metal, and (b) for decorative effect.

The technique of electroplating is basically the same for all metals, although there are certain variations in some of the details. Parts, after having thoroughly cleaned are connected electrically to the cathode bar, and on the anode bars are suspended slabs of the metal being deposited. The solution in which the components are immersed itself contains dissolved salts of the metal to be plated, and in order to increase its conductivity other chemicals which will ionise highly are added. Direct current transmitted through the system results in the migration of the metallic

ions to the cathode and their deposition, upon losing their charge, as metal on the cathode. The metals used as coating materials are : alkaline tin, cyanide cadmium, cyanide copper, cyanide zinc, nickel (neutral solution), acid copper, acid zinc, and acid chromium.

(F) Finishing

Organic finishing consists in coating a surface with a continuous film of an organic film forming material. This film may be applied for protecting the surface from corrosive influences, for enhancing the appearance, or a combination of both.

The organic finishes of industrial importance at the present time are asphaltic paints, oil paints and enamels, synthetic resin enamels and lacquers.

A finishing system consists of the materials or group of materials applied to a surface to produce a desired result. It may be made of one, two or more coats of material. Organic finishing materials are applied by any method that will leave a continuous film of material over the surface. For a long time, the most common method was brushing. This method has been replaced in many cases by spraying or dipping. Hot spraying and electrostatic spraying are two new tools for spray-painting that have been developed.

(F) Gauging and Inspection

Before the advent of mass production methods in industry, products were produced for job-shop work (manufac-

turing products in small quantities and to special design). Each of the mating parts of a machine were hand fitted to each other. They would seldom fit the similar parts of another machine of the same design.

The fundamental basis of mass production is careful control of the dimensions of parts and of processes used so as to obtain uniformity of parts, thus, making them interchangeable between different assemblies of the products. This requires good measuring and indicating devices. These are known as gauges. Gauges are used to indicate the measure of a dimension of a part or to compare dimensions of two or more parts. Adjustable general purpose gauges such as micrometers and vernier callipers which will measure a range of sizes are used for job shop work. Gauges of fixed sizes and gauges which give very accurate readings by high amplification are used for high production work.

The function of accepting or rejecting work on the basis of how well it measures up to established specifications or standards is known as inspection. There are four main points in the whole manufacturing process at which inspection may be necessary: (a) In repetitive production, the first few parts produced when each operation is started may be inspected for defective workmanship so that only a minimum number of parts will be spoiled in setting up the job. (b) Batches or units of semi-finished parts are inspected so that any defective material may be set aside

and no additional work done on it until a decision has been taken as to whether it can be repaired or must be scrapped. (c) Inspection at the assembly operation prevents assembly of defective parts which would slow up the assembly work, or require dismantling or repair of the product.

(d) The fourth inspection is the final inspection of the finished product after it has been assembled. This inspection assures that no parts have been damaged during assembly and that the product functions properly.

Important methods of inspection are: (a) Proof tests, (b) radiographic inspection, (c) magnetic and non-magnetic particle inspection, (d) electromagnetic inspection methods, (e) supersonic inspection and (f) chemical inspection.⁷

4.3 Shop Equipment in the Electrical Machinery Industry

Each of the processes described above necessitates an equipment of the type and size appropriate to the nature of production undertaken. The description of the equipment in the subsequent paragraphs follow broadly the processes described in the previous pages. (A list of machines in an electrical machinery plant along with the prices is given in Appendix B at the end).

The production of castings requires equipment ranging from simple sand moulds to pressure die casting machines,

⁷ The description of the process of inspection as well as that of some other processes described earlier is based mainly on -

Young, James F., Materials and Processes, John Wiley and Sons, Inc., New York, 1954, pp. 1023-1034.

which achieve far greater dimensional accuracy than by other equipment used for this purpose.

The equipment common to forging operation is a forging press. To quote a technical source: "The hydraulic forging press consists essentially of a ram guided in the frame of the press and carrying the upper anvil beneath which on the foundation is the fixed lower anvil. Hydraulic pressure applied to the ram enables a slow 'squeeze' to be given to an ingot or forging placed between the anvils."⁸

The hydraulic forging press is particularly suited for handling very large forgings such as gun tubes, ship's mainshafts, alternator rotor shafts, etc.

Presses are also used in press-tool work or processes used to shape different forms e.g. trimmings, bendings, forming, etc. These presses could be divided into (a) hand-operated presses and (b) power operated presses. Hand operated presses are very simple in construction and are generally used only for small batches of simple work. Power presses have a wide range of capacity. These are provided with a fly wheel and are usually driven by an electric motor.

Machine tools are numerous in type, lathes, drilling machines, milling machines, grinding machines, etc. to instance a few. The differences between many of them, how-

⁸ W. Steeds, Engineering Materials, Machine Tools and Processes, Longmans, 1962, pp. 126-127.

ever, are matters of detail and not of principle.⁹ Steeds classifies machine tools into four groups -- Single purpose, Multi-purpose, Special and Transfer.

Single purpose machine tools are designed to do one particular kind of operation. A shell turning lathe is designed specially for shell turning and is not adaptable for general lathe work, it is not, however, restricted to one particular size or profile of shell.

Multipurpose machine tools are capable of doing a number of different types of operations. For example, a sliding, surfacing, and screw-cutting lathe fitted with a taper attachment can do almost every lathe operation except certain specialised ones. The multi-purpose machine costs more than the single purpose ones, but in most machine shops, it can more easily be kept fully occupied and consequently it is the most widely used type.

The special machine tool is one built specially for some particular job that is required in large quantities. It has to be specially designed for the job and is not usually capable of doing any other job so that it must be scrapped when the job ceases. It costs more than the single or multi-purpose machines but does the job in less time and thus is able to show a saving in the total cost if the number of articles required is sufficiently high.

⁹ Ibid., pp. 190-192.

The transfer machine tools are, in effect, several machines coupled together, and are operated automatically as a single unit. The capital cost of these machines is usually high, but the operating costs are low because fewer operators are required. They are built to order to perform ~~for~~ a specific series of operations on a single component and are essentially high production equipment.

Welding process such as spot welding is done in machines ranging from simple pedal operated ones producing a single weld at each operation to large power operated units which will produce 100 to 200 spot welds each time the unit is operated.

In the gas welding processes, gases are used in a blow pipe which is provided with control valves to regulate their flow and to enable the desired type of flame to be obtained. The blow pipes are provided with interchangeable nozzles or tips of different sizes so that small and large flames may be obtained. The consumption of acetylene, for instance, ranges from about 1 cu. ft. per hour with the smallest nozzle upto 200 cu. ft. per hour with the largest.

Heat treating equipment consists of different batch-type and continuous type furnaces and induction heating apparatus. The 'horizontal' batch furnace is the oldest and still the most common type. It consists of a horizontal heating chamber of reatangular section charged and discharged through a door or opening in front, the bottom being known

as the 'hearth'. The medium and high (over 1850 F) temperature furnaces may be provided with special gaseous atmospheres, suitable for processes like brazing, sintering, and carburizing as well as for hardening and annealing.

Furnaces of the continuous type are modifications of the horizontal batch type furnace provided with a conveying mechanism to carry the parts automatically through the furnace.

The equipment for 'blast' cleaning consists of a storage tank, a heavy rubber hose for carrying the abrasive to the point of use, and a round nozzle that directs the abrasive material against the work being cleaned. Three types of 'blasting' machines are used: barrel type, table-room type and full automatic machines. The barrel type of equipment consists of a tumbling barrel in which sand or grit is introduced through nozzles placed at both ends of the barrel. This method differs from 'barrel-working' in which the parts, usually small, are tumbled against each other and with other materials. The automatic type of equipment consists of an endless belt conveyors running in an enclosure that is equipped with nozzles which blast the work as it moves along on the belt.

Electroplating is performed in 'tanks' or 'barrels' as described before. A variety of equipment is needed for organic finishing operations. Spray guns of various types are used in paint application. Although they vary somewhat

in detail, their ultimate accomplishment is to mix the finishing material with a strong blast of air. The paint is atomised by means of air and sprayed against the surface being painted. Spray painting is done, when possible, in a spray booth equipped with an exhaust fan. This provides for the protection of the operator from paint mist and solvent vapours and for the elimination of the fire hazards.

With this brief description of the capital equipment, we may next look into the way the various kinds of engineering and technical information are recorded in a manufacturing plant.

4.4 Sources of Engineering and Technical Data

The relevant sources of information regarding capital equipment and 'time standards'¹⁰ are listed below with a brief description of each.

Plant and Machinery Card

Various kinds of information regarding the capital equipment is maintained. This includes an upto date list of machines, their prices, depreciation, development rebate obtained on each equipment and so on.

Besides this, modern factories also maintain detailed information regarding each machine on a separate card which is usually called 'plant and machinery card'. As an instance,

¹⁰ i.e. the time of a machine required for a particular operation. Details regarding this term are given in a subsequent paragraph.

a card for a high speed turret lathe in a factory with all the details entered upon it has been reproduced on the next pages.

Besides giving the make, the engineering capacity and the plant location, this card gives information useful for detailed studies of many kinds.

Machine Load Card

A Machine Load Card for the surface grinder in a factory with the detailed^s entered on it has been reproduced on the next page.

This card is maintained for each machine and gives the information regarding the 'load' of the machine i.e. how many different components will be fabricated by this machine and how much total time of this machine will be occupied during the accounting period, say, an year. This is termed as the 'machine load'. The machine load is given according to components, or, according to products, if product-wise information of this kind is available. The time required of the machine for a particular component entered on the machine load card is usually the 'actual' time required.

Job Orders

These are maintained for every part manufactured and give the following information on a sheet of paper:-

(a) The 'standard' time for a given operation, which is the time required for an average operator fully qualified and trained and working at a normal pace, to perform the operation. It is determined by summarizing the allowed time for

MACHINE LOAD CARD

Description of Machine Year
 Machine Surface Grinder Purchased
 'D700S0' 'DISKUS' 1960

Price Rs.40,700

Part No. +	Op.No.	Milli-hours per piece	Qty per year	Hours per year	Other Machines suitable		
SK80006	1	0.065	5400	351.00			
SK80008	1	0.065	5160	335.40			
SK80010	1	0.068	2880	196.00			
SK80014	1	0.068	3360	228.60			
SK80053	1	0.068	720	41.00			
SK80016	1	0.082	1380	114.00			
SK80018	1	0.082	1260	103.30			
Year			1963-64	1964-65	1965-66	1966-67	1967-68
Total Hours Planned							
Total Hours Booked					2326.30	2682.23	3250.8
Hours Out of Service							
Maintenance Cost Est (Rs.)							
Maintenance Cost Act (Rs.)							
Overhead Rate							

+ Code numbers for different parts.

PLANT AND MACHINERY CARD I

Plant No. | C 22

Supplier	G. Boley	Indian Agents	Garlick and Co.	Order No.	SWT - 68
				Date	2-6-1959
Suppliers M/C No.	54815	Manufacturing Date	1959	F.O.R. cost	-
				Date received	-
				Date installed	-
Description of Plant	HIGH SPEED TURRET LATHE			Model	BOLEY RD-25
Capacity	26 mm	Weight of plant	Plant Location		
Size of Table	Max. drill size 7/8"	1000 kgs.	Dept. 1		
Morse Taper	-				
Spindle Speed	For tapping 45-355 For turning 450-3550	No. of Steps	12 each		
Feeds	0.06-0.1-0.16 mm/rev.	No. of Steps	Elec. Motors	HP/KW	R.P.M. Volts
		2			
T-Slots	-		Main	1.3/1.6/2.2	750/1000/ 440/3/50 15000
Distance between T. slots	-				
			Belts - IV -	17 x 1280 mm	K 2 V - 17 x 1500 mm
			Foundation (B-48)		B-58

PLANT AND MACHINERY CARD II

PLANT REPAIRS		PLANT NO.
Date	Nature of Repairs	Cost -- Rs.

all of the individual elements comprising the time study.¹¹ Generally the time is given in milli-hours (thousandth part of an hour) for a batch of a hundred or that of a thousand parts depending upon the lot size.

(b) The appropriate machine for each of the operations to be performed on the part is listed along with. The operations listed on this sheet are to be undertaken in the same sequence by the operator.

(c) The job orders also give the type and the quantity of the raw material required for the particular part.

Sequence of Operation Sheet

In some factories the above mentioned information is listed on a sheet which is called the sequence of operation sheet.

Standard Operation Sheet

This sheet gives the information about the operations and the time required for operations in still more details. It specifies the machine, jigs, tools and the grade of labour required for an operation. The total machine time required for an operation is given in greater details such as set up time, cutting time, handling time, etc. A specimen of a standard operation sheet maintained in a factory is reproduced on the next page.

¹¹ Benjamin W. Niebel, Motion and Time Study. An Introduction to Methods, Time Study and Wage Payment, Richard D. Irwin, Inc., Homewood, Illinois, 1958, p. 312.

The set up time is the time required for the initial preparation of the equipment or the machine. The setting up operation consists of the following tasks:-

- (i) Check job
- (ii) Study drawing
- (iii) Obtain tools
- (iv) Instal jigs
- (v) Adjust speed
- (vi) Instal drill

The time per lot is prorated over lot size in obtaining the final productivity figures in terms of pieces per day. The problem of optimum lot size, therefore, assumes importance.

The machine time is the time required for actual metal removal (by operations like, cutting, drilling, milling, etc.) while handling time is the time required for insertion and removal of material to be machined and the adjustment of the machine between successive pieces. Inspection time is the time during which the machine operator is testing compliance with specifications.

The standard time per piece is calculated on the basis of the time required for these different tasks. Besides these factors, allowance is made for fatigue, personal requirements and other work delays.¹² Time standards for different operations to be performed on a part may be determined in a number of ways, such as, by stop-watch time study, by standard data, by time study formulae etc.¹³

Time standards are used as a basis of wage incentive plans, as a means of comparing various methods of processing

¹² Ibid.

¹³ Ibid., pp. 408-09.

a part and so on. The important use of time standards from the point of view of the present study lies in the fact that by means of time standards, not only the machine capacity as indicated above in the description of machine load cards, could be determined; but further, it is possible to arrive at the maximum output potential of a factory, once the available machine hours and the time required to produce a unit of each product are known. Standard time of different machines required for a batch of hundred units of a product form the elements of the table which has been used as a simplex tableau for the linear programming exercises in the next chapter.

4.5 S u m m a r y

This chapter provides technical background information for the next chapter. The basic processes and the capital equipment described in the foregoing pages are almost common to many electromechanical products. Most of the machines are oriented to a particular process or a set of processes. Transforming raw materials of various sorts into a complicated product like electricity generator set involves, basically, production of batches of particular components. Production of components is achieved through operations at several machines. Operations on a machine involve several tasks such as setting up the machine, checking the job, actual processing of the component and so on. Production of any electromechanical product has, therefore, to be viewed in terms of these basic processes or operations.

CHAPTER 5

UNUTILISED INDUSTRIAL CAPACITY : SOME EXPLORATIONS

5.1 Introduction

The problem of unutilised capacity can be analysed at different levels such as, national economy, industry or an individual firm. The analysis, depending partly on the level chosen, may take different forms. Attempts¹ have been made to explore the theoretical concept of capacity often with the necessary empirical analysis. Different tools have been used² according to their efficiency to grapple the problem at a particular level. This chapter deals particularly with the problem of unutilised capacity at the level of a firm. Two firms, each belonging to a subgroup of the electrical machinery industry, have been studied for this purpose. Firms 'A' and 'B' (as they will be referred to in the following sections) belong to electric fan and switchgear industries respectively.

As shown in the previous chapter, a typical product in the electrical machinery industry is composed of many small parts. Raw material for each of these parts has to pass through several processes³ before the finished parts are assembled to form a final product. Generally, a firm in the

¹ Some of these have been noted in Chapter I.

² Input output technique for instance, has been used to get an overall national index of capacity which has feasible component parts (feasible outputs of different industries). See, L.R.Klein, 'Some Theoretical Issues in the Measurement of Capacity,' Econometrica, Vol. 28, 2, April 1960, pp.272-286.

³ The term 'process' here implies a particular technical conversion process.

electrical machinery industry produces a range of products. The fabrication of each product requires different technical processes and the necessary capital equipment for each process. Thus, we are dealing with the problem of unutilised capacity of a multi-product, multi-equipment firm. The firm is considered here in the sense of actual production centre.

The problem of fuller utilisation of capacity in the case of such a firm may be viewed both in terms of output rates as well as from the point of view of the utilisation of the capital stock.⁴ We may define full capacity as a particular ideal output rate based on certain assumptions and conditions. Comparison of actual output to the 'full capacity' output gives us a measure of unutilised capacity. We may compare the capital equipment being used (the utilised machine time) in a particular production programme to the total capital equipment (total machine time) available. This gives us another measure showing just the other side of unutilised capacity.

In the following section the concept of full capacity of a multi-product, multi-equipment firm has been defined in terms of optimum total value added and optimum total profit.⁵

⁴ See Almarin Phillips, 'Industrial Capacity - An Appraisal of Measures of Capacity', American Economic Review, Papers and Proceedings, Vol. LIII, N.2 May 63, pp. 275-308.

The two aspects of capacity have been discussed by the author at length. The use of programming models to bring forth these two aspects has also been suggested.

⁵ Both these terms viz. profit and value added as used for the two firms, have been discussed in Section 5.3.

In the case of firms studied for this purpose the optimum values were obtained by linear programming technique. These exercises help to bring out the twin aspects⁶ of the problem of unutilised capacity as described in the above paragraph. Particularly, the pattern of utilisation of the capital stock has been studied in greater detail.

Description of the data collected from the two firms, description of the results and the discussion of these results have been given in the Sections 5.4, 5.5 and 5.6 respectively. Important issues emerging from the study have been discussed in the Section 5.6. In the next section, certain concepts used in the linear programming technique have been described.⁷

5.2 Linear Programming Technique - Important Concepts

Linear programming is a mathematical technique for determining the best allocation of resources for achieving given objective(s) in a situation in which resources are limited, or when there are alternative uses for the resources. Linear programming technique has been applied to the problem of optimum utilisation of limited resources by individual firm.⁸ The simplest model is that applied to a competitive firm which cannot influence the prices of the factors it uses or the

⁶ These two aspects have been elaborated in the subsequent sections,

⁷ These have been given as a convenient reference.

⁸ See, Dorfman Samuelson and Solow, Linear Programming and Economic Analysis, McGraw Hill Book Company, Inc., New York, 1958, pp. 130-185 ff. Apart from the other references quoted the exposition of concepts is based mainly on this work.

products it produces. In the following paragraphs, some basic concepts in the linear programming model have been summarised in the light of this example.

'Activity' is an important concept in the linear programming model. To quote Dantzig⁹ - "The linear programming approach is to consider a system as decomposable into a number of elementary functions, the activities. An activity is thought of as a kind of 'black box' (any system whose detailed internal structure one wilfully ignores) into which flow tangible inputs, such as men, materials, and equipment, and out of which may flow the products of manufacture, or the trained crews of the military. What happens to the inputs inside the 'box' is the concern of the engineer or of the educator; to the programmer, only the rates of flow into and out of the activity are of interest. The various kinds of flows are called items. The quantity of each activity is called the activity level. To change the activity level it is necessary to change the flows into and out of the activity." Each activity corresponds to some physical operation. It may be manufacturing a product in a particular way, storing different products or materials and so on.

The firm tries to achieve its objectives by choosing between different activities available to it. It is further assumed that only a finite number of activities are available

⁹ See, George B. Dantzig, Linear Programming and Extensions, Princeton University Press, Princeton, New Jersey, 1963, p. 32.

to the firm. Each activity implies its characteristic pattern of input and output rates which does not change with the scale of operation. This is called the assumption of proportionality. The activity can be operated at any positive level so long as the necessary inputs are available. This is the assumption of non-negativity. Along with these two assumptions there is the third assumption implicit in a linear programming system,¹⁰ viz., the assumption of additivity. Thus, it is assumed that the total resource requirement for production programme is simply the sum of the resource requirements of different activities.

The quantity to be minimised or maximised such as the total costs or total profits, for instance, is called the 'objective function'. There are certain conditions which prevent the firm from making its objective function infinitely small or infinitely large. For instance, a firm is assumed to possess a given inventory of physical assets and no activity however profitable could be operated at a level which it is beyond the capacity of any of the physical assets to meet. The equations expressing these conditions are called the 'constraints' or 'restraints' of the problem. The constraints are of two types. There are constraints expressing the fact that certain activities cannot be negative. The other

¹⁰ "To be a linear programming model, the system must satisfy certain assumptions of proportionality, nonnegativity and additivity." See, George B. Dantzig, op.cit., pp.6-7, 32-33.

set of constraints express the special conditions of the problem such as mentioned above. The solutions to the linear programming problem are of two sorts. The set of activities or a 'programme' which satisfies all the constraints is called a 'feasible programme'. If the programme maximises (or minimises) the objective function, it is called 'optimum feasible programme' or simply 'optimum programme'.

The linear programming technique is a tool of analysis of production in the short run. In this view of production the quantities of inputs and outputs of the firm cannot be altered directly, but only indirectly by means of changing the levels of various activities. From these levels the factor quantities follow as resultants. In the next section the linear programming model as applied to the firms studied for this work has been described.

5.3 The Model¹¹ used for Case Studies

Activities and Constraints

Both the firms studied for this work can be characterised as multi-product, multi-equipment manufacturing plants. The problem of allocation of resources facing either of the firms can be put as follows.

The firm produces 'n' different products. There are 'm' different types of machine groups in the production shop

¹¹ See, Mathur, Valavade and Kirloskar, 'Optimum Capacity and Imbalance of Capital Structure; the Case of Machine Manufacturing Industries', Artha Vijnana, Vol. 9, Nos. 3-4, September-December, 1967, pp. 428-436.

of the firm. Machines within a particular group are substitutable for each other while no substitution is possible between machines in any different machine groups.

Each of the final products requires in its fabrication the use of each or some of the types of machines in the factory for some specified time. This could be stated in a nutshell as follows:

Machine Groups	Products				
	1	2	3	.....j.....	n
1					
2					
3					
.					
.					
i			a_{ij}	.....
.					
.					
m					

The element a_{ij} in the above chart represents the time of the i^{th} machine group required for the fabrication of j^{th} product. Each of the total machine groups (1...m) in the above chart represents a technical conversion process.¹²

¹² A technical conversion process can be defined at various levels. It may be a particular operation on a bar-stock, such as 'facing', or the complete processing of a part on a machine. It may also be defined as the complete fabrication of a product. Here the term 'process' corresponds to technical conversion processes done by machines in a group. (See, Chapter IV).

A product has to undergo a number (1...m) of such processes for its fabrication. The complete production process of any of these 'n' products will be referred to as an 'activity' and the units or the quantity of the product to be produced as the 'level of activity'. Thus, the firm has 'n' activities available for the allocation of its resources (machines).

Our analysis of the firm relates to the short run in which the inventory of the capital equipment is fixed. Total available time of different machine groups per week per month or per any production cycle relevant for the firm is therefore, fixed. If raw materials, labour and all other factors are available in the market at the ruling price as we have assumed subsequently, then the economic choice facing this firm could be described as follows.

The firm has to select the products to be produced (out of the total 'n') and their respective quantities per week, or per month, in a way that will maximise its total profit (or such other objective as the firm may have before it). As the inventory of the capital equipment is given, this choice is subject to the constraint that no more than hundred per cent of the capacity, i.e., the time available of any of the 'm' machine groups can be used. This is a typical problem suitable for the application of linear programming technique. According to the linear programming phraseology the choice consists in deciding at what level to employ each of the available 'n' activities subject to the constraints mentioned above.

Objective Functions

As stated earlier the firms are assumed to be facing a competitive product and factor markets. Prices of the products sold as well as those of the factors purchased are assumed to be given. In this model of the competitive market, firm's objective is assumed to be to maximise profit. This has been tried for both the firms. In the case of Firm A, exact profit margins on each product were not available. The difference between the sales price on the one hand and wages, cost of raw materials, power and fuel on the other, was taken as an approximation to the profit margin. In the case of Firm A, therefore, the term 'gross profit' will be used while stating the profit maximisation function. In the case of Firm B, profit margins on each product were directly available. In the absence of the break-up of the sales price even according to broad items, it is not possible to state how the profit margins on each product, were arrived at.

Two more objective functions were tried for Firm A which assume the existence of certain extraneous factors other than those implicit in a perfect competitive model. Maximum total value added under the given constraints is tried as the objective function for Firm A. Yet another objective function tried for the same firm is to minimise the cost of idle time of machines.¹³ (to plan the production in a way so as to

¹³ Details of this programme have been deferred to subsequent pages.

achieve the objective). The situation implied in these objective functions is not quite imaginary. Maximisation of the total value added is an objective to be tried from the point of view of economy. Minimisation of the total cost of idle machine time¹⁴ is quite a relevant objective for ^{a firm in} an economy like India which is facing foreign exchange scarcity and where some of the manufacturing plants have large import content¹⁵ in their total capital equipment. There is a scarcity of internal capital also.

Public sector undertakings in India for instance, are operating under such conditions: / Sometimes these undertakings operate in a situation where factor and product prices are given. The production programme of these public sector units, however, is not always tuned to maximise profit. It is planned mainly according to the needs of the programmes of industrialisation in the country (and such other social objectives). The 'extra' costs¹⁶ involved in implementing such production plans are either provided in the project reports¹⁷

¹⁴ As will be seen subsequently, the cost of machine time is assumed to be proportionate to the purchase value of a machine.

All the products on the schedule of the firm are necessary for the economy.

¹⁵ See, Chapter 2. Section 2.5 'Investment in the Public Sector Undertakings'.

¹⁶ Over and above those involved had the unit followed the dictates of the market prices and tried to maximise profit.

¹⁷ See, Heavy Electricals (India), Ltd., 10th Annual Report, 1965-66, pp. 4-5.

of the public sector units, or are provided from the public fisc every year.¹⁸

Thus, the output of a firm trying to achieve these two objectives, may not be at the minimum total cost or, at maximum total profit. One may wonder, how a private firm¹⁹ can operate in a competitive market while trying these objectives. It may be noted here that these objective functions have been tried as theoretical exercises in order to study mainly the pattern of utilisation under different situations. All the three objective functions described here have been attempted for the Firm A. Because of the lack of necessary data regarding prices and costs, however, only one viz. profit maximisation function is tried for the Firm B.

Assumptions in the L.P. Model

Following assumptions are made while applying linear programming technique for the analysis of the two firms studied here.

(a) The technique of production is assumed to be constant in the short run to which the analysis here pertains.

(b) Total capacity requirement for the production of a particular product is directly proportional to the number of units of the product made.

¹⁸This, however, is not to justify all the losses incurred by the public sector units in India.

¹⁹The firms studied for this work are private sector units. For the sake of analysis the two objectives being discussed here have been assumed for these firms.

(c) Total capacity requirement for the production programme is simply the sum of the capacity requirements for different products.

(d) While any positive multiple of an activity (product) is possible, negative quantities of activities are not possible.

Optimum production programmes were obtained in the case of both the firms with the linear programming technique. The optimum plans depend ceteris paribus upon the objective functions used. It is obvious that there could be a set of such plans depending upon different objectives the firm is supposed to maximise and a variety of different conditions faced by the firm that are incorporated in the model. In the next section the concepts of 'full capacity' and 'un-utilised capacity' of a multi-product, multi-equipment plant have been developed on the basis of values of objective functions obtained in different optimum plans. This also leads to a corresponding measure showing the level of utilisation of the capital stock which as we shall see, is another side of the problem of excess capacity.

5.4 Optimum Capacity and Measurement of Unutilised Capacity

Linear programming solution gives the value of the objective function, i.e. total value added or total profit that will result by implementing the optimum programme. This value, the maximum that can be obtained under the circumstances faced by the firm, is a measure of the economic or business

significance of the firm. The capacity of a multi-product, multi-equipment firm may be defined as the value of the optimum production calculated from the method described above. The comparison of the actual production to the optimum production²⁰ gives an idea of the utilized capacity of the firm. There can be a spectrum of definitions based on the concept described above and the corresponding estimates of utilized capacity of a firm. These are exemplified in a subsequent section.

Linear programming analysis gives important information regarding the capital assets of firms. The optimal solution implies values to be placed on the various scarce resources which define the opportunities open to the firm. Thus, we get a shadow price of each capital asset which is determined by its scarcity value in a particular optimum plan. We also get the unutilized time ('slack activities') or the idle capacity of each machine group in the respective optimum plans.

To get an overall idea of the unutilized machine capacities a suitable weighted average of the idle capacities can be taken. In the following analysis weights are taken

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The comparison may be made on the basis of the output values, or the value added, or the profit in the two situations depending upon the indicator used to get the optimal programme. Thus, percent ~~un~~utilized capacity may be obtained as

$$\frac{\text{Total value added in the actual programme}}{\text{Total value added in optimum programme}} \times 100$$

in proportion to the purchase price of each machine.²¹ The weighted average will give us an indicator of the idle time of the capital equipment as a whole.

If we assume that there are no market constraints (in the sense that all the output of the firm is sold at prices ruling in the market), as we have done, the reasons for unused machine capacities which appear while applying different optimum plans have to be searched in some other factors than that of insufficient aggregate demand. These could be better discussed only after presenting the necessary data in this respect. Anticipating what we discuss in a subsequent section it may be stated here, that the idle machine capacities under the circumstances described above (viz. the infinite market potential) are a function of the objective function being maximized, the relative demand for and the relative prices and costs of the products, and last but not the least important, certain policies on the part of the

²¹ The rate or the cost of machine time proper, depends on the following factors.

- (A) Costs connected with the hardware, viz.
 - (i) Depreciation, (ii) Interest on the capital locked up, (iii) Repair and maintenance, (iv) Insurance.
- (B) Costs connected with the space required for (1) operator, (ii) Machine and (iii) Inventories.
- (C) Costs of work in process-(i) Insurance, (ii) Interest.

Costs connected with the hardware (machine) i.e. (A) above account for the largest share of the cost of machine time. These costs in turn depend mostly on the price of the machine. The cost of the machine time, therefore, has been taken as proportionate to the price of the respective machine.

firm itself and the government.²² In this chapter the effects of changing the objective functions and changing relative prices have been worked out. The next section gives an outline of the basic data used for linear programming models.

5.5 Description of the Data

Electric Fan Industry - Firm 'A'

The firm analysed in this industry produces ten different products; most of them are electric fans and the rest being fractional horse power motors. The machinery in the factory has been classified into twenty-four different groups;²³ for instance, drilling machines, milling machines, etc. The classification was based mainly on the machine type and its feed size.²⁴ Different levels of aggregation are possible while grouping the machines, depending upon the availability of data and the accuracy of the results required. In this particular case the problem of classification of machines did not exist, as the 'time data'²⁵ were

²² See, Morris Buddin and Samuel Paul, 'The Utilisation of Indian Industrial Capacity (1949-1959)', The Indian Economic Journal, Vol. 9, 1961-62, pp. 19-47.

²³ See, Table 5.1. Also see, Appendix C at the end for the considerations followed in grouping the machines in the case of Firm B.

²⁴ See, Chapter IV. In the case of lathes, for instance, the feed size implies the size of the barstock that can be fed, or, could be accommodated by the chuck (a part of the lathe which holds the material that is being machined).

²⁵ The time of different machines required in the fabrication of each product.

supplied by the industrial engineering department of the firm according to these groups of machines. The assumption in grouping the machines in this way is that certain amount of substitutability among the machines classified under a particular group is possible.²⁶

The information as regards the number of shifts each machine is worked in the factory was available. No flat basis such as one shift or two shifts, etc. was adopted in this case. The available hours for each group of machines were calculated on the basis of the above-mentioned information. As no exact information regarding the allowance made for different factors like 'scrap factor', 'fatigue' and maintenance etc. ^{was} ~~being~~ available, eight hours per shift was assumed to be the time available per machine per shift.²⁷ The factory works 25 days per month.

Available groupwise machine hours were the only constraint on the production used in this model. The basic table (structural matrix), thus, consists of twenty-four rows which represent the twentyfour machine groups and ten activity columns representing the ten products being produced by the firm. The elements or the figures in the table repre-

²⁶ This means that if a particular machine in a group is booked completely, any other machine in the same group could be used for carrying out the particular operation.

²⁷ To a small extent, therefore, the available machine hours have been over-estimated.

Sr. No.	Description of the Machine Groups	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	Total machine hours available per month
1	Small Centre Lathe	0.0208	0.0000	0.0350	0.0000	0.1532	0.1632	0.0863	0.5102	0.1000	0.0000	≤ 2400
2	Large Centre Lathe	0.8273	0.2630	0.3890	0.3890	0.5851	1.9511	1.7390	1.3394	1.1359	0.0000	≤ 8000
3	Capstan	0.1268	0.2262	0.0916	0.0916	0.6044	0.6044	0.4017	0.6538	0.1997	0.0000	≤ 3600
4	Special Purpose Lathe	0.0717	0.0717	0.0138	0.0138	0.0000	0.0000	0.0000	0.0060	0.0890	0.0000	≤ 1200
5	Automatics	0.0144	0.0144	0.0144	0.0144	0.0000	0.0000	0.0000	0.0000	0.0122	0.0000	≤ 1800
6	Cylindrical Grinding	0.0400	0.0332	0.0400	0.0400	0.1077	0.0000	0.1258	0.0670	0.1600	0.0000	≤ 0800
7	Surface Grinding	0.0000	0.0000	0.0000	0.0000	0.0028	0.0028	0.0518	0.0000	0.0000	0.0000	≤ 0200
8	Stator Grinding	0.0695	0.0720	0.0525	0.0523	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	≤ 1200
9	Arbor Press	0.0139	0.0101	0.0100	0.0100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	≤ 0200
10	Hack Saw	0.0190	0.0190	0.0218	0.0218	0.0360	0.0540	0.0000	0.0390	0.0090	0.0000	≤ 0800
11	Down Rod Threading	0.0449	0.0449	0.0449	0.0449	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	≤ 0400
12	Spinning	0.0000	0.0000	0.0456	0.0456	0.0000	0.0000	0.1598	0.0000	0.0000	0.0000	≤ 0400
13	Trimming	0.0000	0.0000	0.0465	0.0465	0.0000	0.0000	0.1598	0.0000	0.0000	0.0000	≤ 0400
14	Hobbing	0.0000	0.0000	0.0000	0.0000	0.2436	0.2436	0.1598	0.0000	0.0000	0.0000	≤ 0400
15	Shaping	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1600	0.0000	≤ 0200
16	Shearing	0.0000	0.7450	1.0100	1.0100	0.3500	0.1000	0.0100	0.0290	0.0250	0.0100	≤ 0800
17	Circle Cutting Machine	0.0000	0.2700	0.3000	0.3000	0.0000	0.0000	0.0075	0.0150	0.0000	0.0100	≤ 0200
18	Hydraulic Press	0.0000	0.7500	2.1200	2.1200	0.5200	0.1500	0.0200	0.5000	0.0600	0.0150	≤ 0400
19	Press 10 Ton	0.0000	0.0000	3.2000	3.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	≤ 2400
20	Press 30 Ton	0.0000	1.1500	2.0000	2.0000	4.3700	0.2500	0.0075	0.6500	0.1000	0.0300	≤ 1600
21	Press 60 Ton	0.0000	3.1700	2.6000	2.6000	0.5600	0.1600	0.0110	0.1250	0.0000	0.0100	≤ 1000
22	Press Deep Drawing 150 Tons	0.0000	0.9500	1.1500	1.1500	0.0000	0.0000	0.0150	0.0250	0.0000	0.0150	≤ 0200
23	Press-Gearred 150 Tons	0.0000	0.3750	0.3750	0.3750	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	≤ 0200
24	Rolling Machines	0.0000	0.0000	0.2500	0.2500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0075	≤ 0400

Source: Case Study Data.

Objective FunctionsTo Maximise

1. Value Added:

$$A = 27.03 x_1 + 42.16 x_2 + 37.03 x_3 + 39.15 x_4 + 32.58 x_5 \\ + 60.95 x_6 + 133.50 x_7 + 45.13 x_8 + 42.70 x_9 + 208.67 x_{10}$$

2. Gross Profit at the current wage rate:

$$B = 19.03 x_1 + 35.16 x_2 + 29.03 x_3 + 32.15 x_4 + 21.58 x_5 \\ + 38.95 x_6 + 96.50 x_7 + 25.63 x_8 + 22.70 x_9 + 153.67 x_{10}$$

3. Gross Profit with 5% increase in wages:

$$C = 18.63 x_1 + 34.81 x_2 + 28.63 x_3 + 31.80 x_4 + 21.03 x_5 \\ + 37.85 x_6 + 94.65 x_7 + 24.66 x_8 + 21.70 x_9 + 150.92 x_{10}$$

4. ----- with 10% increase in wages:

$$D = 18.23 x_1 + 34.46 x_2 + 28.23 x_3 + 31.45 x_4 + 20.48 x_5 \\ + 36.75 x_6 + 92.80 x_7 + 23.68 x_8 + 20.70 x_9 + 148.17 x_{10}$$

5. ----- with 15% increase in wages:

$$E = 17.83 x_1 + 34.11 x_2 + 27.83 x_3 + 31.10 x_4 + 19.93 x_5 \\ + 35.65 x_6 + 90.95 x_7 + 22.71 x_8 + 19.70 x_9 + 145.42 x_{10}$$

6. ----- with 20% increase in wages:

$$F = 17.43 x_1 + 33.76 x_2 + 27.83 x_3 + 30.75 x_4 + 19.38 x_5 \\ + 34.55 x_6 + 89.10 x_7 + 21.73 x_8 + 18.70 x_9 + 142.67 x_{10}$$

7. ----- with 5% decrease in wages:

$$G = 19.43 x_1 + 35.51 x_2 + 29.43 x_3 + 32.50 x_4 + 22.13 x_5 \\ + 40.05 x_6 + 98.35 x_7 + 26.61 x_8 + 23.70 x_9 + 156.42 x_{10}$$

sent the time required of different machines to fabricate a particular product. In the case of the first column of Table 5.1 for instance, representing the product x_1 , we see that it takes 0.8273 of a large centre lathe to fabricate a unit of product x_1 , while it does not require spinning, trimming and other machines listed subsequently in its fabrication. Hence the time requirement has been entered as zero.

The first two objective functions considered in this model were (a) to maximise total value added and (b) to maximise gross profit. The two objective functions are those which may be taken as being maximised from the point of view of the national economy and a firm respectively. The subsequent five objective functions (see Table 5.1) are the variants of the second. The gross profit margins at changing wage rate²⁸ were obtained on each product. The five variants of the objective function maximising gross profit were used only to test the stability of results and to assess the effect of changes in the relative prices on the capacity utilization.

Along with the two objective functions stated above a third one was tried for this firm. This was to minimise the total cost of the idle machine time.

²⁸ Which amounts to changing the relative price structure. A 5 per cent decrease or increase in wage rate will have a varied impact on the cost of production of different products depending on the proportion of labour component in the total cost of production of the particular product.

In the objective functions stated in Table 5.1, the active variables correspond to the ten products on the list of the firm. The slack variables (not stated in the objective functions given in Table 5.1) are the idle time of machines.

In the objective function under consideration now, the 'active' variables are the idle capacities of machines while the products on the list of the firm become the slack variables. In symbolic terms this objective function can be stated as follows :-

$$\text{Min. } C = c_1S_1 + c_2S_2 + \dots + c_{24}S_{24} \\ + 0x_1 + 0x_2 + \dots + 0x_{10}$$

where C,	total cost of idle machine time.
$c_i; [i=1, 2, \dots, 24],$	cost of an hour of a machine.
$S_i; [i=1, 2, \dots, 24],$	the idle time of a machine.
$x_i; [i=1, 2, \dots, 10],$	slack activities.

The optimum plan with respect to this objective function is one in which the total cost of idle machine time is minimum. The optimisation is subject to the same set of twentyfour constraints corresponding to available groupwise machine time, as assumed in the earlier optimisation programmes. The value coefficients in the objective function (c_iS) represent the machine hour costs. The cost of an hour of a machine is taken to be proportionate to the market price of the machine. Thus, the cost of 400 machine hours of rolling machine (24th row in Table 5.1) is taken to be the pur-

chase price of the rolling machine. From this, the unit cost i.e. the cost of an hour of the rolling machine has been imputed in the objective function. This forms the 'c₂₄' in the aforementioned objective function. The purchase prices of machines have been used as approximation to their scarcity values.

The implications of this programme are discussed in the subsequent sections.

Switchgear Industry - Firm B.

Switchgear (motor-starters, switchboards, fuses, control panels etc.) is the major product line of the firm analysed in this industry. Occasionally, however, the firm meets small orders for cake mills and petrol pumps from the same production shop. Though switchgear is the major product line, the assemblies and sub-assemblies²⁹ have a varied type of material and machinery requirements. In this major production line alone, which constitute ninetyfive per cent of the total production (by value), hundred and thirty products were taken into consideration. The other products were omitted. The reasons being their very minor share in the total production and more important, the non-availability of time data in any form.

A full note on the construction of the table consisting

²⁹ Many assemblies and sub-assemblies are sold as end products themselves. However, they also form a part of some other major product on the list.

of time coefficients used in the analysis of this firm is given as Appendix 'C' at the end. Only the salient features of the data are described here.

Machines ranging to a number of about three hundred, were classified into sixty groups depending upon the machine type, its feed size, and other details regarding engineering capacity. Each machine is available for two shift operations. Week is the shortest period used in planning the production. Machine capacities (available machine time) were calculated as per this period. After making allowances for scrap factor, down time, etc., a machine is available for 79.9 hours a week on a two shift basis.³⁰ As shown in Table 5.2 next, there are sixty constraints in this model corresponding to the available time of different machines. There are hundred and thirty activity columns according to the products taken into consideration.

The time data originally available for about five thousand parts, were transformed³¹ into those for the hundred and thirty final products. Thus, the basic table or the structural matrix in this model³² consists of sixty rows and hundred and thirty columns. Constraints corresponding only to machine capacities are considered in the model. The time

³⁰ For full details, see Appendix C.

³¹ For details, see Appendix C, at the end. Also see, Appendix D for the data forming the structural matrix.

³² The size of the table in this case being very large, only the mathematical presentation of the model has been given in the Table 5.2. Complete table has been given as Appendix D at the end.

TABLE 5.2. MATHEMATICAL FORMULATION OF THE LINEAR PROGRAMMING PROBLEM: FIRM 'B'

	Products	R.H.S.1 Ψ available M/C Hrs. (Standard)	R.H.S. 2 Ψ available M/C Hrs. (Actual)
Rows	$a_{11}x_1 + a_{12}x_2 + \dots + a_{1j}x_j + \dots + a_{1,130}x_{130}$	$\leq b_1$	$\leq \bar{b}_1$
Restrictions corresponding to machine capacity	$a_{i1}x_1 + a_{i2}x_2 + \dots + a_{ij}x_j + \dots + a_{i,130}x_{130}$	$\leq b_i$	$\leq \bar{b}_i$
	$a_{60,1}x_1 + a_{60,2}x_2 + \dots + a_{60j}x_j + \dots + a_{60,130}x_{130}$	$\leq b_{60}$	$\leq \bar{b}_{60}$
Max. Total Profit	$Z = P_1x_1 + P_2x_2 + \dots + P_jx_j + \dots + P_{130}x_{130}$		
	Objective function		

Ψ Right Hand Side

Instead of solving the optimisation problem with respect to two structural matrices as mentioned before, it is convenient to solve the same problem with respect to two right hand sides. The two right hand sides R.H.S. 1 and R.H.S. represent the two sets of constraints--(a) that according to the available standard machine hours of different machine groups and (b) that according to the available actual machine hours of different machine groups (See, Appendix C).

coefficients in the basic tables are based on 'standard time'.

Maximization of the total profit was considered as the objective function. Table 5.3 gives the profit margins on each of the hundred and thirty products used for the maximising function. Maximization of the total value added as an objective function could not be tried as the necessary price and cost data were not available for each product of this firm. Two linear programming problems were solved. The difference between the two problems relates only to the time data used in the basic table.³³ The two problems are:

- (a) To maximise total profit with respect to constraints due to available machine time. The basic table or the structural matrix being based on the standard time.
- (b) To maximise total profit with respect to constraints due to available machine time. The basic table is based on the actual time.

An important piece of information in this case study is that relating to the efficiency of the labour who operates a particular machine. The standard time for a particular operation is based on the concept of average efficiency of

³³ In the first problem the elements of the structural matrix show the standard time of different machines required for a product. This is based on the concept of average efficiency of an operator of the machine. In the second problem the elements of the structural matrix show the actual time of different machines required for a product. This takes into account the actual efficiency of the operator. See the next paragraphs; also see, Appendix C for details.

**TABLE 5.3. PROFIT MARGINS ON DIFFERENT PRODUCTS ⁺ USED IN
THE MAXIMISING FUNCTIONS - FIRM B.**

Product No.	Profit Rs.	Product No.	Profit Rs.	Product No.	Profit Rs.
1	1.85	23	33.00	45	16.20
2	1.70	24	3.75	46	13.40
3	0.85	25	7.45	47	27.00
4	2.25	26	39.20	48	12.80
5	2.05	27	43.55	49	38.30
6	1.75	28	36.75	50	114.00
7	4.20	29	40.90	51	31.50
8	3.95	30	19.00	52	38.10
9	8.65	31	23.80	53	57.60
10	5.20	32	24.20	54	158.55
11	12.35	33	36.20	55	34.00
12	12.00	34	38.80	56	66.05
13	11.15	35	47.15	57	75.05
14	10.75	36	49.30	58	275.00
15	14.85	37	87.00	59	65.50
16	13.60	38	119.00	60	331.50
17	8.00	39	98.00	61	330.00
18	10.80	40	20.30	62	81.00
19	10.80	41	69.60	63	331.00
20	30.80	42	35.80	64	3.14
21	33.70	43	112.70	65	3.38
22	38.00	44	888.00	66	5.43

⁺ Source: Case Study Data.

TABLE 5.3. CONTINUED

Product No.	Profit Rs.	Product No.	Profit Rs.	Product No.	Profit Rs.
67	9.29	89	5.73	111	68.90
68	3.00	90	8.63	112	53.00
69	5.93	91	6.02	113	72.00
70	10.37	92	9.78	114	49.95
71	4.07	93	19.60	115	68.30
72	3.48	94	7.25	116	12.10
73	3.41	95	4.80	117	13.95
74	4.73	96	3.00	118	13.90
75	5.86	97	91.25	119	4.60
76	8.20	98	6.20	120	7.45
77	10.85	99	5.40	121	4.00
78	13.91	100	2.25	122	9.20
79	13.32	101	10.90	123	11.90
80	3.31	102	13.65	124	6.10
81	4.64	103	31.15	125	129.00
82	5.94	104	33.75	126	174.00
83	13.91	105	43.30	127	119.00
84	17.95	106	52.75	128	258.00
85	4.42	107	61.60	129	721.00
86	5.83	108	100.85	130	569.00
87	4.71	109	88.15		
88	7.17	110	87.70		

an operator who has acquired the requisite skill and has undergone the training required. In actual practice, the labour available may not be up to the standard and an operation may take more time of a machine than shown by the standard time. For each machine the firm maintains the record of what are called the 'efficiency factors' so as to arrive at the total time of the machines that will actually be required. Efficiency factors for some of the machines are given in Table 5.4. The efficiency factor of surface grinders (item No. 17, Table 5.4) is 45. This means that if the standard time required to do the grinding operation on a particular part with the help of this machine, is 45 millihours, the actual time required by the operator will be 100 millihours.

The information regarding the 'efficiency factors' is quite important from other considerations, apart from its use³⁴ in the linear programming problems solved for the firm B. It shows that an extra investment, apart from those in buildings and capital equipment etc. is necessary for the development of the requisite skills on the part of operators of the machines. This part of the investment and the time lag necessary to develop the skills has to be noted in any industrial development programme.

³⁴ In the form of two structural matrices based on 'standard' time and 'actual' time respectively.

TABLE 5.4. EFFICIENCY FACTORS FOR MACHINES † - FIRM 'B'

Sr. No. 1	Description of the machines 2	Efficiency factor 3
1	Single spindle drilling Machines	100
2	High Speed Drilling Machines	N.A.
3	Bench Grinders	100
4	Centre Lathe	100
5	Capstan Lathes	100
6	Turret Lathes	100
7	H. Speed Turret Lathe	100
8	Single Spindle Automats	60
9	Screw Slitting Machine	100
10	Screwing Machine	100
11	Band Saw	100
12	Circular saw	100
13	A Cut-off Grinder	100
14	Single Spindle Drilling Machines	55
15	Multi spindle Drilling Machine	55
16	Radial Drilling Machine	55
17	Surface Grinders	45
18	Automatic Belt Grinding Machine	45
19	P. Milling Machine	100
20	Strip Bending Machine	100
21	Shot Blasting Plant	N.A.
22	Spot Welding Machine	100

† Source: Case Study Data

TABLE 5.4. CONTINUED

Sr. No. 1	Description of the Machines 2	Efficiency factor 3
23	Tapping Machines	60
24	Hydraulic Presses	60
25	Fly Presses	65
26	Power Presses	65
27	Guillotine Shearing Machines	60
28	Spot Welding Machines (15 KVA)	60
29	Tumbling Barrel	N.A.
30	Bakelite Preform Press	60
31	Bakelite Moulding Presses	75
32	Hydraulic Presses (1 to 10 Ton)	70
33	Air Presses	70
34	Revetting Machine	70
35	Spot Welding Machines (65 KVA)	70
36	Electric Drying Oven	70
37	Thermal Relay Winding Machine	70
38	Vacuum Impregnation Plant	70
39	Automatic Cut. Off Grinder	100
40	Painting Machines	55
41	Electroplating Apparatus	95
42	Testing Equipment	70

5.6 Description of the Results

The data as described in Section 5.5 earlier were used mainly to bring forth certain aspects of the problem of unutilised capacity and issues related to this problem. The results of the analysis are presented in the following three sub-sections. Those regarding the optimum production plans are discussed in the first sub-section A. Measures of utilised capacity in terms of 'optimum values' and 'actual values' of profit and value added are given in the sub-section B. Measures of utilisation of machine capacities under a variety of conditions are presented in the sub-section C. It would have been excellent from the point of view of a comprehensive analysis, to assume all the set of conditions for each of the two firms and present the measures of utilised capacity and other results accordingly. This, however, was not possible because of the limitations due to available data regarding the two firms. An attempt has been made to bring forth the relevant aspects of the problem as best as possible with the available data.

A. Optimum Production Plans

Table 5.5 gives the results regarding optimum production plans as worked out in the case of firm 'A'. Out of ten products on the actual production schedule of the firm 'A', only four appear in the different optimal programmes. Optimum plans with the first two objective functions viz. (a) to maximise the total value added and (b) to maximise the total

△

TABLE 5.5. OPTIMUM PRODUCTION PLANS- FIRM 'A'

Programme ⁺		Product	Units	Value of the objective function-Rs.
(i)	To maximise the total value added	1	7,784	30,53,867
		9	50	
		5	240	
		10	13,333	
(ii)	To maximise the total gross profit at the current wage rate	1	8,908	22,33,673
		9	418	
		5	265	
		10	13,333	
(iii)	With 5% increase in the wage rate	1	8,908	21,92,976
		6	245	
		5	261	
		10	13,333	
(iv)	With 10% increase in the wage rate	1	8,908	21,52,334
		6	245	
		5	261	
		10	13,333	
(v)	With 15% increase in the wage rate	1	8,908	21,11,691
		6	245	
		5	261	
		10	13,333	
(vi)	With 20% increase in the wage rate	1	8,908	20,71,049
		6	245	
		5	261	
		10	13,333	
(vii)	To maximise gross profit with 5% decrease in the wage rate	1	8,908	22,74,467
		9	418	
		5	265	
		10	13,333	

△ In all the seven programmes mentioned in the table, constraints on the production are those with respect to the available time of different machine groups.

+ Total value added and total gross profit in the actual production plan are Rs. 4,04,817 and Rs. 3,27,050 respectively for this firm. These figures are compared with the optimum values of the total value added and total gross profit obtained in the programmes (i) and (ii) in this table. This comparison gives the first two measures presented in the table subsequently.

gross profit are only slightly different. While the products are the same, there is some difference in the quantities of the products to be produced. Further, with a 5 per cent increase in the wage rate and with the same objective function in the third programme, activity '9' in the earlier plan is substituted by activity '6'. This shows that activity '9' requires more labour inputs than '6' and becomes costlier to produce with the increase in wage rate. This change remains constant in the subsequent plans till the wages are increased by 20 per cent. With the decrease in the wage rate by 5 per cent, there is no change in the products which appear in the optimum plan from those obtained at the current wage rate and with gross profit as the maximising function. Thus, adjustment to price involves discrete shifts in production plans. In other words an optimum plan remains stable over a range of prices. The shift between the plans occurs at a critical price level at which it is profitable to shift resources between activities.

Table 5.6 gives the products, their quantities and the values of objective function as they appear in the optimum plans in the case of firm 'B'.

The optimum plan has got concentrated in only four³⁵ products out of the total hundred and thirty at the same time

³⁵ It may be noted that the number of constraints in this problem ~~was~~^{is} sixty.

pushing up the size of total profit considerably³⁶ as compared to the one obtained with the actual production plan. While the products which appear in the two optimum plans are similar their quantities are slightly less in the second programme which has time coefficients based on the 'actual time'. Consequently, the total profit in the second optimum plan is also slightly less.

TABLE 5.6. OPTIMUM PRODUCTION PLANS - FIRM 'B'

Programme	Product Sl.No.	Quantity (Units)	Δ Value of the Objective Function-Rs.
I. To maximise total profit with respect to constraints due to available machine time; the structural matrix being based on the standard time	4	13317	1,96,45,135
	11	49937	
	64	3551111	
	85	1775556	
II. To maximise total profit with respect to constraints due to available machine time; the structural matrix being based on actual time	4	7990	1,84,67,373
	11	32459	
	64	3373556	
	85	1686778	

Δ Total profit in the actual production plan is Rs.2,02,359. This figure is compared with the values of optimum total profit given above. The comparison gives us the last two measures in the Table 5.7.

This will be seen by the coefficients of utilized capacity given in Table 5.7.

(B) Measures of Utilised Capacity in Terms of Output Rates

The measures of utilized capacity given in the Table 5.7 are obtained on the basis of the concepts discussed in Section 5.4 earlier. Thus, the ratio of the value added in actual production programme to that in the optimum production plan gives us a measure of utilized capacity of the firm, and similarly in the case of other indicators used.

TABLE 5.7. UTILISED CAPACITY IN TERMS OF OPTIMUM AND ACTUAL VALUES OF TOTAL VALUE ADDED, TOTAL GROSS PROFIT AND TOTAL PROFIT - FIRMS A AND B

	Programme Δ	Utilized Capacity (per cent)
<u>Firm 'A'</u>		
I.	To maximise total value added	13.26
II.	To maximise total gross profit	14.64
<u>Firm 'B'</u>		
I.	To maximise total profit. The structural matrix being based on standard time.	1.03
II.	To maximise total profit. The structural matrix being based on actual time.	1.10

Δ In all the four programmes the constraints used are only those corresponding to available time of different machine groups. There are no constraints due to market potential for the products.

(C) Utilisation of the Capital Stock

The linear programming analysis of the firms is based on detailed engineering and technical data along with the

economic data like prices and costs. The analysis gave important information regarding the group of machines which were completely used and those which had idle capacity. This information was available along with the corresponding optimum production plans with different objective functions. In order to get a suitable measure of utilisation of machine capacities in a particular programme, the following procedure was adopted. Idle machine hours in each machine group were listed. Weights were given to the (idle) machine time (purchase) according to the market price of machines in each group. A weighted average of idle time in different machine groups was, thus, obtained. As shown in Section 5.4 earlier, it is fairly valid to assume the rate or the cost of a machine to be proportionate to the price of the machine. These weighted averages are presented as percentages in the case of firm A. In the case of firm B, however, though the prices of the machines were separately available, it was not possible to establish one to one correspondence for the machines included in each group and the price data. In the case of this firm, groupwise idle machine capacities are presented in detail. These are corresponding to the actual production plan of the firm. The data for the two firms gives an idea about the utilisation of capital equipment under different set of conditions. No comparison between different situations and between the two firms has been attempted here.

(i) With Optimum Plans

Table 5.8 lists the objective functions used in different

programmes in the case of firm producing electric fans and the corresponding weighted average (per cent) of idle machine capacities in each programme.

TABLE 5.8. UNUTILIZED MACHINE CAPACITY OF THE FIRM IN THE ELECTRIC FAN INDUSTRY WITH OPTIMUM PRODUCTION PLANS UNDER CERTAIN ASSUMED CONDITIONS

Programme	Idle Machine Time (percent)
I. To maximise the total value added	46.67
II. To maximise the total gross profit	49.41
III. To maximise the total gross profit with 5% increase in the wage rate	49.87
IV. To minimise the total cost of idle machine time	35.33

Table 5.9 next gives detailed groupwise idle machine capacities (slack activities) which appear in the optimum plans for Firm A.

(i) In the first and the second programmes listed in the Table 5.8 above, it is assumed that the firm has ten products on its list out of which the optimum plan has to be chalked out. Further the relative price structure is assumed to be constant. Change in the measure of idle capacities (time) of machines reflects the change in the objective function in the two programmes.

(ii) In the third programme, the wage rate has been increased by 5 per cent. This implies a change in the relative cost structure of the ten products. The difference

TABLE 5.9. GROUPWISE IDLE CAPACITIES OF MACHINES WITH OPTIMUM PRODUCTION PATTERNS - FIRM 'A'

Machine Group	Programmes Δ		
	To maximise value added	To maximise gross profit	To maximise gross profit with 5% increase in the wage rate
1	86.52	88.85	88.95
2	-	-	-
3	61.62	61.86	60.14
4	44.22	43.67	46.77
5	84.08	83.33	83.96
6	32.85	43.53	51.95
7	99.66	99.63	99.29
8	54.92	48.40	48.40
9	45.90	38.08	38.08
10	79.02	77.18	76.02
11	12.63	-	-
12	100.00	100.00	100.00
13	100.00	100.00	100.00
14	92.68	91.93	84.61
15	-	66.56	100.00
16	68.91	70.43	68.87
17	33.33	33.33	33.33
18	-	9.27	6.95
19	100.00	100.00	100.00
20	1.53	-	-
21	73.20	71.82	68.16
22	-	-	-
23	100.00	100.00	100.00
24	65.62	71.86	75.00
Weighted Average	46.67	49.41	49.87

Δ All the three programmes are subject to the constraints corresponding to groupwise machine capacities only.

between the second and the third measure of idle machine capacities, reflects the change in the relative prices.

(iii) The maximum utilisation of the machine capacities (especially in a country like India facing the scarcity of the capital and foreign exchange), given a set of products, could be considered a valid objective for a firm. Thus, the firm according to this objective should so plan the production that the maximum amount of machine capacities that exist are used. (This objective may not coincide with that of maximisation of the total profit on different products produced).

Such a programme was tried for Firm A and the measure of average idle machine time was found out. For this programme the objective function used was to minimise the cost of idle machine time. As stated in a foregoing section, cost of the machine time was assumed to be proportionate to the purchase price of the machine. The optimum plan chooses products (out of ten) in such a way that the total cost of machine time is minimum subject to the constraint that no more than 100 per cent of the capacity of any machine group is used. Even with so much leeway, average thirtyfive per cent of the total machine time remains idle (see, Table 5.8). The likely factors for this result are discussed in the subsequent Section 5.7.

(b) Utilisation of the capital stock with Actual
Production Plan - Firm 'B'

As pointed out in the previous chapter the time standard data are a convenient tool for arriving at the 'machine loads' or the machine time booked for a particular production plan. This means that if a particular production plan is to be implemented, with the help of time standards (the standard time of a machine to fabricate a unit of a particular product) we can know as to how much time each machine in the workshop will be engaged. This exercise was carried out for the firm producing switchgears on the basis of its current production plan. Table 5.10 gives the groupwise machine time (per cent) used while implementing the actual production plan³⁷ for Firm B. This takes into account the market restrictions for all the hundred and thirty products.³⁷ A glance at the groupwise utilised machine capacities given in the Table 5.10 will show that some of the machines are used more than hundred per cent,³⁸ while there are others which are hardly used at all.

³⁷ This, however, is not an optimum plan with market restraints, in addition to those corresponding to machine capacities.

³⁸ Two explanations of the over-utilization of the capacity of certain groups are possible:

(a) We have assumed two shift basis for working out machine capacity (time) available. Some of the machines in these groups may, however, be worked on a third shift.

(b) It is possible that a particular processing for which the machine is being used is done by ancillary units. In our exercise pertaining to the calculation of the machine time requirements on the basis of standard time data, the total time required for a particular process is recorded.

TABLE 5.10. GROUPWISE UTILISATION OF MACHINE CAPACITIES
WITH THE EXISTING PRODUCTION PATTERN -
FIRM 'B'

<u>Machine</u> <u>Group No.</u>	<u>Groupwise (%)</u> <u>utilised capacity</u> <u>of machines on the</u> <u>basis of the given</u> <u>output for 1966-67.</u>	<u>Machine</u> <u>Group No.</u>	<u>Groupwise (%)</u> <u>utilised capacity</u> <u>of machines on the</u> <u>basis of the given</u> <u>output for 1966-67</u>
1	0.14	30	36.15
2	0.72	31	42.26
3	23.42	32	4.99
4	0.67	33	79.61
5	1.62	34	27.08
6	1.35	35	4.86
7	14.86	36	30.65
8	32.89	37	35.42
9	19.70	38	43.19
10	19.33	39	0.20
11	5.56	40	10.81
12	20.18	41	296.51
13	0.02	42	25.59
14	50.76	43	89.04
15	2.33	44	65.79
16	20.48	45	57.14
17	95.27	46	12.94
18	9.07	47	36.47
19	6.43	48	47.18
20	12.29	49	12.50
21	12.17	50	116.76
22	22.24	51	8.02
23	32.81	52	0.20
24	2.28	53	15.92
25	7.46	54	60.38
26	117.39	55	0.33
27	8.02	56	11.47
28	56.97	57	14.39
29	62.29	58	30.93
		59	30.93
		60	83.99

Incremental Investments for Larger Actual Production Plans

If we assume the same pattern of actual output (the same relative quantities of different products actually produced) and a larger size of demand for the same, the additional investment required to sustain a larger production plan could be worked out with the help of the data presented in the Table 5.10. Thus, if we double the quantities of all the products in the present actual plan, the corresponding capacity (machine time) requirements will also be doubled. The additional investment has to go into the machines which are completely booked and become bottlenecks in a larger production plan. These additional investments were worked out broadly on the basis of prices of different machines as given in the Appendix B, at the end. The results are given in the Table 5.11 below.

TABLE 5.11. INCREMENTAL INVESTMENT IN MACHINERY REQUIRED TO SUSTAIN LARGER ACTUAL PRODUCTION PLANS (WITH THE SAME PRODUCT MIX)

Production plan	Incremental investment required (Rs.)
1. Twice the current output	8,12,960
2. Thrice the current output	15,90,546

The present output could be doubled with additional investment of Rs. 8,12,960, while it could be trebled with additional investment of Rs. 15,90,546. It may be noted

that the total book value of the existing machinery was Rs. 27,51,998 as on 1st April 1965. The investment required for the further multiples of the present production has not been given in the table as it was quite substantial as compared to the total book value of the existing machinery and appeared to be of no significance as balancing investment.

5.7 Discussion of the Results³⁹

Starting with the optimum production plans, which is the first important item in the description of the results, an important feature to be noted is the concentration of the optimum plans over a few products. One of the reasons for this may be sought in the policies of the firms. Maximization of the total profit as we have assumed in the model for shortrun analysis may not be the only objective sought by the firms. It may be to maintain a steady clientele. In the process, a firm may also have to produce in actual practice the products which are not quite profitable along with those which are most profitable. Our optimum plans, however, take the total profit (on the total value added) as the sole criterion.

Constraints on production due to demand for each product

³⁹ Instead of entering into a general discussion of the causes of unutilised capacity such as lack of demand, shortage of raw materials, etc., it is preferred here to take up a particular set of results and discuss the likely factors behind it. While doing this, the experience of earlier studies has been taken into account. Certain points mentioned subsequently (for instance, possibility of a change in the technology) are beyond the scope of the assumptions made earlier in the linear programming model. These points have been noted because of their relevance to the problem analysed here in a larger context.

have not been included in the linear programming model used here.⁴⁰

The measures (based on the assumption of infinite demand potential) showing that a firm is using only one per cent or fourteen per cent of its capacity may sound stunning. These measures show that there^{are} imperfections in markets and that the prices and the markets are not properly dovetailed.

The different measures of capacity utilisation show, in the first instance, that there is not a single measure of capacity utilisation, but a variety of measures are possible and they are relevant in their proper context. More measures of capacity utilisation could be obtained under a variety of assumptions and constraints. The exercises attempted here may be treated as a starting point in actual empirical analysis at the level of a firm for measures of capacity utilization.

Perhaps more important are the results regarding the pattern of utilization of machine capacities. As we saw in the earlier sections about half of the machine capacities are idle in a plan which assumes infinite market potential

⁴⁰ Sales potential for each product was not readily available with either of the two firms studied. In the absence of this information an alternative would have been to put some multiple of the present output as 'demand constraints'. This, however, did not seem to be quite significant. Moreover, details regarding the utilisation of machine capacities, as the actual production programme is carried out, were separately available. Study of this latter aspect viz. the pattern of utilisation of the capital equipment under a variety of conditions is an important purpose of this work.

for the products in the case of Firm A. An actual production programme is quite likely to be diversified for many reasons as discussed before. Table 5.10 given earlier, (Firm 'B') however, shows that idle capacities exist on a number of machine groups in the actual plan also. Thus, out of the total number of 60 machine groups given in this table, 45 machine groups, are not used even upto 50 per cent of their capacity.⁴¹ This is not all. Machines are not run at the average speed at which they could be.⁴² Factors affecting these results and the important related issues are broadly discussed as follows:-

(a) At the outset, it may be noted that even during the prime shift, some of the machines spend their time idle. This is not solely due to bad planning on the part of a firm. The parts for most electrical machinery are so varied in their machinery requirements that it is virtually impossible for most firms to plan in such a way that all the machines are fairly completely booked.

(b) The capital equipment in a factory is installed after taking into account the market for a particular set of products and by choosing a particular technology. An entrepreneur intending to invest in electric motor industry,

⁴¹ This, however, is a general observation. Without a weighted average of machine capacities (as calculated in the case of Firm A), any comparison of actual plan and the optimum plan on this aspect is not possible.

⁴² See, the efficiency factors given in Table 5.4 in the case of Firm 'B'.

for instance, fixes the range of production taking into account the market conditions prevailing at the time and which according to him, or his market research bureau, are likely to prevail for a period of years. The necessary types of machinery and their respective number of units are chosen. The factory is set up. If the project planning is efficient, there is a certain balance among facilities.⁴³

In a dynamic situation, however, many alterations and changes are possible. The relative prices and costs may change. Relative demand for the products in a given set may change. Firms have to make the necessary changes in the product-mix in tune with their objective such as, maximising profit.

These changes in the product-mix obviously affect the utilization of machine capacities. In a dynamic situation, therefore, the achievement of continuous balance in the capital equipment such that each machine group is almost fully used may prove uneconomical, if not technically impossible.

(c) Measures of utilisation of machine capacities such

⁴³This implies that excepting a few machines, which are required for some special operations and are required for only a small amount of time, it is seen that a majority of others will be fairly completely booked given the necessary demand for the set of products chosen.

as given in Table 5.8 earlier, depend among other things on the objective function and the relative prices. Both these factors (especially the relative prices) are crucial in determining an optimum production plan under a given set of conditions. Because changing price (or cost) structure will change both the value added as well as the profit for an individual product. By changing the relative prices of the products on the production schedule of the firms, it is possible to obtain different measures of utilisation of machine capacities (or measures of idle machine capacities).

It has to be noted here that the capital equipment of a firm is purchased to be utilised over a long period of time. During this period, a firm may experience wide ranging fluctuations in the prices of its products and costs of the inputs. A measure of idle machine capacities which is dependent on relative price structure may not be considered enough.

(d) A measure of unused machine capacities could be obtained which is independent of the relative price structure of the products. Programme No. 4 mentioned in Table 5.8 was tried from this point of view. As stated earlier, the objective of the firm in this programme is assumed to be to plan the quantities of the ten products on its production schedule in such a way that the total idle machine time is minimized.⁴⁴

⁴⁴ Some scheme of priority or weightage is necessary while selecting the machines for fuller utilisation in this pro-

The measure of idle machine time in this programme was found to be 35.33 per cent as given in Table 5.8 above. This is the lowest limit or the 'lower bound' for the measure of idle machine capacities. Further, this measure is independent of any price structure (related to products) prevailing in the economy. In other words, under the given condition as assumed for this programme,⁴⁵ the firm concerned cannot utilise 35.33 per cent of its capital stock whatever the price structure may be.

Summing up, it may be stated that the measures of idle machine capacities reflect the different patterns of utilisation of the given capital stock. These patterns as we saw are determined by the product-mix adopted by the firm. The product-mix is determined in the main, by the relative price structure prevailing in the economy and the objective that the firm tries to maximise. In the case of firm A which was analysed for this study it was found that 35 per cent of the capital stock cannot be utilised whatever proportions of the 10 products the firm chooses to produce.

(e) Different explanations for this 'minimum idle machine time' as indicated above are possible. The factor stated at

gramme. The purchase price of different machines was used for this purpose. Thus, the objective function in this programme is to minimise the cost of idle machine time (cost of machine time is assumed to be proportionate to the purchase price of machinery). Prices do enter in this optimisation programme in the form of the cost of machine time. However, these are quite stable and do not experience any fluctuation as in the case of relative prices of the products.

⁴⁵ See Sections 5.5 and 5.6.

the outset, viz. the diversified machinery requirements of many products of the electrical machinery industries is quite important. Unless there is some arrangement like 'common servicing facilities'⁴⁶ firms have to purchase a particular machine such as the shaping machine⁴⁷ in the case of Firm A for instance, even though it is scarcely used. Absence of such a machine may put the whole production plan out of gear. Such a machine, or a group of them, shows large amount of idle capacity in any production plan.

(f) Yet another possibility is the change in the technology and product-mix itself. A firm which was using certain parts cast in its own foundry may start purchasing them from outside, being cheaper. There is, thus, a substitution of the material used for the part of the machine on which it was fabricated. The redundant capital asset till it is on the books of the firm goes as hundred per cent unutilised, though no change in the quantities of the existing product mix would use it completely.

(g) The equipment purchase policies of industrial firms in India are sometimes affected by the import control policies of the government. The uncertainties regarding the import policy have prompted the management to buy certain machines:

⁴⁶Where different firms get a particular operation (service) done from a single entrepreneur, or a servicing centre, instead of installing the machine in their own production shop.

⁴⁷See, Table 5.1. Shaping machine is used only for the 9th product out of total ten in the list.

whenever import of the same is allowed, without any immediate need felt for it.⁴⁸

(h) In an interview with the production manager of a firm, it was stated that the firms purchase their capital assets with a sufficiently long perspective (about 5 to 6 years ahead). This leads to the existence of a much higher number of machines as compared to the requirements of the current production programme. Exigencies due to erratic demand⁴⁹ pattern sometimes compel the firms to have a number of machines of a 'stand-by' nature.

(i) Measures of unutilised machine capacities have an important bearing on the capital output ratios or capital coefficients⁵⁰ as these are sometimes referred to. These coefficients are often based on published data, either from the balance sheets of the firms or other statistics of an

⁴⁸ See, Appendix C at the end. As shown in that note, quite a large number of machine groups (81 out of the total of 148) were not used as far as the current production plan of the firm was concerned.

⁴⁹ As soon as the Indian rupee was devalued in 1966, the firm producing switchgears, studied for this work, got an order for a thousand units of petrol pumps. This was due to the fact that imported items of petrol pumps became costlier. The order, if accepted, was to be met from the same production shop.

⁵⁰ Here, the difference between the two terms relates to the level of aggregation of the capital stock used to calculate these ratios. In the term 'capital-output ratio', the total requirement of the capital stock for a particular output is calculated. The term 'capital coefficients' is used in the context of 'input-output tables and other disaggregative models'. Capital requirement of a particular output in this term is implied at a disaggregated level. Capital stock is usually classified in terms of an industry classification such as machine tools, electrical machinery, transport, equipment, diesel engines, and so on.

aggregative nature. It is obvious that in the case of firms which have a large idle machine stock, for one reason or the other, as discussed above; the measures of capital output ratios or capital coefficients are quite likely to get inflated. Thus, we get a higher estimate of the capital requirement for a particular industrial sector than is technically warranted.

(j) As Table 5.11 given earlier shows, it is possible to carry out a larger production programme (upto 200 to 300 per cent of the present output) with investment on a few machine groups only. This fact is quite important to be noted when decisions for expansion of the output of a particular industrial sector are taken.

5.8 S u m m a r y

In this chapter, an attempt was made to analyse in detail, the problem of unutilised capital resources of industrial plants. Two firms, one in the electrical fan industry and the other in the switchgear industry (two subgroups of electrical machinery industry) were studied for this purpose. This attempt revealed certain important aspects of the problem. It also helped in conceptualisation of industrial capacity and that of excess capacity.

Two broad types of measures of excess capacity have been defined. One is in terms of the difference between the actual output rate of a product-mix and capacity output rate (or in terms of such other indicators as profit, or value

added etc. as noted in the Section 5.4) of the same mix. The other is the difference between the capital stock being utilised for an output (either actual or optimum) and the total capital stock. The latter is more relevant while assessing some of the structural factors operating at the level of a firm, as mentioned in the foregoing paragraphs.

In the case of one of the firm studied for this work it was found that about 35 per cent of its machine capacities cannot be utilised even when the firm tries to minimise the total (cost of) idle machine time with the best choice of the relative quantities of the ten products on its list. Analysis of the capital structure (machines) of the other firm studied for this work shows that the firm can increase its output upto 200 to 300 per cent with investment on certain machine groups only. Some of the reasons for these results have been stated in the earlier pages.

CHAPTER 6

S U M M I N G U P

Four sub-groups of the electrical machinery industry in India viz. Motors, Transformers, Switchgears and Fans, have been studied. Certain important aspects of these four industries, particularly those which have a bearing on the problem of unutilised capacity (such as the supply of raw materials) have been looked into. This part of the study is mostly based on published statistics, reports and interviews.

An attempt has been made to analyse the capital structure (plant and machinery) and the nature and extent of unutilised capacity at the level of a firm, in these industries. This part is based on case studies of two firms belonging to Switchgear and Fan industries respectively. Published statistics regarding industries and various surveys on the problem of unutilised capacity show that a substantial amount (roughly between 15 and 57 per cent) of the capacity of these industries remained idle during the years 1961 to 1967. Studies made for the earlier period viz. 1950s also indicate the existence of unutilised capacity in a number of industries including the four considered here.

6.2 Motors, transformers, ^{and} switchgears ~~and fans~~ are important capital goods while fan is a durable consumer good. Each of these four industries could be fruitfully subjected to a separate study. Considerations like the availability of data, interlinkage on the demand side, common basic tech-

nical processes and others, however, lead to grouping them together for this work. An important objective of this study as indicated above is to analyse the unutilised resources of industrial firms. This seemed to transcend many particulars of these industries and together made them a workable group.

6.3 Electric fan industry was the first among the four (dealt with here) to be established in India, with the first factory set up in 1920 at Calcutta. Motor and transformer industries were established during the second world war. The manufacture of switchgears started around late 1950s. Motors, transformers and switchgears are manufactured in various ratings, designs and types. Motors, for instance, vary from those belonging to fractional horse power category (upto 1/1000th h.p.) to those with a few thousand horse power ratings. Those in the higher ratings and sizes are broadly referred to as heavy electricals while those in the lower ratings and smaller sizes, and light articles like fans are called light electricals.

6.4 Demand for motors, transformers and switchgears closely follows the power generating capacity in the country. Demand for fans follows mainly the electrification programmes and building construction activity in the country apart from other factors.

The economically utilisable hydroelectric power potential of the Indian Union is estimated to be 41.155 million

kW. According to the Energy Survey Commission's report (1965), the schemes for generating electricity that were in operation, under construction and whose investigation had been completed covered a total potential of about 11.6 million kW. A large untapped potential of hydro-electricity exists for exploitation in the future. India has limited resources of good coal and so far is yet known, only meagre resources of oil.

that
6.5. Published statistics show the electrical machinery industry (inclusive of all the subgroups) stood seventh by its share in the total value added by the manufacturing industries. Official surveys such as the 'Annual Survey of Industries' divide the units in the electrical machinery industry into large, medium and small scale units according to the size of the capital invested. Units having fixed capital of Rs. 5 lakhs and below are defined as small scale units. Those with fixed capital between Rs. 5 lakhs and 25 lakhs as medium and those above Rs. 25 lakhs as large-scale units. The large scale sector, on the basis of its share of the total fixed capital invested, number of persons employed and the total value added by ~~the~~ manufacture, is predominant in this industry.

6.6 According to the 'Industrial Policy Resolution' of the Government of India, the manufacture of heavy electrical machinery of different types is reserved for the public sector units. Exceptions are, however, being made to this

policy recently and some of the private units are being licensed to manufacture heavy electrical machinery.

6.7 The Heavy Electricals (India) Ltd. and the Bharat Heavy Electricals, Ltd. are the two public sector units operating in the Electrical Machinery Industry. Branches of the Bharat Heavy Electricals, Ltd. are spread in the different parts of the country. The production of the public sector units viz. that of the heavy electrical machinery is of a complex nature and involves many materials and technical processes. The skills involved are being built up through the training centres offering necessary training facilities situated around the manufacturing plants of these units. The design and manufacturing know-how is being acquired through collaboration agreements as well as through independent development programmes.

6.8 Foreign private investment in the electrical machinery industries amounted to Rs. 14.7 crores in December 1961. This amount is exclusive of the foreign investment in the public sector units. Direct investments formed a larger share of the total than the portfolio investments. Foreign companies mainly operate through their branches or subsidiaries in India. They also operate through collaboration agreements with Indian firms. The public sector units as well as many private units in the four industries considered here have collaboration agreements with the leading producers of electrical machinery abroad.

6.9 Imports of a certain range of output of motors, transformers, switchgears and almost a complete range of fans have been banned. Imports of fans especially that of parts and accessories are, however, allowed against exports of fans upto a certain percentage of the f.o.b. value of exports. Tariff protection has been granted to a sizeable range of production in these four industries. Reports of the Tariff Commission as well as the declarations regarding the Import Trade Control policy by the Government of India show that protection either in the form of import duties or import restrictions granted to these industries followed soon after the capacity for respective product groups was available in the country.

6.10 An important feature regarding these four sectors to be noted is the fast changing composition of the product-mix. This is not so much due to technological developments. Technology in all the four sectors is in fact of the nature of a 'transplant' from the advanced countries to this country. The changing product-mix is due mainly to the wider range of output in each sector that is being produced at present than was the case in the immediate past. Thus, in the case of switchgears we almost started with 'all imports' and 'no indigenous production' situation. In the case of transformers and motors the production was limited to a very limited range of smaller sizes, while in the case of fans it included only a few types. Production of

all these industries at present covers a much wider range. This process of diversification is going to continue perhaps at a faster rate than before as the capacity that has been created for almost a complete range of output required in this country is put to use.

Statistics regarding exports and imports of motors, transformers, switchgears and fans for the four selected years during 1950-51 to 1965-66 has been given in Chapter III. In the case of motors, transformers and switchgears, exports on a very minor scale started around 1960-61. In the case of fans, exports started a little earlier, around 1955-56. Except in the case of fans, however, there was no significant increase in the quantum of exports till 1965-66, for the rest of the product group.

6.11 In spite of the increase in productive capacity being available in the country, imports in the case of all the four product groups show a sizeable increase. In the case of motors, transformers and switchgears this is possibly due to the fact that indigenous manufacturing capacity is not yet capable of meeting the diversified demand for these three product groups created by the power development and electrification programmes and by the process of industrialisation. In the case of fan industry it is claimed that productivity^e capacity for almost^a complete range of fans is available in the country. Increase in the imports of this product is, therefore, difficult to explain.

6.12 Raw materials form an important item in the total

cost of production of the electrical products studied here. Materials consumed by the electrical machinery industries range from iron and steel, nonferrous metals like copper and aluminium, ceramics, rubber to modern plastics, Electrical sheet steel, copper strips and copper wires, various insulating materials, ball and roller bearings, are some of the important items of raw materials required.

6.13 There is a continued shortage of flat steel products like cold rolled grain oriented steel, electrical sheet steel etc. It is of vital importance that the existing steel plants produce flat steel products to their full installed capacity and in a quality which meets with the requirements of the industry. This is of special importance in the context of the delay in the Bokaro Steel Plant project. There are many instances where matching the production pattern of the existing steel plants to the changing demand pattern of the consuming industries will save a substantial amount of foreign exchange to the country.

6.14 India has to depend on imports to a large extent for the supply of non-ferrous metals except aluminium. In respect of imports of these metals from the countries abroad, it is necessary that India has direct contracts with the exporting countries like U.S.A., Chile, North Rhodesia, Congo, Japan and others. At present, the import

prices of these metals are determined at the 'London Metal Exchange'.

6.15 Another important problem in respect of the supply of certain raw materials is posed by the lack of standardization in the orders placed by the manufacturers of electrical machinery. An instance is porcelain bushings ordered by the transformer manufacturers. This leads to a long delivery period as every order has to be treated as a special order.

6.16 A substantial amount of progress has been made in respect of substitution of copper by aluminium in the case of wires and cables. In many other applications such as, new insulation materials, the substitution possibilities are yet to be fully explored.

6.17 Published statistics regarding the consumption of raw materials by the electrical machinery industries does not give a complete picture of the industries linked with it this way.

6.18 An important characteristic of the four industries studied here, which is really common to all modern industries, is the fact that efficient production is achieved through a network of supply relationships of another kind. Firms in a particular industry have to depend on a large number of other firms in different industries for steady supplies of components manufactured according to strict specifications. Firms supplying components are not always of an ancillary nature but may be large industrial units.

If this facility is lacking a firm has to go into the production of each part itself, or depend on an inefficient part producer, leading to either higher costs or to low quality output as the case may be. This fact has not received its due attention in both the development and tariff policies.

Insistence by the Government regarding domestic content regulations and concomitant import control regulations lead manufacturing concerns to duplicate too broad a spectrum of manufacturing capabilities, resulting in the overequipment of machinery. Instead the trade and development policies could be redirected towards a narrower, more efficient range of manufacturing activities. This re-orientation will require detailed studies of process wise inputs of skills, machinery and materials and availability of these in the country.

6.19 There is a large degree of overlap of processes, skills and capital equipment among the four industries studied here. Important machinery required in the electrical industries could be divided into four classes - (a) fabricating equipment which consists of machine tools and metal forming machines such as hydraulic and mechanical presses, etc., (b) cleaning, electroplating and materials heating equipment, (c) Assembling machines such as riveting machines, welding machines, etc. and (d) materials handling equipment such as cranes, hoists, industrial

trucks, etc. The most important among these by the numbers as well as value are those in the class (a) viz., machine tools and presses.

6.20 No published statistics regarding the inventories of capital equipment according to different types are available, not to speak of the inputs of machine time for different products in this industry. The table given in the Appendix D showing the inputs of machine time in the switchgear industry may be viewed as a beginning in this direction. Similar table for fans has been given in Chapter V.

6.21 For a disaggregative analysis of the unutilised resources (plant and machinery) of firms, two units belonging to the switchgear and fan industries respectively were studied. Linear programming technique has been used as a tool of analysis for this purpose. The exercises are based on engineering and technical data such as, inputs of machine time and machine capacities, as well as economic data. Linear programming technique helped to look into the problem of unutilised capacity by direct analysis of firms rather than depending on published statistics regarding the actual output and capacity output etc. Measures of capacity could be obtained under a variety of assumed conditions. These exercises throw light on certain important aspects of the measures of capacity as well as the nature of capital structure of the industrial firms.

6.22 There is not a single coefficient or a percentage which we can point out as the measure of unutilised capacity in the case of a multiproduct, multiequipment manufacturing plant. A variety of measures are possible and they are relevant in their proper context.

Given the product-mix for a firm, two types of measures of excess capacity are possible which themselves may vary with the changing assumptions. One is the difference between the actual output rate of the mix and a capacity output rate of the same mix.¹ The other is the difference between the capital stock being utilised for the output and the total capital stock. Both measures are equally important.

The latter measure is especially useful to find out a realistic estimate of the capital output ratio. Unutilised capital stock inflates the estimates of capital requirement for a particular output than is technically warranted.

6.23 Unused machine capacities do not appear because of the insufficient demand alone. These may occur because of the changes in the relative prices or costs which usually induce an entrepreneur to alter the relative quantities of the different products produced. The composition of the output (relative quantities of products made) is also determined by the objective pursued by the firm.

In the case of one of the firms studied for this work it was found that about 35 per cent of its capital stock cannot be utilised whatever the relative quantities of the

¹This comparison may be based on the total value added by the manufacture in the two situations, or, on the basis of other indicators as seen in Chapter V.

given products (on its list) the firm produces so as to maximise the utilisation of its machine capacities. Though some of the reasons responsible for this phenomenon have been discussed in Chapter V, comprehensive analysis in this respect is a subject of further research study. It may only be stated here that the reasons for these unutilised machine capacities have to be sought into the factors other than the lack of demand; or the shortage of raw materials which are usually mentioned as the causes of unutilised resources.

6.24 Theoretical planning models often proceed on the assumption that capital is scarce and labour abundant in the developing economies. This is too simplified an approach for many industries in these economies. Many subgroups of electrical machinery industry in India, for instance, require highly skilled and experienced personnel. Labour of this kind has been one of the scarcest factors of production and abundant unskilled labour is of little use to it. It requires substantial amount of additional ~~investment~~ investment to train the labour into the required degree of skill.

In the absence of such labour readily available, the alternative is to recruit semi-skilled labour which results in machines being run much below par as we saw in a table in the earlier Chapter V, giving the 'efficiency factors' of different machines.

It is sometimes assumed that skills, like plant and

machinery, are a direct result of investment (in say education). Planners only have to devote more resources to it. However, formal education although essential, may not be sufficient to insure the creation of skills that are most needed by an industrial enterprise.

APPENDIX A - A DETAILED LIST OF TECHNICAL PROCESSES IN THE
ELECTRICAL MACHINERY INDUSTRY

The list of technical processes given in the subsequent pages was used as a basis while coding and processing the technical data in the case of Firm 'B' manufacturing switch-gears and controlgears. A three digit code number was followed for each technical process while processing the data on the computer. Each process has been considered separately. The list has been given here as it shows the range of technical processes involved. It includes the manufacturing processes for almost all the products in the electrical machinery complex.

PROCESSES [BROAD GROUPS]	CODING SYSTEM		
A. CASTING PROCESSES	1	X	X
B. HEAT TREATING	2	X	X
C. WELDING AND ALLIED PROCESSES	3	X	X
D. HOT WORKING PROCESSES	4	X	X
E. POWDER METALLURGY (INCLUDING NON-METALLIC POWDERS)	5	X	X
F. MACHINING PROCESSES	6	X	X
G. COLD-WORKING PROCESSES (EXCLUDING MACHINING)	7	X	X
H. CLEANING, PLATING AND ORGANIC FINISHING OF METALS	8	X	X
I. ASSEMBLY, INSPECTION, TESTING AND OTHER OPERATIONS	9	X	X

A. CASTING PROCESSES 1 X X

Operation		Code Number		
I.	NON-METALLIC MOULD CASTING	1	1	X
	(i) Sand Mould Casting	1	1	1
	(ii) Plaster-of-Paris Castings	1	1	2
	(iii) Lost Wax Casting			
II.	METAL MOULD CASTING	1	2	X
	(i) Permanent Mould Casting	1	2	1
	(ii) Semipermanent Mould Casting	1	2	2
	(iii) Die Casting	1	2	3
	(iv) Cold Chamber Pressure Casting	1	2	4
	(v) Centrifugal Casting	1	2	5

B. HEAT TREATING 2 X X

Operation		Code Number		
I.	SOFTENING PROCESSES	2	1	X
	(i) Tempering	2	1	1
	(ii) Stress Relieving	2	1	2
	(iii) Normalising	2	1	3
	(iv) Spheroidizing	2	1	4
	(v) Annealing	2	1	5

Continued/

Operation		Code Number		
II.	HARDENING PROCESSES	2	2	X
(i)	Quench Hardening	2	2	1
(ii)	Martempering	2	2	2
(iii)	Austempering (Isothermal Treatments)	2	2	3
III.	CASE HARDENING PROCESSES	2	3	X
(i)	Nitriding	2	3	1
(ii)	Cyaniding	2	3	2
(iii)	Carbonitriding	2	3	3
(iv)	Gas Carburizing	2	3	4
(v)	Pačk Carburising	2	3	5
(vi)	Liquid Carburizing	2	3	6
(vii)	Induction Hardening	2	3	7
(viii)	Flame Hardening	2	3	8

C.	<u>WELDING AND ALLIED PROCESSES</u>	3	X	X
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Operations		Code Number		
I.	PRESSURE PROCESSES (Resistance Welding)	3	1	X
(i)	Seam Welding	3	1	1
(ii)	Spot Welding	3	1	2
(iii)	Upset Butt Welding	3	1	3
(iv)	Flash Butt Welding	3	1	4
(v)	Projection Welding	3	1	5

Continued/

Operations		Code Number		
II.	OTHER PRESSURE PROCESSES	3	2	X
	(i) Forge Welding	3	2	1
	(ii) Pressure Thermit Welding	3	2	2
III.	NON-PRESSURE PROCESSES (ARC WELDING)	3	3	X
	(i) Shielded, Atomic Hydrogen	3	3	1
	(ii) Shielded, Metal Arc	3	3	2
	(iii) Shielded Carbon Arc	3	3	3
	(iv) Unshielded, Metal Arc	3	3	4
	(v) Unshielded Carbon Arc	3	3	5
IV.	NON-PRESSURE PROCESSES (GAS WELDING)	3	4	X
	(i) Air-Acetylene	3	4	1
	(ii) Oxy-Acetylene	3	4	2
	(iii) Oxy-Other Fuel	3	4	3
V.	OTHER NON-PRESSURE PROCESSES	3	5	X
	(i) Thermit Welding	3	5	1
VI.	BRAZING PROCESSES (ELECTRIC BRAZING)	3	6	X
	(i) Arc	3	6	1
	(ii) Induction	3	6	2
	(iii) Resistance	3	6	3
VII.	OTHER BRAZING PROCESSES	3	7	X
	(i) Gas Brazing	3	7	1
	(ii) Furnace Brazing	3	7	2

Continued/

Operations	Code Number		
(iii) Dip Brazing Metal Bath	3	7	3
(iv) Dip Brazing, Chemical Bath	3	7	4
VIII. SOLDERING PROCESSES	3	8	X
(i) Soldering	3	8	1

D. HOT-WORKING PROCESSES 4 X X

Operations	Code Number		
I. EXTRUSION PROCESSES (HOT WORKING)	4	1	X
(i) Extrusion	4	1	1
II. FORGING	4	2	X
(i) Drop Forging	4	2	1
(ii) Machine or upset Forging	4	2	2
(iii) Smith Forging	4	2	3
(iv) Press Forging	4	2	4
III. OTHER HOT WORKING PROCESSES	4	5	X
(i) Rolling	4	5	1

Continued/

E.	<u>POWDER METALLURGY (INCLUDING NON-METALLIC POWDERS)</u>	5	X	X
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Operation		Code Number		
I.	BRIQUETTING OPERATION	5	1	X
	(i) Preforming	5	1	1
II.	MOULDING OPERATIONS	5	2	X
	(i) Injection Moulding	5	2	1
	(ii) Hot-Compression Moulding	5	2	2
	(iii) Transfer Moulding	5	2	3
	(iv) Extrusion	5	2	4
	(v) Blow Moulding	5	2	5
	(vi) Slush Moulding	5	2	6
	(vii) Cold Moulding	5	2	7
	(viii) Laminating	5	2	8
III.	OTHER OPERATIONS	5	5	X
	(i) Sintering	5	5	1

Continued/

F. MACHINING

6 X X

Operations	Code Number		
1. Boring	6	1	1
2. Broaching	6	1	2
3. Chamfering	6	1	4
4. Contouring	6	1	6
5. Counterboring	6	1	7
6. Countersinking	6	1	8
7. Cutting	6	1	9
8. Drilling	6	2	5
9. Die Sinking	6	2	6
10. Engraving	6	2	9
11. Facing	6	3	1
12. Gear Cutting	6	3	5
13. Grinding (Surface)	6	3	7
14. Grinding (Cylindrical)	6	3	8
15. Grooving	6	3	9
16. Honing	6	4	1
17. Jig Boring	6	4	3
18. Lapping	6	4	5
19. Milling	6	4	9
20. Flanishing	6	5	1
21. Notching	6	5	3
22. Reaming	6	5	5

Continued/

Operations	Code Number		
7. Coining	7	2	1
8. Cold Rolling	7	2	2
9. Crimping	7	2	3
10. Cut Off (including Cutting Sheets, Strips, etc.)	7	2	4
11. Crimp and Bend	7	2	5
12. Dinking	7	3	1
13. Drawing	7	3	2
14. Embossing	7	3	4
15. Enlarging	7	3	5
16. Embossing and Blanking	7	3	6
17. Embossing and Piercing	7	3	7
18. Embossing and Piercing and Blanking	7	3	8
19. Embossing, Notching and Cutting Off	7	3	9
20. Extrusion (Colding Working)	7	4	0
21. Fixing	7	4	1
22. Flanging	7	4	2
23. Flaring	7	4	3
24. Flaring and Embossing	7	4	4
25. Forming	7	4	5
26. Forming and Embossing	7	4	6
27. Forming and Piercing	7	4	7
28. Forging	7	4	8

Continued/

Operations	Code Number		
29. Heading	7	5	0
30. Hubbing	7	5	1
31. Knurling	7	5	3
32. Lancing	7	5	5
33. Marking	7	5	7
34. Piercing	7	6	1
35. Piercing and Blanking	7	6	2
36. Piercing, Flaring and Blanking	7	6	3
37. Piercing, Flaring, Blanking and Bending	7	6	4
38. Pierce and Cut Off	7	6	5
39. Punching	7	6	9
40. Riveting	7	7	1
41. Roll Forming	7	7	2
42. Seaming	7	7	5
43. Shaving	7	7	6
44. Shearing	7	7	7
45. Shell Drawing	7	7	9
46. Spinning	7	8	0
47. Stamping	7	8	1
48. Straightening	7	8	2
49. Stitching	7	8	3
50. Swaging	7	8	4
51. Swedging	7	8	5
52. Thread Rolling	7	9	1
53. Trimming	7	9	2
54. Upsetting	7	9	5
55. Wire Drawing	7	9	6
56. Combination of different operations on presses (not specified)	7	9	9

H. CLEANING, PLATING AND ORGANIC FINISHING OF METAL

	8	X	X
Operations	Code Number		
I. CLEANING PROCESSES	8	1	X
(i) Cleaning	8	1	1
(ii) Sand blasting	8	1	2
(iii) Shot Blasting	8	1	3
(iv) Tumbling	8	1	4
(v) Rolling	8	1	5
(vi) Burnishing	8	1	6
(vii) Cleaning and Shot Blasting	8	1	7
(viii) Deburring	8	1	8
(ix) Separating Oil, Swarf, etc.	8	1	9
II. PRETREATMENT PROCESSES	8	2	X
(i) Degreasing	8	2	1
(ii) Pickling	8	2	2
(iii) Complete Pretreatment Processing	8	2	9
III. ELECTROPLATING (BARREL)	8	3	X
(i) Silver Plating	8	3	1
(ii) Nickel Plating	8	3	2
(iii) Zinc Plating	8	3	4
(iv) Tin Plating	8	3	5
(v) Cadmium Plating	8	3	6

Continued/

Operations		Code Number		
IV.	ELECTROPLATING (VAT)	8	4	X
	(i) Silver Plating	8	4	1
	(ii) Nickel Plating	8	4	2
	(iii) Zinc Plating	8	4	3
	(iv) Chromium Plating	8	4	4
V.	OTHER METAL COATINGS	8	5	X
	(i) Calorizing	8	5	1
	(ii) Galvanizing	8	5	2
VI.	ORGANIC FINISHES	8	6	X
	(i) Asphaltic Painting	8	6	1
	(ii) Oil Painting and Enameling	8	6	2
	(iii) Finishing by Lacquers	8	6	5
	(iv) Polishing	8	6	4
I.	<u>ASSEMBLY, INSPECTION, TESTING AND OTHER PROCESSES</u>	9	X	X
Operations		Code Number		
I.	ASSEMBLY OPERATIONS	9	1	X
	(i) Winding	9	1	1
	(ii) Screwing	9	1	2
	(iii) Pasting	9	1	3
	(iv) Other Assembly Operations	9	1	9

Continued/

Operations		Code Number		
II.	INSPECTION	9	2	X
	(i) Inspection (at Various Stages)	9	2	1
III.	TESTING	9	3	X
	(i) Hydraulic Testing	9	3	1
	(ii) Pneumatic Testing	9	3	2
	(iii) Radiographic Testing	9	3	3
	(iv) Magnetic and Nonmagnetic Particle Testing	9	3	4
	(v) Electromagnetic Testing	9	3	5
	(vi) Supersonic Testing	9	3	6
	(vii) Chemical Testing	9	3	7
	(viii) Electrical Testing	9	3	9
	(ix) Other Tests and Retests	9	3	0
IV.	OTHER PROCESSES	9	5	X
	(i) Impregnation	9	5	1
	(ii) Material Heating	9	5	2

APPENDIX B. PRICES OF MACHINES IN A SWITCHGEAR MANUFACTURING PLANT

Description 1	Original Value Δ Rs. 2	Book Value as on 1-4-1966 Rs. 3
I. MACHINE TOOLS		
<u>Lathes</u>		
1. Herbert-Kirloskar Capstan Lathe	39,966	24,230
2. Alfred-Herbert Capstan Lathe	34,534	16,852
3. 'Traub' Automatic Lathe	23,794	7,135
4. 'Traub' Automatic Lathe	15,918	5,454
5. 'Bolley' High Speed Turret Lathe	22,635	11,009
6. 'Traub' Automatic Lathe	16,037 8,013	6,915 6,494
7. 'Traub' Automatic Lathe	12,545	5,644
8. Herbert Lathe	1,10,461	78,125
9. BMF High Speed Lathe	54,402	41,983
10. Indigenous Master Lathe	2,601	2,902
<u>Drilling Machines</u>		
11. Praga Drilling Machine	1,555	784
12. Praga 4 Spindle Drilling Machine	5,769	3,733
13. Praga 4 Spindle Drilling Machine	13,061	9,153
14. Pillar Drilling Machine	7,059	1,777
15. Praga Drilling Machine	1,648	877
16. Praga Drilling Machine	2,050	1,392

Continued/

Δ The manufacturing facilities were set up in 1959.

1	2	3
17. Praga Drilling Machine	2,002	1,193
18. 'Steinel' Single Spindle Drilling Machine	1,570	834
19. Herbert Single Spindle Drilling Machine	2,167	1,075
20. Herbert Spindle Drilling Machine	5,186	2,857
21. Herbert 4 Spindle Drilling Machine	38,571	22,362
22. Praga Drilling Machine	2,079	1,048
23. Praga Drilling Machine	1,957	1,097
24. Herbert Four Spindle Drilling Machine	91,497	59,358
25. Investa Drilling Machine	15,528	9,325
26. Bluthardt Single Spindle Drilling Machine	27,082	15,888
27. Praga Drilling Machine	3,157	2,029
28. Praga Drilling Machine	3,973	2,971
29. Praga Drilling Machine	1,957	1,220
30. Praga 4 Spindle Drilling Machine	1,556	661
31. Praga Drilling Machine	8,418	5,811
32. Praga Drilling Machine	1,648	876
33. Praga 4 Spindle Drilling Machine	19,287	13,334
34. Drilling Machine	11,001	7,031
35. Praga Spindle Drilling Machine	17,791	12,126

Continued/

1	2	3
36. Praga Drilling Machine	15,656	10,582
37. Herbert Drilling Machine	29,822	22,554
38. Herbert Drilling Machine	34,842	26,218
39. BMF Radial Drilling Machine	74,757	55,748
40. Kerry Super 8 Speed Drilling Machine	1,747	1,415
41. 2 Nos. Khertone Super Drilling Machine	3,777	3,059
42. 3 Nos. Kerry Super Drilling Machine	7,047	5,832
43. Kerry Super Drilling Machine	1,794	1,534
<u>Grinding Machines</u>		
44. Reliance Drill Grinding Jig No.3	325	239
45. Morrisflex Flexible Grinder	1,710	848
46. Wolf H.D. Portable Grinder	452	238
47. Wolf GO4 4" Elec. Grinder	452	238
48. Morrisflex Flexible Shaft Grinder	1,710	794
49. Scholls Abrasive Cut-off Grinder	5,409	2,682
50. NEI Bench Grinder	469	232
51. Rumanian Double Ended Grinder	3,317	1,514
52. Reichle Vertical Spindle Surface Grinder	12,104	4,047
53. Prolifix Belt Grinding Machine	1,979	935
54. Diskus Surface Grinder	45,290	21,385
55. Svend Hydraulic Surface Grinder	12,495	5,690

Continued/

1	2	3
56. NEI Bench Grinder	469	232
57. NEI Bench Grinder	469	232
58. Tool Grinding Machine	25,113	16,033
59. Excello Style Surface Grinding Machine	27,833	17,987
60. Single Spindle Grinding Machine	31,495	24,596
61. NEI Double Bench Grinder	761	519
62. 21 Nos. Bicycle Grinders	29,221	21,271
63. Victor Belt Grinder	750	581
64. Horizontal Spindle Surface Grinder	15,967	12,365
65. Bicycle Grinder (in Transit)	11,385	11,385
<u>Tapping Machines</u>		
66. Ultromati Tapping Machine	6,570	3,773
67. 'Remit' Tapping Machine	984	614
68. 'Remit' Tapping Machine	955	626
69. 'Remit' Tapping Machine	955	626
70. Precise Tapping Machine	2,071	1,510
71. 'Remit' Tapping Machine	1,465	1,186
<u>Milling Machines</u>		
72. Lud and Loewe Milling Machine	61,950	40,649
73. Lud and Loewe Milling Machine	37,937	23,794
74. 'XLO' Ram Turret Milling Machine	29,838	26,854
75.		Continued/

	1	2	3
<u>Other Machine Tools</u>			
75. Morris 1/2 Ton Elevating Truck		546	352
76. 'Goliath Bar Bending Machine		552	234
77. 'Rems' Pipe Cutting Off Machine	2,667		1,726
78. 'HMV' Threading Machine		13,280	5,638
79. 'Hirt' Rod Pointing Machine		2,437	1,576
80. 'Traub' Swarf Separator		4,108	2,183
81. 'Wagner' Threading Machine		8,285	2,370
82. 'Pehaka' Band Saw		15,986	7,765
83. Punching Machine		1,411	947
84. 'Traub' Screw Slitting Machine		1,221	635
85. Circular Screw		1,192	601
86. Unitcut Abrasive Wheel		2,200	1,410
87. Flexible Shaft Machine		3,038	1,931
88. Worm Reduction Gear Unit		670	463
89. Kilburn Printing Machine		1,881	1,582
90. Shaping Machine		1,818	1,399
91. Morrisflex Machine		1,873	1,364
92. Unicut Abrasive Cut Off Machine	2,826		2,070
93. Thermal Relay Winding Machine	15,007		11,548
94. Petit Drafting Machine		808	622
95. 12" La#pmaster Lapping Machine	1,465		1,186
96. Garlick Band Saw		3,222	2,755

Continued/.

	1	2	3
II. P R E S S E S			
<u>Power Presses</u>			
97. 'Weingarten' Power Press		2,90,787	1,84,606
98. 'Weingarten' Power Press		2,15,213	1,34,176
99. 'Paul-Muller' Power Press		1,80,185	1,13,797
100. Ameteeep Power Press		1,15,439	84,239
101. Ameteeep 40 Ton Power Press		44,094	26,940
102. Ameteeep Power Press		59,424	40,026
103. Ameteeep Power Press		49,796	32,750
104. 2 Nos. Ameteeep Press		42,862	34,390
105. Pneumatic Power Press		4,219	3,469
106. Russian Power Press		14,034	8,149
<u>Hydraulic Presses</u>			
107. 'Muller' Hydraulic Drawing Press		1,07,805	55,848
108. 'Result' Hydraulic Press		28,514	16,731
109. 'Muller' Hydraulic Press		13,557	16,731
110. Bracker Hydraulic Single Column Press		29,166	19,831
111. Mills Hydraulic Press		41,171	30,826
112. Hydraulic Pedestal Press		28,485	21,346
113. 25 Ton Hydraulic Press		5,298	4,126
114. Hydraulic Press		29,094	23,655
<u>Other Presses</u>			
115. Arbor Press		180	125
116. 'Drabert' Guillotine Shearing Machine		46,766	24,862

Continued/

	1	2	'3
117. 'John and Blund' Bakelite Press		79,236	43,569
118. Refix Pipe Bending Machine		2,550	1,885
119. Cradle for Weingaerten Press		1,370	1,110
120. Indian Make Footlever Press		836	609
121. Doam 50 Ton Press		2,393	1,745
122. 4 Nos. Strip Bending Machine		5,383	4,143
123. 2 Nos. German Make Hand Sheer		764	661
124. Arbor Press		404	364
125. Guillotine Power Sheer		30,393	24,619
126. 2 Nos. Deem 5 Tons Pun#ching Press		4,193	3,057
III. <u>MOULDING MACHINES</u>			
127. Fabrication of Moulding Machine		331	206
128. Moulding Machine		2,031	1,332
IV. <u>MACHINES FOR CLEANING, PRETREATMENT AND OTHER PROCESSES</u>			
129. Tumbling Barrel		1,848	1,196
130. LK Electric Drying Oven		940	847
131. Dust Collector		2,963	2,533
132. Mild Steel Hot Rinsing Tank		656	424
133. Phosphetising Tank		1,607	1,118
134. Cold Rinsing Tank		683	433
135. Solvent Degreaser		15,593	8,287

Continued/

1	2	3
136. M. S. Tumbling Barrel	1,950	1,408
137. Mild Steel Cold Rinsing Tank	1,201	906
138. 3 HP MMM Polishing Motor	7,937	5,436
139. Table with Dust Extractor	289	190
140. Guyson Shotblast Cabinet	5,580	4,431
141. Dust Exhaust Unit	4,409	3,571
142. Degreasing Tank for Paint Shop	18,148	16,878
143. 1 No. Pickling Tank	1,893	1,760
144. Pretreatment Plant	13,094	9,540
145. Mild Steel Pickling Tank	631	439
146. Mild Steel Pickling Tank	630	439
147. Blower for Pretreatment Plant	3,843	3,112
V. <u>ELECTROPLATING EQUIPMENT</u>		
148. 3 Nos. Selenium Metal Electroplating Rectifiers	4,726	4,253
149. Heaters and Thermostats for Tanks	8,010	5,378
150. 2 Nos. Sludge Collecting S.S. Tanks	1,855	1,605
151. M. S. Cold Heating Tanks	3,537	2,901
152. 2 Nos. Heating Tanks	3,537	2,901
153. Sulphuric Acid Tank	8,589	6,989
154. Hot Cathodic Tank	1,900	1,767
155. 7 Nos. Cold Rinsing Tanks	2,924	2,720

Continued/

	1	2	3
156. 1 No. Silver Strike Stand		735	684
157. Silver Plating Tank		1,228	1,142
158. Hot Water Rinsing Tank		975	907
159. Neutralising Tank		418	389
160. Silver Stripping Tank		557	518
161. Silver Tank		943	877
162. 9 Nos. Cold Water Rinsing Tank		7,683	7,145
163. 1 Anodic Cleaning Tank		1,898	1,766
164. 1 Neutralising Tank		854	794
165. 8 Nos. Cold Water Rinsing Tank		6,829	6,351
166. 1 No. Hot Cathodic Degreasing Tank		2,780	2,585
167. 5 Nos. Zinc Plating Tanks		10,680	9,932
168. 1 No. Acid Dip Tank		1,112	1,034
169. 4 Nos. Nickel Barrel Tanks		11,009	10,238
170. 2 Nos. M. S. Hot Water Tanks		5,383	5,006
171. 1 No. Nickel Stripping Tank		1,415	1,316
VI. <u>MACHINES FOR WELDING AND ALLIED PROCESSES</u>			
172. Rocketarc arc welding transformer		2,276	1,214
173. Spot Welding Machine		28,151	20,706
VII. <u>PAINTING EQUIPMENT</u>			
174. Hohn and Kolb Spray Painting Gun		884	584

Continued/

	1	2	3
175. 6 Nos. Spray Painting Guns		4,800	3,340
176. Paint Storage Tank		312	225
177. Spray Painting Cabin		2,652	1,748
178. Spray Painting Booth		3,324	2,159
179. 'Kilburn' Paint Stoving Oven		24,000	15,079
180. 7 Nos. Paintshop Cages		1,265	982
181. Spray booth with exhaust system for Petrol Pump		1,656	1,416
182. Spray Painting Cabin		4,437	3,568
VIII. <u>ASSEMBLING AND OTHER MACHINES</u>			
183. 'Steinel' Reveting Machine		4,919	2,995
184. 'Douglass' Coil Winding Machine		12,920	6,660
185. Winding Machine for Thermal Relay		7,006	3,723
186. Kleertone Coil Winding Machine		525	472
IX. <u>TESTING EQUIPMENT</u>			
187. Impulse Testing Set		943	657
188. Load and Junction Testing Set		2,640	1,773
189. Test Stand for Petrol Pump		636	411
190. TUA Serge Insulating Testing Set		3,126	1,451
191. Electronic Coil Tester		695	484
192. Temporary Rise Test Bench		2,875	2,151
193. Testing Apparatus for Coils		2,054	906

Continued/

	1	2	3
194. Zenith Insulating Testing Unit	1,456		739
195. Single Register Impulse Counter	326		212
196. Megger Earth Tester	1,040		517
197. 'Kocour' Electroplating Tester	5,085		2,701
198. Erichson Cup Testing Machine	7,060		3,279
199. Calibration Bench for Thermal Relays	2,961		2,073
200. Calibration Bench for Thermal Relays	1,073		601
201. Test Panel for Petrol Pump Motor	557		451
202. HP 250 Hardness Tester	6,174		3,906
203. Cam Operated Switch Testing Bench	226		203
204. Meter Test Stand	1,988		1,784
205. Chamber for Salt Spray Test	2,918		2,183
206. 2 Nos. High Voltage Breakdown Tester	1,485		1,143
207. 2 Nos. Cone Diamond Hardness Tester	602		488
208. Spring Testing Machine	5,266		4,268
209. LK Thermostatically Controlled Oven	800		648
210. 'Garlic' Pressure Test Pump	768		689
211. 1 No. Casellas Air Meter	1,030		924

X. OTHERS

212. 20 Nos. Transport Trolleys	7,446		4,998
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Continued/

1	2	3
213. Portable Temperature Indicators	662	412
214. 2 Pneumatic Screw Drivers	918	498
215. Rollers Fitted with 2 ball bearings	4,800	3,106
216. 'Morris' 1/2 ton elevating truck	547	367
217. 2 Nos. Centrifugal Dryers	7,373	6,304
218. M.S. Ventilation Riser	242	153
219. 'Moulison' Vertical Siren	959	509
220. Mandrills	1,132	742
221. Pygmy Hand Pallet Truck	1,544	1,335
222. Reliance Drill Grinding Jig No. 3	325	239
223. Switchboard Assembly Trolley	2,433	1,748
224. Trolley for Scrap material	539	403
225. 2 Nos. Paint Shop Conveyor Cage	562	406
226. P.V.C. Plant - 0549	913	684
227. 3 Nos. 'Jyoti' Coolant Pumps	794	481
228. Kirloskar 5 HP Elec. Motor	665	352
229. 'Buffalo' Factory Ventilation Fan	17,128	9,608
230. 'Buffalo' Exhaust Fan	5,480	3,084
231. Exhaust Fan	1,971	1,109
232. Exhaust Fan for Paint Shop	1,741	976
233. 'Buffalo' Exhaust Fan 30	2,210	1,250
234. 7 Nos. Ventilation Ducts	12,531	9,135

Continued/

1	2	3
235. GSC Ring Mounted Propeller Fan	463	259
236. BVC 24 " Dia. Diaphragm Mounting Fan	704	417
237. Electric Hoist	4,076	2,456
238. IAT Overhead Monorail Conveyor	1,910	1,201
239. 'Wolf' Pneumatic Impact Wrench	1,338	866
240. 'Titan' Elec. Hoist, 1500 Kg.	2,711	1,367
241. 'GEPA' Oil Centrifuge	2,060	1,333
242. 'Obel' High Frequency Heater	3,597	1,815
243. 'Obel' High Frequency Heater	3,597	1,816
244. Rubber Lined Tank	896	624
245. 'Kilburn' Drying Oven	4,342	2,455
246. GEC Exhaust Fan	648	404
247. GEC Exhaust Fan	648	404
248. Electric Hoist	7,408	5,400
249. Chain Pulley Block	1,000	656
250. Chain Pulley Block	974	639
251. Jib Crane	287	198
252. 3 Nos. Exhaust Fans	1,987	1,448
253. Kirloskar Motor	1,071	781
254. Wolf Portable Electric Drill	464	304
255. Wolf Portable Electric Drill	546	358
256. Morris 1/2 Ton Geared Pulley Block	485	346

Continued/

1	2	3
257. Morris 1/2 Ton Cap. Elevating Truck	556	447
258. Malik Electronic Coil Connector	835	608
259. 3 Nos. Elevating Trucks	1,651	1,328
260. Aerial Flow Fan	2,140	1,647
261. Bajaj Kaycee Heat Sealer	585	500
262. 2 Nos. Morris 1/2 ton elevating truck	1,101	919
263. Morris 1 ton balanced spurgear pulley block	759	576
264. Morris Spur Gear Pulley Block	558	425
265. 1 No. High Frequency Sets	4,679	3,411
266. 1 No. Vibrating Machine	889	684
267. 2 Nos. Dieselectric Heaters	3,826	3,100
268. 1 No. Hoist Operated Basket	663	545
269. Trolley for 1/2 ton Jib Crane	869	713
270. Trolley for Inspection Dept.	1,088	895
271. Switchboard Assembly Trolley	2,949	2,424
272. Monorail with 3 ton elec. hoist	1,956	1,505
273. Buffalo Fan	1,074	870
274. 2 Nos. K type Fans	1,384	1,111
275. Walkie Steaker	23,451	17,912
276. Crown Lift Truck	14,514	11,168
277. 3 Nos. Elevating Truck	1,668	1,392
278. 1 No. Platform Truck	4,788	3,879

Continued/

1	2	3
279. 1 No. Obel High Frequency Heater	3,493	2,830
280. Battery Charger - Westinghouse	2,700	2,187
281. Battery Charger	1,950	1,579
282. 2 Nos. Dielectric Heaters	5,119	4,146
283. Magnotool drilling device	1,512	1,225
284. 2 Nos. Garlick Electric Hoists	16,060	13,009
285. 2 Nos. 'Pigmy' Pallet Trucks	3,077	2,862
286. 2 Nos. 'Bieco' 20 HP Induction Motors	4,500	4,050
287. Hyster Reach Truck	34,611	28,035
288. Jumbo Platform Truck	12,485	10,112
289. Suspension Stand for Pneumatic nut runner	742	666
290. 2 Nos. Russian make elec. Hoists	6,255	5,348
291. 3 Nos. Pigmy model 1000 hand pallet truck	4,631	4,156
292. 3 Nos. Reversible Heavy Duty Wrench	4,557	3,896
293. Wolf Portable Drill	506	433

ADDITIONS DURING 1965-66

Description	Date of Purchase	Original Value	Book Value as on 31-3-1966
1	2	3	4
<u>(1) Lathes</u>			
1. P 0803 MK Harihar Lathe	July 1965	9,311	8,380
2. C-29 'Herbert' Senior Monoslide Capstan Lathe	Aug. 1965	59,727	54,054
3. G-28 Herbert Capstan Lathe	Oct. 1965	34,445	32,723
<u>(2) Drilling Machines</u>			
4. P 0830 'Dumore' Automatic Drill-M-tap Machine	Dec. 1965	7,881	7,487
5. P 0829 'Dumore' Automatic Drill-M-tap Machine	Dec. 1965	7,881	7,487
6. 65-056 to 059 Wolf/Portable Drilling Machine	Feb. 1966	1,051	4
7. D 95 Herbert 4 Spindle Drilling Machine	Nov. 1965	30,431	28,909
8. D-971 Herbert 4 Spindle Drilling Machine	Nov. 1965	30,431	28,909
9. D-101 Herbert 'M' Multiple Spindle Drilling Machine	Nov. 1965	18,762	17,824
10. D-100 Herbert 'M' Multiple Spindle Drilling Machine	Nov. 1965	18,761	17,823
11. 'Herbert' 4 Spindle Drilling Machine	Feb. 1966	29,273	27,809

Continued/

	1	2	3	4
<u>(3) Grinding Machines</u>				
12. Grinding Fixture		Jan. 1966	1,935	1,810
13. J and S Grinding Machine P-0783		April 1965	21,547	19,010
14. G-61 NEI Bench Grinder		Sept. 1965	515	1
15. G-58 'Osmond' Abrasive Cut-off Grinder		Sept. 1965	6,475	5,698
16. G-59 Surface Grinder Model 1011		Oct. 1965	54,470	51,202
<u>(4) Other Machine Tools</u>				
17. Wire Stitching and Cutting Mechanism		Mar. 1966	823	823
18. T-124 Pitch Controlled Tapping and Threading Machine		Dec. 1965	9,153	8,695
19. T-120 WMW Automatic Tapp- ing Machine		Dec. 1965	6,110	5,804
20. T-121 WMW Automatic Tapp- ing Machine		Dec. 1965	6,111	5,805
21. T-122 WMW Automatic Tapp- ing Machine		Dec. 1965	6,111	5,805
22. T-123 WMW Automatic Tapping Machine		Dec. 1965	6,111	5,805
23. 'BSA' No. 1 Automatic Tapp- ing and Threading Machine		March 1966	9,992	9,992
24. 'BLISS' No. 319 Trimming, Bending Machine		March 1966	26,288	26,288
25. 'WMW' Automatic Tapping Machine		Dec. 1965	12,597	11,967
26. Edel Turret Punching Machine 1 No. Attachments for Auto- matic Feeding of Power Press		In transit	37,361	37,361

Continued/

1	2	3	4
<u>(5) Pretreatment processing Machines</u>			
27.	Pretreatment Tanks	Nov. 1965	14,522 13,796
<u>(6) Presses</u>			
28.	P-165 'Ameeteep' 20 Tons, Power Press	Nov.1965	6,424 6,103
29.	P-164 'Ameeteep' 20 Tons, Power Press	Nov. 1965	7,181 6,822
30.	P-166 WMW Hydraulic Bake- lite Moulding Press	Aug. and Sept. 1965	20,448 18,403
31.	45-725 Godrej Eccentric Power Presses	March 1966	38,282 38,282
32.	WMW Bakelite Moulding Press - B-167	Dec. 1965	28,757 27,319
33.	B 168 WMW Bakelite Mould- ing Press	Dec. 1965	28,758 27,320
34.	B 169 WMW Bakelite Mould- ing Press	Dec. 1965	28,767 27,329
35.	'Kargas Hammer' repeating Power Press	Nov. 1965	1,13,891 1,08,198
36.	HP-127 WMW Hydraulic Bench Press	Dec.1965	5,393 5,123
37.	Aut. Bakelite Moulding Press - 3 Nos.	In transit	43,320 43,320
<u>(7) Electroplating Equipment</u>			
38.	S.S. Sulphuric Acid Tank	Mar. 1966	8,847 8,847
39.	S.S. Tanks	Oct. 1965	5,263 5,000
40.	S.S. Sulphuric Acid Tank	May 1965	5,922 5,330

Continued/

1	2	3	4
41. S.S. Sulphuric Acid Tank	March 1966	3,856	3,856
42. S.S. Tank for Sulphuric Acid	Oct. 1965	6,878	6,534
43. Chilling Plant for Electroplating Shop	Oct. 1965	20,799	19,759
44. Various Equipments for Electroplating Shop	Sept. 1965	1,53,143	1,37,829
<u>(8) Painting Equipment</u>			
45. S.S. Cage for Paint Shop	June 1965	551	1
46. M.S. Tank for Paint Shop	July 1965	8,929	8,036
<u>(9) Machines for Welding and Allied Processes</u>			
47. Gas Brazing Apparatus	Oct. 1965	301	1
48. Malik Type AMAR Spot Welding Machine	June 1965	3,491	3,142
49. P 0786 Pear Model Spot Welder	June 1965	22,868	20,618
<u>(10) Moulding Machines</u>			
50. WMW Hydraulic Moulding Press	Sept. 1965	19,787	17,808
<u>(11) Assembling and other Machines</u>			
51. Timer Coil Winding Mechanism	Feb. 1966	995	945
52. P.0797 Douglas Multi-Winder	June 1965	15,089	13,580
<u>(12) Testing Equipment</u>			
53. Meter Testing Stand	June 1965	370	1
54. Vibrator Machine for RRC Fuse Shop	Feb. 1966	969	921
55. C.T. Testing bench	March 1966	2,354	2,354

Continued/

	1	2	3	4
56. M.V. Contact Testing Bench		Sept. 1965	4,546	4,091
57. Test Bench for Combination Starter		Mar. 1966	1,810	1,810
58. Fuse Testing Bench		Sept. 1965	7,283	6,773
59. I 317 High Voltage Testing Set		Dec. 1965	1,800	1,710
60. I 320 High Voltage Testing Set		Jan. 1966	1,800	1,710
61. 'Philips' Universal Measuring Instrument		March 1966	282	807
(13) <u>Others</u>				
62. 1/2 Ton Radial Jib Crane		Nov. 1965	1,143	1,086
63. Paintshop Conveyor Cage		July 1965	757	681
64. 2 Nos. Overhead Cranes for Casting Stores		July 1965	20,526	18,473
65. 'Therelek' Hot Air Drying Oven		July 1965	7,576	6,818
66. EP-789 'Therelek' Hot Air Drying Oven		July 1965	7,576	6,818
67. EP-788 'Therelek' Electric Oven		May 1965	7,752	6,977
68. NP-604 'Buckaya' Pneumatic Reversible Impact Wrench		June 1965	1,678	1,510
69. P 192 Jyoti Centrifugal Pumping Set		Dec. 1965	1,226	1,165
70. Bicycle Generator Set 1 No.		In transit	1,67,783	1,67,783

TOOLS ATTACHED TO VARIOUS PLANT AND MACHINERY DURING 1965-66

Description of the machines	Date of Purchase	Original Value of the tools attached	Book value as on 1-4-1966
1	2	3	4
1. 'WEINGARTEN' Power Press 63 tons	July 1965	8,923	8,031
2. 'AMEETEEP' Power Press 40 tons	Nov. 1965 Dec. 1965	1,047 5,008	5,753
3. 'AMEETEEP' Power Press 40 tons	Dec. 1965 Jan. 1966 Nov. 1965	1,888 2,062 1,342	5,028
4. 'PAUL MULLER' Power Press 45 tons	June 1965 Sept. 1965 Aug. 1965	2,116 2,260 1,899	5,647
5. 'AMEETEEP' Power Press 20 tons	May 1965 June 1965 Oct. 1965	1,100 1,960 2,461	5,092
6. 'AMEETEEP' Power Press 20 tons	Sept. 1965 Aug. 1965 Nov. 1965	1,938 1,878 2,524	5,832
7. 'AMEETEEP' Power Press 20 tons	Mar. 1966 Jan. 1966	4,776 3,945	8,524
8. 'AMEETEEP' Power Press 20 tons	Jan. 1966	6,955	6,607
9. 'AMEETEEP' Power Press 20 tons	March 1966 Dec. 1965	5,720 1,274	6,931
10. 'OSMOND' Cut-off Grinder	Sept. 1965 Jan. 1966	3,182 1,262	3,987
11. 'LUD AND LOEWE' Milling Machine	June 1965	2,633	2,370
12. 'MILLS' Hydraulic Press 30 tons	July 1965	1,755	1,579
13. J and L Bakelite Moulding Press 60 tons	Oct. 1965	7,874	7,481

Continued/

1	2	3	4
14. WMW Bakelite Moulding Press 63 tons	Dec. 1965	7,478	7,104
15. WM ^w Bakelite Moulding Press 100 tons	Dec. 1965	4,004	3,804
16. Bakelite Moulding Press 100 tons	Mar. 1966	5,034	5,034
17. Bakelite Moulding Press 100 tons	Mar. 1966	4,297	4,297
18. WMW Bakelite Moulding Press 63 tons	Oct. 1965	4,875	4,631
19. 'AMEETEEP' Power Press 20 tons	Oct. 1965	883	839
20. 'HERBERT' 2 Spindle Drilling Machine	July 1965	900	810
21. Bracket Hydraulic Press 10 tons	July 1965	1,608	1,447
22. 'PRAGA' 1/2" 4 spindle Drilling Machine	Nov. 1965	970	921
23. 'MULLER' Hydraulic Press 100 tons	Dec. 1965	1,996	1,896
24. 'AMEETEEP' Power Press 40 tons	March 1965	4,191	4,191
25. 'AMEETEEP' Power Press 40 tons	March 1966	3,891	3,891
26. 'WEINGARTEN' Power Press 100 Tons	March 1966	6,172	6,172
27. 'AMEETEEP' Power Press 20 tons	March 1966	5,876	5,876
28. Pneumatic Power Press	Dec. 1965	7,282	6,918
29. CP 30008 Pneumatic Screw Drivers (6 Nos.)	Jan. 1966	4,318	4,167
30. Pneumatic Operated Screw Drivers (2 Nos.)	Jan. 1966	3,406	3,287

APPENDIX C. A NOTE ON THE CONSTRUCTION OF THE TABLE SHOWING THE STANDARD TIME OF DIFFERENT MACHINES REQUIRED IN THE FABRICATION OF SWITCHGEARS (LIGHTER EQUIPMENT) - THE SIMPLEX TABLEAU, FIRM 'B'

Introduction

This note deals with the construction of the table (Simplex Tableau) used for the linear programming analysis of Firm 'B' in the Switchgear Industry. It shows the standard time of different machines required for each of the hundred and thirty products produced by the firm, and the time of different machines available per week.

Considerable spadework was necessary before actual linear programming exercises could be attempted as all the time data were available for basic parts or components. Requirements of machine hours for final products had to be compiled with the help of 'component records' and information obtained from 'job orders' and other files maintained in different departments of the firm (plant).

In the case of many industries belonging to the metal working complex, the researcher who attempts disaggregative analysis of the kind undertaken in this study, is likely to face a similar problem regarding data. As the basic technical processes in many industries of metal working complex are similar, the procedure outlined in the subsequent pages may prove a useful reference.

The note begins with a survey in Section I of the data

collected from different records in the manufacturing plant. Sections II and III deal with the compilation of productwise requirements of parts and subassemblies and productwise requirements of machine hours, respectively. The formulation of linear programming problem is described in Section IV.

I

THE DATAComponent Records

This is a file which records the requirements of parts and subassemblies in an assembly. The assembly itself may be a final product which is sold or an intermediate product which forms a part of the final product. A typical page in this file gives the following information.

Assembly

SS 90035 ¹	contains -	Qty-Units
	SS 40004	1
	SS 40005	1
	SS 90023	1
	SS 90042	1
	SS 00174	1

It means that a unit of SS 90035, an assembly, requires one unit each of SS 90023 and SS 90042, both being sub-assemblies

¹This and the subsequent five digit figures starting with two alphabets are the code numbers of assemblies and parts. The code number for an assembly starts with '9' as its first digit.

and one unit each of SS 40004, SS 40005 and SP 00174, all being basic parts. This information will also be available for SS 90023 and SS 90042; for the subassemblies which go into these two assemblies, and so on.

The data from component records are transferred to cards punched for all assemblies and subassemblies (including end products) as shown in the card design (see card code No.001, page 270).

Digits 1 to 3 - represent card number

Digits 4 to 12 - represent assembly/subassembly. Digits 4 and 5 represent series which is also represented by digits 6 and 7 in terms of alphabets. The 8th digit (in the field 4-12) will always be 9 for an assembly (as distinguished from loose parts).

Each assembly requires subassemblies and loose parts.

Digits 34-41 - represent the quantity of the subassembly or a loose part required for the assembly.

Digits 43-51 - represent the code number for the sub-assembly or part.

For each assembly there will be as many cards in the 001 card file, as the number of different subassemblies and parts required for the particular assembly mentioned in the component record.

Resource Requirements

This part of the data gives the machine time for all manufactured parts. Technical coefficients or elements in

the Simplex tableau are based on these data. This information was punched on cards in the following way (see card code No. 002, page 270).

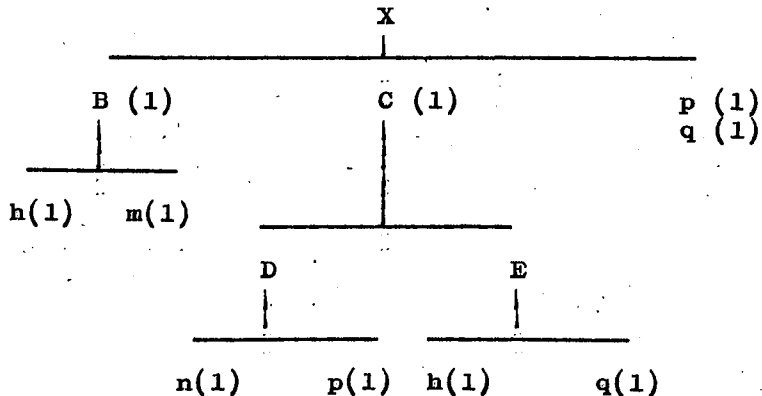
- Digits 1 - 3 - represent card number.
- Digits 4 - 12 - represent component (i.e. an assembly or a part) code number.
- Digit 13 - represents the category, i.e. whether the item is manufactured, imported, purchased or obsolete.
- Digits 14 - 17 - represent the department code.
- Digits 18 - 19 - represent the serial number of operation performed on the component.
- Digits 20 - 22 - represent the type of operation (see, Appendix-A) performed.
- Columns 33-37 - represent the code number of the machine.
- Columns 38-44 - give the machine milli hours required for hundred units of the components.

Machine time is in terms of standard milli hours for a batch of hundred units. In the case of some parts and assemblies, standard time was not available for some operations and resort had to be taken to 'estimate of time' mentioned in the cost cards.

II

COMPILATION OF PRODUCTWISE REQUIREMENTS OF PARTS AND ASSEMBLIESProcessing the Component Records

The component record, i. e. the 001 card file was processed on the computer so as to get the requirements of manufactured, purchased and imported components for each of the end products. Following example of a hypothetical end product 'X' should give a rough idea of the problem² involved. The diagram given below is a bar chart for product 'X'. It shows at a glance parts and subassemblies that go to form the end product 'X'.

BAR CHART FOR THE END PRODUCT 'X'

Here, X, B, C, D and E are assemblies; h, m, n, p and q are loose components. The numbers in the brackets show

²For the computer formulation of the problem, see "IBM 1620, SORT-MERGE PROGRAMME".

the units required of each item for one unit of 'X'.

'X' is a final product which is assembled out of two subassemblies B and C, and the loose components p and q. Assembly C is further composed of two subassemblies D and E.

The problem essentially consists in searching the major assembly 'X' with the help of component records down through the subassemblies B, C, D and E upto the basic parts. The similar parts are then merged together and totals are taken for each. The requirements of the product X will be written as follows:-

Product	Subassembly/ Component	Quantity
X	X	1
	B	1
	C	1
	D	1
	E	1
	h	2
	m	1
	n	1
	p	2
	q	2

When all the hundred and thirty final products are considered, the requirements can be written in a matrix form as shown below (see, p. 274).

The requirements of the product X (let us consider it as one of the 130 products in the matrix 'A'), contains X itself along with other subassemblies and parts. This is because of the fact that matrix 'A' has been conceived as a step in arriving at the productwise requirements of machine time. Assembling of two subassemblies B and C along with loose components p and q into the final assembly 'X' may itself require some labour and machine time in the assembly department. In the 002 file, this time will be entered against 'X' which has to be accounted for, when we calculate the total machine time requirements of X. Inclusion of the item X in the requirements of 'X' therefore, becomes necessary.

The elements of matrix 'A' or the quantity figures in the table denote the units of subassemblies and basic parts required for a unit of the final product represented in a column.

Apart from serving as a step in obtaining the productwise machine time requirements, matrix 'A' may prove useful by itself in many aspects of the production planning and control.

III

PRODUCT-MACHINE HOURS TABLE

Operations on the 002 cards file

As a step in obtaining the 'Productwise machine time requirements' we have to note certain points regarding the 002 card file as it was used for the purpose.

Matrix 'A'

		Products	
		1, 2, 3,	i ... 128, 129, 130
P	1		
a	2		
r	3		
t	..		
s	.		
	.		
	.		
	4500		
	4501		
s	.		
u	.		
b	.		
a	.		
s	.		
s	.		
e	.		
m	.		
b	.		
l	.		
i	.		
e	.		
s	5000		

Any column, say i th, in the 'A' Matrix comprises of, upto 4500th element, the parts required for a unit of the i th final product. Elements from 4501 to 5000 represent the subassemblies required for the same. Symbolically a_{ri} (r , i th element of 'A' matrix) represents the requirements of r th part/subassembly for one unit of i th product. Wherever $r \leq 4500$, it represents r th part, whereas if, $r > 4500$ it represents r th subassembly.

The object is to obtain the machine time required for different products. Only manufactured components requiring machine time were, therefore, considered, while all the purchased and imported components as well as assemblies requiring only labour time were left out of consideration as far as this stage of the problem is concerned.

Machine Groups

Next important change that had to be made in the arrangement of 002 file was regarding the machine numbers. In the machinery list as maintained by the firm, each machine is identified by a separate number. Two machines having the same make, similar type, same engineering and/or feed capacity are separately identified. Machines are grouped according to departments and within a department, each machine is separately identified by a code number. Keeping this system would have increased the size of the linear programming problem.

For our present purpose, machines within a department were grouped according to type and engineering capacity. Make of the machine was ignored. In a particular department say Machine Shop Castings, all the single spindle drilling machines $3/4$ inch were given the same three digit code number, while single spindle drilling machines $1\ 1/4$ inch in the same department were given another code number. Machines, though of similar type and the same engineering capacity, if they are situated in different departments,

are put in different groups. This was done, keeping in view the fact that in the process of organising production, machines of the same type and capacity, if they are situated in different departments, are not always transferable for one another and form restrictions of different type. If single spindle drilling machines (1/2 inch) in one department become bottleneck, similar machines in other department cannot always be counted upon, as the inventories (castings etc.) are not quickly transferable from one place to another. In the linear programming problem, groupwise time of machines available in a particular period (a week) will form the 'constraints' on the maximising function.

The total number of new machine groups, came to a hundred and fortyeight. However, when master cards for new Machine Groups were sought to merge with the data cards, only sixty groups out of the total of hundred and forty-eight were actually merged, indicating that a large number of machines were not being used at the time of this investigation.³

Thus, for this study the data file of 002 cards gives the machine millihours according to these sixty Machine Groups required for a batch of hundred units of respective

³ Only those groups, machines from which are being utilised, have been given in the table in the Appendix-D. This has been done in order not to make the size of the table in the Appendix-D unweildy.

components. Let us call this as Matrix 'B' which can be written as follows.

Matrix 'B'

Machine groups	Parts and Assemblies	
	1, 2, 3, j	5000
1		.
2		.
3		.
.		.
.		.
.		.
i	a_{ij}
.		.
.		.
.		.
60		.

An element ' a_{ij} ', in this table shows the time of i th machine group required for a batch of hundred units of the j th part.

Multiplication of the Two Matrices

We have two sets of information viz., the productwise requirements of parts and subassemblies or 'A' matrix, and machine time requirements of all the manufactured parts and subassemblies according to machine groups or the 'B' matrix. - Using these two sets of information, the next task was to obtain productwise machine hours required. This involved the multiplication of the two matrices : Matrix 'B' and

Matrix 'A'. Mathematically, this can be stated as:

$$B(m,c) \times A(c,p) = F(m,p)$$

or,

$$B(60,5000) \times A(50000,130) = F(60,130)$$

where,

p = products

c = components (i.e. parts and subassemblies)

m = machine groups

F = resultant final matrix

'F' Matrix

The final matrix F(60,130) (see, Appendix D, next) which will be the basis for the linear programming problem has sixty rows and hundred and thirty columns.

		Products						
		p	1,	2	3	.... j	....	130
M								
Machine Groups	1							
	2							
	3							
	.							
	.							
	.							
	1						
.								
.								

(ij)th element of the Matrix 'F' represents the millihours of a machine from ith machine group required for a batch of hundred units of the jth product.

IV

LINEAR PROGRAMMING PROBLEMThe Basic Matrix

The table giving the productwise requirements of different machine millihours or the 'F' Matrix forms the basic matrix in the linear programming problem for Firm B (see, p. 188 , Chapter V, for the mathematical formulation of the problem). Columns in this table indicate the technology vectors² for different products, while rows indicate the restrictions due to machine capacity.

Objective Function

The objective function is to maximise the total profit. Coefficients prefixing the variables in the objective function represent the profit margin, i.e. the difference between unit sales price and unit ex-factory cost of a particular product.

Right Hand Side(s)

The linear programming problem has got two right hand sides (which hence forth will be referred to as R.H.S. 1 and

⁴A column in this table is a summary description of the production technique adopted by the firm in respect of that product. It shows the machines with which the product was manufactured and the time of each machine required.

R.H.S. 2). It may be recalled here that the a_{ij} s or the elements in the 'F' matrix are the standard time (milli-hours) of different machines required for hundred units in the case of each product as mentioned earlier. In order to make the results of the linear programming problem more realistic, it was necessary to convert the coefficients based on standard time into those based on actual time. This was done by using what is called the 'efficiency factor'. This is available for each machine and it relates to the efficiency of the labour who operates the machine. In the case of single spindle automat in the department 'Machine Shop Small Parts' (see Appendix-D, next) for instance, the efficiency factor is sixty. This means: when the standard time required to machine a component on this lathe is sixty milli-hours, the actual time required will be hundred millihours. This is due to the level of efficiency of the operator. Converting coefficients based on standard time into actual time implied inflating the a_{ij} values in a particular row as per the efficiency factor.

Here, the difficulty should be evident. Sixty rows in the 'F' matrix indicate groups of machines. There would have been no problem, had the efficiency factors of different machines included in a group been the same. But this is rarely a case. In order to avoid the averaging of the efficiency factors of different machines included in a particular group, it was decided to change the right-hand-side element

values of the set of sixty restrictions instead of changing the matrix elements in the respective rows.

Take for instance a machine in the first Machine group. Inequality in respect of this machine could be written as:

$$a_{11} x_1 + a_{12} x_2 + \dots + a_{1,130} x_{130} \leq b_{1,1}$$

where, $b_{1,1}$ is the available time of a machine in the first group.

If the efficiency factor for this machine is, say, sixty, while converting the a_{ij} coefficients in this row, based on standard time into those based on actual time, we have

$$100/60(a_{11}x_1) + 100/60(a_{12}x_2) + \dots + 100/60(a_{1,130}x_{130}) \leq b_{1,1}$$

i.e.

$$100/60(a_{11}x_1 + a_{12}x_2 + \dots + a_{1,130}x_{130}) \leq b_{1,1}$$

which may be written as

$$a_{11}x_1 + a_{12}x_2 + \dots + a_{1,130}x_{130} \leq 60/100(b_{1,1})$$

Instead of inflating the a_{ij} values each time, corresponding right hand side elements i.e. the available time of each machine was deflated according to the efficiency factor. The total deflated time of all the machines in a group was entered as the available time of the machine group on the right hand side in the case of each of the sixty machine groups.

A week is the production period and the machine capacities

are calculated as per this period. On a 'two shifts' basis, ninetyfour working hours of each machine in the manufacturing plant are available per week (forty-seven hours/week). Out of this, fifteen per cent have to be deducted on account of machine breakdown, scrap factor etc., and 79.9 hours or 79900 millihours (one hour = thousand millihours) are finally available per machine per week. If there are ten machines in a particular machine group the total time (without consideration of the efficiency factor) will be simply $79900 \times 10 = 799000$.

The available machine hours as per each machine group over a week, calculated in this way, form the R.H.S. 1. Optimising with reference to R.H.S. 1 implies that our structural coefficients (elements in the 'F' matrix) are based on standard time of the machine.

When the structural coefficients based on the actual time are required, however, a further operation as indicated in the algebraic formulation above is performed. That the efficiency factor of a particular machine is sixty, simply means that ~~###~~ only sixty per cent of 79900 millihours per week, per machine will actually be available. For different groups, the actual available time was calculated by making use of the efficiency factors. This provided R.H.S. 2. Optimising with respect to R.H.S. 2 implies in other words, that the structural coefficients are obtained on the basis of actual time instead of standard time.

Instead of having two separate matrices, one based on the standard time and another based on the actual time as bases for optimisation, two right hand sides R.H.S. 1 and R.H.S. 2 were used which by implication mean having two separate basic matrices, and achieve the same purpose.

Production pattern which maximises the total profit was obtained with respect to machines restrictions only. In effect two variants of the linear programming problems were solved.

(a) To maximise total profit with respect to restrictions due to groupwise available machine time; given that the structural matrix is based on 'standard time'.

(b) To maximise total profit with respect to restrictions due to groupwise available machine time; given that the structural matrix is based on 'actual time'.

Matrix 'F' along with the two sets of right hand side elements has been given in Appendix-D next.

APPENDIX D. THE TABLE SHOWING THE STANDARD TIME OF
DIFFERENT MACHINES REQUIRED IN THE
FABRICATION OF SWITCHGEARS - FIRM B.

S. No.	Description of Machine Group	Products									
		1	2	3	4	5	6	7	8	9	10
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
3	Bench Grinders 8"	-	-	-	-	-	-	-	-	-	-
4	Centre Lathe	-	-	-	-	-	-	-	-	-	-
5	Capstan Lathes, 2D.	-	-	-	-	-	-	-	-	-	-
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	-	-	-	-	-
7	High Speed Turret Lathe	-	-	-	-	-	-	-	-	-	-
8	Single Spindle Automats A 15	1200	1200	1200	1200	1200	1200	1272	2172	2172	2172
9	Screw Slitting Machine	-	-	-	-	-	-	-	-	-	-
10	Screwing Machine	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP CASTINGS											
11	Band Saw	-	-	-	-	-	-	-	-	-	-
12	Circular Saw 8"	-	-	-	-	-	-	-	-	-	-
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	-	-
14	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		1	2	3	4	5	6	7	8	9	10
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	-	-	-	-	-	-	-	-	-	-
16	4 Spindle Drilling Machines 1/2"	-	-	-	-	-	-	-	-	-	-
17	4 Spindle Drilling Machine 3/4"	-	-	-	-	-	-	-	-	-	-
18	2 Spindle Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
19	Radial Drilling Machine HMT	-	-	-	-	-	-	-	-	-	-
20	Surface Grinders D-700-SO	-	-	-	-	-	-	-	-	-	-
21	Surface Grinders 18"	-	-	-	-	-	-	-	-	-	-
22	Surface Grinder 600 R. K.	-	-	-	-	-	-	-	-	-	-
23	Automatic Belt Grinding Machine	-	-	-	-	-	-	-	-	-	-
24	Milling Machines	-	-	-	-	-	-	-	-	-	-
25	Strip Bending Machine	-	-	-	-	-	-	-	-	-	-
26	Shot Blasting Plant	-	-	-	-	-	-	-	-	-	-
SHEET METAL SHOP											
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	-	-	-	-
PRESS SHOP											
28	Surface Grinder 24" x 8"	-	-	-	-	-	-	-	-	-	-
29	Tapping Machines	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		1	2	3	4	5	6	7	8	9	10
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	-	-	-	-	-	-	-	-	-	-
31	Hydraulic Press 100 Ton	-	-	-	-	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	-	-	-	960	960	960	-	-	-	-
34	Power Press 40 Ton	-	-	-	-	-	-	-	-	-	-
35	Power Presses 63 Ton	3000	3000	3000	-	-	-	3720	3720	3720	3720
36	Power Presses 100 Ton	-	-	-	-	-	-	-	-	-	-
37	Guillotine Shearing Machine 6 MM	-	-	-	-	-	-	-	-	-	-
38	Spot Welding Machine 15 KVA	-	-	-	-	-	-	-	-	-	-
39	Tumbling Barrel	-	-	-	-	-	-	-	-	-	-
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	-	-	-	-	-	-	-	-	-	-
41	Bakelite Preform Press	-	-	-	-	-	-	-	-	-	-
42	Bakelite Preform Presses, 60 & 63 Ton	-	-	-	-	-	-	-	-	-	-
43	Bakelite Moulding Presses 100 Ton	-	-	-	-	-	-	-	-	-	-
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	-	-	-	-	-	-	-	-	-	-
45	Zinc (Barrel) Plating	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		1	2	3	4	5	6	7	8	9	10
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	-	-	-	-	-	-	-	-	-	-
47	Nickel (Vat) Plating	-	-	-	-	-	-	-	-	-	-
48	Zinc (Vat) Plating	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY MOTOR STARTERS										
49	Hydraulic Press 1 Ton	-	-	-	-	-	-	-	-	-	-
50	Hydraulic Presses, 5 & 7.5 Tons .	-	-	-	-	-	-	-	-	-	-
51	Air Presses 4"	-	-	-	-	-	-	-	-	-	-
52	Rivetting Machine	-	-	-	-	-	-	-	-	-	-
53	Spot Welding Machines	-	-	-	-	-	-	-	-	-	-
54	Electric Drying Oven	-	-	-	-	-	-	-	-	-	-
55	Thermal Relay Winding Machines	-	-	-	-	-	-	-	-	-	-
56	Vacuum Impregnation Plant	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY SWITCHBOARDS										
57	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
	PAINT SHOP										
59	Spray Painting Machines	-	-	-	-	-	-	-	-	-	-
60	Testing Equipment	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		11	12	13	14	15	16	17	18	19	20
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
3	Bench Grinders 8"	-	-	-	-	-	-	-	-	-	-
4	Centre Lathe	-	-	-	-	-	-	-	-	-	-
5	Capstan Lathes, 2D.	-	-	-	-	-	-	-	-	-	-
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	-	-	-	-	-
7	High Speed Turret Lathe	-	-	-	-	-	-	-	-	-	-
8	Single Spindle Automats A 15	-	-	-	-	-	-	-	-	-	-
9	Screw Slitting Machine	-	-	-	-	-	-	-	-	-	-
10	Screwing Machine	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP CASTINGS											
11	Band Saw	-	-	-	-	-	-	-	-	-	-
12	Circular Saw 8"	-	-	-	-	-	-	-	2725	2900	1700
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	-	-
14	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	2200

S. No.	Description of Machine Group	Products									
		11	12	13	14	15	16	17	18	19	20
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	-	-	-	-	-	-	-	-	-	-
16	4 Spindle Drilling Machines 1/2"	-	-	-	-	-	-	740	3660	-	-
17	4 Spindle Drilling Machine 3/4"	-	-	-	-	-	-	-	2810	4830	5370
18	2 Spindle Drilling Machines 1/8"	-	-	-	-	-	-	2580	6395	6280	6430
19	Radial Drilling Machine HMT	-	-	-	-	-	-	-	-	-	-
20	Surface Grinders D-700-SO	-	-	-	-	-	-	-	-	-	4959
21	Surface Grinders 18"	-	-	-	-	-	-	-	5734	5734	-
22	Surface Grinder 600 R. K.	-	-	-	-	-	-	2000	-	-	-
23	Automatic Belt Grinding Machine	-	-	-	-	-	-	-	-	-	-
24	Milling Machines	-	-	-	-	-	-	-	6200	10100	7100
25	Strip Bending Machine	-	-	-	-	-	-	-	-	-	-
26	Shot Blasting Plant	-	-	-	-	-	-	-	4400	8800	17000
SHEET METAL SHOP											
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	-	-	-	-
PRESS SHOP											
28	Surface Grinder 24" x 8"	-	-	-	-	-	-	-	-	-	-
29	Tapping Machines	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		11	12	13	14	15	16	17	18	19	20
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	-	-	-	-	-	-	-	-	-	-
31	Hydraulic Press 100 Ton	-	-	-	-	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	340	340	340	340	-	-	7	14	14	14
34	Power Press 40 Ton	-	-	-	-	-	-	-	-	-	-
35	Power Presses 63 Ton	160	160	160	160	7620	7620	-	-	-	-
36	Power Presses 100 Ton	-	-	-	-	-	-	-	-	-	-
37	Guillotine Shearing Machine 6 MM	38	38	38	38	-	-	1	1	1	1
38	Spot Welding Machine 15 KVA	-	-	-	-	-	-	-	-	-	-
39	Tumbling Barrel	-	-	-	-	-	-	-	-	-	-
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	-	-	-	-	-	-	-	-	-	-
41	Bakelite Preform Press	-	-	-	-	-	-	-	-	-	-
42	Bakelite Preform Presses, 60 & 63 Ton	-	-	-	-	-	-	-	-	-	-
43	Bakelite Moulding Presses 100 Ton	-	-	-	-	-	-	-	-	-	-
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	-	-	-	-	-	-	3	12	12	12
45	Zinc (Barrel) Plating	-	-	-	-	-	-	184	624	624	1156

S. No.	Description of Machine Group	Products									
		11	12	13	14	15	16	17	18	19	20
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	-	-	-	-	-	-	-	-	-	-
47	Nickel (Vat) Plating	-	-	-	-	-	-	-	-	-	-
48	Zinc (Vat) Plating	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY MOTOR STARTERS										
49	Hydraulic Press 1 Ton	-	-	-	-	-	-	-	-	-	-
50	Hydraulic Presses, 5 & 7.5 Tons	-	-	-	-	-	-	-	-	-	-
51	Air Presses 4"	-	-	-	-	-	-	-	-	-	-
52	Rivetting Machine	-	-	-	-	-	-	-	-	-	-
53	Spot Welding Machines	-	-	-	-	-	-	-	-	-	-
54	Electric Drying Oven	-	-	-	-	-	-	-	-	-	-
55	Thermal Relay Winding Machines	-	-	-	-	-	-	-	-	-	-
56	Vacuum Impregnation Plant	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY SWITCHBOARDS										
57	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
	PAINT SHOP										
59	Spray Painting Machines	-	-	-	-	-	-	467	2134	2134	2134
60	Testing Equipment	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		21	22	23	24	25	26	27	28	29	30
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
3	Bench Grinders 8"	-	-	-	-	-	-	-	-	-	-
4	Centre Lathe	-	-	-	-	-	-	-	-	-	-
5	Capstan Lathes, 2D.	-	-	-	-	-	-	-	-	-	-
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	-	-	-	-	-
7	High Speed Turret Lathe	-	-	-	-	-	-	-	-	-	-
8	Single Spindle Automats A 15	-	-	-	-	-	-	-	-	-	-
9	Screw Slitting Machine	-	-	-	-	-	-	-	-	-	-
10	Screwing Machine	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP CASTINGS											
11	Band Saw	-	-	-	-	-	-	-	-	-	-
12	Circular Saw 8"	2300	1950	1600	-	1725	1700	1950	1700	1950	-
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	-	-
14	Single Spindle Drilling Machines 3/4"	-	2980	-	-	-	2200	2980	2200	2980	-

S. No.	Description of Machine Group	Products									
		21	22	23	24	25	26	27	28	29	30
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	-	-	-	3500	-	-	-	-	-	-
16	4 Spindle Drilling Machines 1/2"	-	-	-	750	3660	-	-	-	-	-
17	4 Spindle Drilling Machine 3/4"	4050	5020	5920	-	5960	5370	5020	5370	5020	-
18	2 Spindle Drilling Machines 1/8"	7835	9765	10465	1375	9605	6430	9765	6430	9765	4650
19	Radial Drilling Machine HMT	-	-	-	-	-	-	-	-	-	-
20	Surface Grinders D-700-SO	5000	4959	5126	-	2500	4959	4959	4959	4959	-
21	Surface Grinders 18"	-	-	-	-	5734	-	-	-	-	-
22	Surface Grinder 600 R. K.	-	-	-	2000	-	-	-	-	-	3417
23	Automatic Belt Grinding Machine	-	-	-	-	-	-	-	-	-	-
24	Milling Machines	6800	9900	12700	-	6200	7100	9900	7100	9900	-
25	Strip Bending Machine	-	-	-	-	-	-	-	-	-	-
26	Shot Blasting Plant	12800	15000	10400	9600	10800	17000	15000	17000	15000	-
	SHEET METAL SHOP										
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	-	-	-	-
	PRESS SHOP										
28	Surface Grinder 24" × 8"	-	-	-	-	-	-	-	-	-	-
29	Tapping Machines	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		21	22	23	24	25	26	27	28	29	30
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	-	-	-	-	-	-	-	-	-	-
31	Hydraulic Press 100 Ton	-	-	-	-	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	14	14	14	36	14	14	14	14	14	176
34	Power Press 40 Ton	-	-	-	-	-	-	-	-	-	-
35	Power Presses 63 Ton	-	-	-	-	-	-	-	-	-	-
36	Power Presses 100 Ton	-	-	-	-	-	-	-	-	-	-
37	Guillotine Shearing Machine 6 MM	1	1	1	11	1	1	1	1	1	15
38	Spot Welding Machine 15 KVA	-	-	-	-	-	-	-	-	-	-
39	Tumbling Barrel	-	-	-	-	-	-	-	-	-	-
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	-	-	-	-	-	-	-	-	-	-
41	Bakelite Preform Press	-	-	-	-	-	-	-	-	-	-
42	Bakelite Preform Presses, 60 & 63 Ton	-	-	-	-	-	-	-	-	-	-
43	Bakelite Moulding Presses 100 Ton	-	-	-	-	-	-	-	-	-	-
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	12	12	12	3	12	12	12	12	12	-
45	Zinc (Barrel) Plating	1156	1304	1304	191	664	1312	1304	1156	1304	326

S. No.	Description of Machine Group	Products									
		21	22	23	24	25	26	27	28	29	30
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	-	-	-	-	-	-	-	-	-	-
47	Nickel (Vat) Plating	-	-	-	-	-	-	-	-	-	-
48	Zinc (Vat) Plating	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY MOTOR STARTERS										
49	Hydraulic Press 1 Ton	-	-	-	-	-	-	-	-	-	-
50	Hydraulic Presses, 5 & 7.5 Tons	-	-	-	-	-	-	-	-	-	-
51	Air Presses 4"	-	-	-	-	-	-	-	-	-	-
52	Rivetting Machine	-	-	-	-	-	-	-	-	-	-
53	Spot Welding Machines	-	-	-	-	-	-	-	-	-	-
54	Electric Drying Oven	-	-	-	-	-	-	-	-	-	-
55	Thermal Relay Winding Machines	-	-	-	-	-	-	-	-	-	-
56	Vacuum Impregnation Plant	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY SWITCHBOARDS										
57	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
	PAINT SHOP										
59	Spray Painting Machines	2134	3134	3134	467	3201	2134	3134	2134	3134	533
60	Testing Equipment	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		31	32	33	34	35	36	37	38	39	40
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
3	Bench Grinders 8"	-	-	-	-	-	-	-	-	-	-
4	Centre Lathe	-	-	-	-	-	-	-	-	-	-
5	Capstan Lathes, 2D.	-	-	-	-	6	-	-	-	-	-
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	-	-	-	-	-
7	High Speed Turret Lathe	-	-	-	-	-	-	-	-	-	-
8	Single Spindle Automats A 15	-	-	-	-	-	-	-	-	-	-
9	Screw Slitting Machine	-	-	-	-	-	-	-	-	-	-
10	Screwing Machine	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP CASTINGS											
11	Band Saw	-	-	-	-	-	-	-	-	-	-
12	Circular Saw 8"	2300	1600	1950	1950	2750	1950	1950	1950	1950	-
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	-	-
14	Single Spindle Drilling Machines 3/4"	-	-	4180	4180	4030	4030	-	-	3910	-

S. No.	Description of Machine Group	Products									
		31	32	33	34	35	36	37	38	39	40
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	-	-	-	-	-	-	-	14700	14700	-
16	4 Spindle Drilling Machines 1/2"	-	-	-	-	-	-	-	-	-	32880
17	4 Spindle Drilling Machine 3/4"	4050	5920	900	900	1960	980	5090	5090	980	-
18	2 Spindle Drilling Machines 1/8"	7835	10465	9555	9555	9385	9385	5180	10460	11470	-
19	Radial Drilling Machine HMT	-	-	-	-	-	-	-	-	-	-
20	Surface Grinders D-700-SO	5000	5126	4918	4918	5894	5834	6084	6084	7584	-
21	Surface Grinders 18"	-	-	-	-	-	-	-	-	-	5734
22	Surface Grinder 600 R. K.	-	-	-	-	-	-	-	-	-	5
23	Automatic Belt Grinding Machine	-	-	-	-	-	-	-	-	-	-
24	Milling Machines	6800	12700	9900	9900	24200	14100	14100	14100	14100	-
25	Strip Bending Machine	-	-	-	-	-	-	-	-	-	-
26	Shot Blasting Plant	12800	10400	67200	67200	62200	62200	29000	46100	75800	-
SHEET METAL SHOP											
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	-	-	-	-
PRESS SHOP											
28	Surface Grinder 24" × 8"	-	-	-	-	-	-	-	-	-	-
29	Tapping Machines	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		31	32	33	34	35	36	37	38	39	40
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	-	-	-	-	-	-	-	-	-	-
31	Hydraulic Press 100 Ton	-	-	-	-	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	14	14	14	14	14	14	14	14	14	15
34	Power Press 40 Ton	-	-	-	-	-	-	-	-	-	-
35	Power Presses 63 Ton	-	-	-	-	-	-	-	-	-	-
36	Power Presses 100 Ton	-	-	-	-	-	-	-	-	-	-
37	Guillotine Shearing Machine 6 MM	1	1	1	1	1	1	1	1	1	15
38	Spot Welding Machine 15 KVA	-	-	-	-	-	-	-	-	-	-
39	Tumbling Barrel	-	-	-	-	-	-	-	-	-	-
	BAKELITE MOULDING SHOP										
40	High Speed Drilling Machine 1/8"	-	-	-	-	-	-	-	-	-	-
41	Bakelite Preform Press	-	-	-	-	-	-	-	-	-	-
42	Bakelite Preform Presses, 60 & 63 Ton	-	-	-	-	-	-	-	-	-	-
43	Bakelite Moulding Presses 100 Ton	-	-	-	-	-	-	-	-	-	-
	ELECTROPLATING SHOP										
44	Nickel (Barrel) Plating	12	12	12	12	12	12	12	12	12	-
45	Zinc (Barrel) Plating	1156	1304	1616	1616	2494	2494	2934	3414	3414	490

S. No.	Description of Machine Group	Products									
		31	32	33	34	35	36	37	38	39	40
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	-	-	-	-	-	-	-	-	-	-
47	Nickel (Vat) Plating	-	-	-	-	-	-	-	-	-	-
48	Zinc (Vat) Plating	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY MOTOR STARTERS										
49	Hydraulic Press 1 Ton	-	-	-	-	-	-	-	-	-	-
50	Hydraulic Presses, 5 & 7.5 Tons	-	-	-	-	-	-	-	-	-	-
51	Air Presses 4"	-	-	-	-	-	-	-	-	-	-
52	Rivetting Machine	-	-	-	-	-	-	-	-	-	-
53	Spot Welding Machines	-	-	-	-	-	-	-	-	-	-
54	Electric Drying Oven	-	-	-	-	-	-	-	-	-	-
55	Thermal Relay Winding Machines	-	-	-	-	-	-	-	-	-	-
56	Vacuum Impregnation Plant	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY SWITCHBOARDS										
57	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
	PAINT SHOP										
59	Spray Painting Machines	2134	3134	2666	2666	5200	5200	4201	3134	5200	1866
60	Testing Equipment	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		41	42	43	44	45	46	47	48	49	50
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	1860	-	-	-	-	-	-	-
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
3	Bench Grinders 8"	600	600	600	1800	300	600	3000	300	300	6000
4	Centre Lathe	-	-	-	-	-	-	-	-	-	-
5	Capstan Lathes, 2D.	-	-	-	48000	-	-	-	-	-	-
6	Turret Lathe, No. 8 Preoptive	-	-	-	5400	-	-	-	-	-	-
7	High Speed Turret Lathe	-	-	-	-	-	-	-	-	-	4950
8	Single Spindle Automats A 15	27656	22466	32838	48367	861	11544	5716	1223	483	18597
9	Screw Slitting Machine	4500	4500	2600	11028	3786	3786	-	4500	-	-
10	Screwing Machine	2332	2332	2332	4664	-	-	-	1166	1166	-
MACHINE SHOP CASTINGS											
11	Band Saw	4950	4950	5400	-	-	-	-	1400	-	-
12	Circular Saw 8"	1400	1400	4050	-	-	-	3800	-	-	7600
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	-	-
14	Single Spindle Drilling Machines 3/4"	-	-	6920	-	-	1425	-	-	-	-

S. No.	Description of Machine Group	Products									
		41	42	43	44	45	46	47	48	49	50
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	3670	3670	4220	4784	5720	5115	3200	3200	-	6400
16	4 Spindle Drilling Machines 1/2"	9330	9330	11481	42900	2790	2220	-	-	-	-
17	4 Spindle Drilling Machine 3/4"	7450	7450	11220	1667	-	-	14800	38040	-	29600
18	2 Spindle Drilling Machines 1/8"	28255	28255	32640	23100	8700	8528	15800	16935	-	31600
19	Radial Drilling Machine HMT	-	-	-	20880	-	-	-	-	-	-
20	Surface Grinders D-700-SO	8917	8917	4459	-	-	-	-	-	-	-
21	Surface Grinders 18"	-	-	-	-	2500	2500	2500	2500	-	5000
22	Surface Grinder 600 R. K.	-	-	-	-	-	-	-	-	-	-
23	Automatic Belt Grinding Machine	-	-	-	312000	-	7	8400	-	-	-
24	Milling Machines	-	-	-	1051300	1647	3294	3300	-	-	12700
25	Strip Bending Machine	-	-	-	-	-	-	-	-	-	16800
26	Shot Blasting Plant	14800	14800	47000	-	10300	20700	-	15000	-	30000
SHEET METAL SHOP											
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	15000	-	-	-
PRESS SHOP											
28	Surface Grinder 24" x 8"	-	-	-	-	-	-	-	-	-	-
29	Tapping Machines	15360	12288	18432	10214	-	6144	1510	-	-	3020

S. No.	Description of Machine Group	Products									
		41	42	43	44	45	46	47	48	49	50
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	6360	5088	7632	-	-	2544	-	-	-	-
31	Hydraulic Press 100 Ton	-	-	-	-	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	28101	23721	32923	37119	14	8914	6885	3041	-	14157
34	Power Press 40 Ton	-	-	-	-	-	-	-	-	-	-
35	Power Presses 63 Ton	3735	2988	4482	2160	-	1494	1800	-	-	3600
36	Power Presses 100 Ton	7230	5784	8676	6072	-	2892	1678	522	-	3350
37	Guillotine Shearing Machine 6 MM	2628	2331	3038	7084	2	686	540	175	-	1099
38	Spot Welding Machine 15 KVA	-	-	-	-	-	-	-	-	-	-
39	Tumbling Barrel	-	-	-	-	-	-	-	-	-	-
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	-	-	-	-	-	-	-	-	-	-
41	Bakelite Preform Press	-	-	-	-	-	-	-	-	-	-
42	Bakelite Preform Presses, 60 & 63 Ton	-	-	-	-	-	-	-	-	-	-
43	Bakelite Moulding Presses 100 Ton	-	-	-	-	-	-	-	-	-	-
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	173	146	206	1242	8	62	212	200	-	424
45	Zinc (Barrel) Plating	4300	3781	5653	15610	274	910	871	976	137	2087

S. No.	Description of Machine Group	Products									
		41	42	43	44	45	46	47	48	49	50
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	-	-	-	98646	-	-	-	2688	-	-
47	Nickel (Vat) Plating	1174	1174	2444	-	-	-	16362	-	-	32724
48	Zinc (Vat) Plating	-	-	-	33920	-	-	9776	-	-	19552
	ASSEMBLY MOTOR STARTERS										
49	Hydraulic Press 1 Ton	-	-	-	-	-	-	-	-	-	-
50	Hydraulic Presses, 5 & 7.5 Tons	-	-	-	-	-	-	-	-	-	-
51	Air Presses 4"	-	-	-	-	-	-	-	-	-	-
52	Rivetting Machine	-	-	-	-	-	-	-	-	-	-
53	Spot Welding Machines	-	-	-	-	-	-	-	-	-	-
54	Electric Drying Oven	-	-	-	-	-	-	-	-	-	-
55	Thermal Relay Winding Machines	-	-	-	-	-	-	-	-	-	-
56	Vacuum Impregnation Plant	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY SWITCHBOARDS										
57	Single Spindle Drilling Machines 3/4"	2338	2338	-	-	-	-	-	-	-	-
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
	PAINT SHOP										
59	Spray Painting Machines	2734	2734	3750	-	2267	1850	2116	1734	-	4232
60	Testing Equipment	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		51	52	53	54	55	56	57	58	59	60
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	2800	2800	-	-	2800
3	Bench Grinders 8"	3000	-	3300	7800	4800	600	5400	1200	2800	1200
4	Centre Lathe	-	-	-	-	-	-	-	-	-	-
5	Capstan Lathes, 2D.	-	-	-	-	-	-	-	24000	-	24000
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	-	-	-	-	-
7	High Speed Turret Lathe	423	-	-423	5373	-	-	-	6800	-	6800
8	Single Spindle Automats A 15	6337	-	8940	20721	5777	1706	8863	20530	-	21910
9	Screw Slitting Machine	-	-	4500	-	1120	4500	5620	3086	-	3086
10	Screwing Machine	-	-	1166	-	6100	2332	2332	12000	-	-
MACHINE SHOP CASTINGS											
11	Band Saw	-	-	1200	-	-	2200	2200	-	2200	2200
12	Circular Saw 8"	4750	-	4750	9500	-	-	6100	-	-	12000
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	600	600
14	Single Spindle Drilling Machines 3/4"	-	-	-	-	4250	-	4250	-	-	-

S. No.	Description of Machine Group	Products									
		51	52	53	54	55	56	57	58	59	60
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	3200	-	6400	6400	2392	3670	6062	2392		2392
16	4 Spindle Drilling Machines 1/2"	18740	-	18740	37480	27310	-	27310	31010		37010
17	4 Spindle Drilling Machine 3/4"	7170	-	32490	14340	-	23220	23220	9310	31020	40330
18	2 Spindle Drilling Machines 1/8"	19315	-	35870	38630	17582	27595	46652	44005	2460	48030
19	Radial Drilling Machine HMT	3125	-	-	-	6985	-	6985	17920	-	17920
20	Surface Grinders D-700-SO	3125	-	6250	6250	3917	3585	7501	4459		4459
21	Surface Grinders 18"	-	-	-	-	-	-	-	-	-	-
22	Surface Grinder 600 R. K.	-	-	-	-	-	-	-	-	-	-
23	Automatic Belt Grinding Machine	1000	-	1000	2000	22800		22800	44700		44700
24	Milling Machines	-	-	-	6100	87700	-	87700	121800	-	1218000
25	Strip Bending Machine	-	-	-	-	-	-	-	-		-
26	Shot Blasting Plant	15400	-	40800	30800	31400	22700	54400	56200		56686
	SHEET METAL SHOP										
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	-	-	-	-
	PRESS SHOP										
28	Surface Grinder 24" x 8"	-	-	-	-	-	-	-	-	-	-
29	Tapping Machines	1591	-	1591	3182	2710		2710	2731		2731

S. No.	Description of Machine Group	Products									
		51	52	53	54	55	56	57	58	59	60
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	546	-	546	1092	-	-	-	-	-	-
31	Hydraulic Press 100 Ton	-	-	-	-	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	6300	-	10745	13356	3775	8640	16733	7208	5360	13200
34	Power Press 40 Ton	-	-	-	-	-	-	-	-	-	-
35	Power Presses 63 Ton	-	-	-	-	-	-	-	540	-	540
36	Power Presses 100 Ton	2806	-	2806	5612	1375	4180	5557	1518	2016	3534
37	Guillotine Shearing Machine 6 MM	567	-	1237	1636	1652	1232	3461	1906	662	2566
38	Spot Welding Machine 15 KVA	-	-	-	-	-	-	-	-	-	-
39	Tumbling Barrel	-	-	-	-	-	-	-	-	-	-
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	-	-	-	-	-	-	-	-	-	-
41	Bakelite Preform Press	-	-	-	-	-	-	-	-	-	-
42	Bakelite Preform Presses, 60 & 63 Ton	-	-	-	-	-	-	-	-	-	-
43	Bakelite Moulding Presses 100 Ton	284	284	556	568	206	824	1006	223	800	999
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	-	-	-	-	-	-	-	-	-	-
45	Zinc (Barrel) Plating	1451	-	2429	3191	3410	5232	8222	4781	2754	6021

S. No.	Description of Machine Group	Products									
		51	52	53	54	55	56	57	58	59	60
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	-	-	28812	-	6621	7416	14037	24660	7530	32190
47	Nickel (Vat) Plating	13542	-	13542	27084	-	-	-	-	-	-
48	Zinc (Vat) Plating	11525	11525	11525	23050	2418	-	2418	11299	-	11299
	ASSEMBLY MOTOR STARTERS										
49	Hydraulic Press 1 Ton	-	-	-	-	-	-	-	-	-	-
50	Hydraulic Presses, 5 & 7.5 Tons	-	-	-	-	-	-	-	-	-	-
51	Air Presses 4"	-	-	-	-	-	-	-	-	-	-
52	Rivetting Machine	-	-	-	-	-	-	-	-	-	-
53	Spot Welding Machines	-	-	-	-	-	-	-	-	-	-
54	Electric Drying Oven	-	-	-	-	-	-	-	-	-	-
55	Thermal Relay Winding Machines	-	-	-	-	-	-	-	-	-	-
56	Vacuum Impregnation Plant	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY SWITCHBOARDS										
57	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	3660	-	3660
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
	PAINT SHOP										
59	Spray Painting Machines	2116	-	4474	4232	4799	2734	7608	5433	-	5433
60	Testing Equipment	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		61	62	63	64	65	66	67	68	69	70
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
3	Bench Grinders 8"	300	600	900	-	-	-	-	-	-	-
4	Centre Lathe	-	-	-	-	-	-	-	-	-	-
5	Capstan Lathes, 2D.	24000	-	24000	-	-	-	-	-	-	-
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	-	-	-	-	-
7	High Speed Turret Lathe	6800	-	6800	-	-	-	-	-	-	-
8	Single Spindle Automats A 15	22756	1698	25834	-	4187	4187	4187	4187	4187	4187
9	Screw Slitting Machine	6074	2600	8674	-	-	-	-	-	-	-
10	Screwing Machine	-	2332	2332	-	-	-	-	-	-	-
MACHINE SHOP CASTINGS											
11	Band Saw	-	4050	4050	-	-	-	-	-	-	-
12	Circular Saw 8"	10200	-	10200	-	-	-	-	-	-	-
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	-	-
14	Single Spindle Drilling Machines 3/4"	-	770	770	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		61	62	63	64	65	66	67	68	69	70
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	2392	20005	22397	-	-	-	-	-	-	-
16	4 Spindle Drilling Machines 1/2"	30150	1200	31350	-	-	-	-	-	-	-
17	4 Spindle Drilling Machine 3/4"	-	-	7749	-	-	-	-	-	-	-
18	2 Spindle Drilling Machines 1/8"	52390	75642	129597	-	-	-	-	-	-	-
19	Radial Drilling Machine HMT	38765	-	38765	-	-	-	-	-	-	-
20	Surface Grinders D-700-SO	4459	4042	8501	-	-	-	-	-	-	-
21	Surface Grinders 18"	-	-	-	-	-	-	-	-	-	-
22	Surface Grinder 600 R. K.	-	-	-	-	-	-	-	-	-	-
23	Automatic Belt Grinding Machine	156000	-	156000	-	-	-	-	-	-	-
24	Milling Machines	522600	1078800	1601400	600	1200	1200	2600	6200	8800	
25	Strip Bending Machine	-	-	31200	-	-	-	-	-	-	-
26	Shot Blasting Plant	19700	52300	72486	-	-	-	-	-	-	-
SHEET METAL SHOP											
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	-	-	-	-
PRESS SHOP											
28	Surface Grinder 24" x 8"	-	-	-	-	-	-	-	-	-	-
29	Tapping Machines	5107	-	5107	-	378	378	378	378	378	378

S. No.	Description of Machine Group	Products									
		61	62	63	64	65	66	67	68	69	70
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	-	-	-	-	283	283	283	283	283	283
31	Hydraulic Press 100 Ton	-	-	-	-	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	14174	794	15628	-	2141	2521	2901	5212	3915	8884
34	Power Press 40 Ton	-	-	-	-	-	-	-	-	-	-
35	Power Presses 63 Ton	1080	-	1080	-	-	-	-	-	-	-
36	Power Presses 100 Ton	3036	-	3499	-	-	-	-	-	-	-
37	Guillotine Shearing Machine 6 MM	3457	42	3499	-	84	89	94	163	179	215
38	Spot Welding Machine 15 KVA	-	-	-	-	-	-	-	-	-	-
39	Tumbling Barrel	-	-	-	-	-	-	-	-	-	-
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	-	-	-	-	-	-	-	-	-	-
41	Bakelite Preform Press	-	-	-	-	1417	1667	1667	2167	1917	3167
42	Bakelite Preform Presses, 60 & 63 Ton	-	-	-	-	-	-	-	-	-	-
43	Bakelite Moulding Presses 100 Ton	-	-	-	-	8000	10667	10667	16001	13334	26669
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	223	52	275	-	34	51	68	162	107	318
45	Zinc (Barrel) Plating	8804	6702	16514	4	164	164	164	164	164	164

S. No.	Description of Machine Group	Products									
		61	62	63	64	65	66	67	68	69	70
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	49323	-	-	-	-	-	-	-	-	-
47	Nickel (Vat) Plating										
48	Zinc (Vat) Plating	19309	-	19309	-	-	-	-	-	-	-
	ASSEMBLY MOTOR STARTERS										
49	Hydraulic Press 1 Ton	-	-	-	-	-	-	-	-	-	-
50	Hydraulic Presses, 5 & 7.5 Tons	-	-	-	-	-	-	-	-	-	-
51	Air Presses 4"	-	-	-	-	-	-	-	-	-	-
52	Rivetting Machine	-	-	-	-	-	-	-	-	-	-
53	Spot Welding Machines	-	-	-	-	-	-	-	-	-	-
54	Electric Drying Oven	-	-	-	-	-	-	-	-	-	-
55	Thermal Relay Winding Machines	-	-	-	-	-	-	-	-	-	-
56	Vacuum Impregnation Plant	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY SWITCHBOARDS										
57	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
	PAINT SHOP										
59	Spray Painting Machines	1417	3317	4736	-	-	-	-	-	-	-
60	Testing Equipment	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		71	72	73	74	75	76	77	78	79	80
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
3	Bench Grinders 8"	-	-	-	-	-	-	-	-	-	-
4	Centre Lathe	-	-	-	-	-	-	-	-	-	-
5	Capstan Lathes, 2D.	-	-	-	-	-	-	-	-	-	-
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	-	-	-	-	-
7	High Speed Turret Lathe	-	-	-	-	-	-	-	-	-	-
8	Single Spindle Automats A 15	4187	4187	4187	4187	4187	4187	4187	4187	4187	4187
9	Screw Slitting Machine	-	-	-	-	-	-	-	-	-	-
10	Screwing Machine	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP CASTINGS											
11	Band Saw	-	-	-	-	-	-	-	-	-	-
12	Circular Saw 8"	-	-	-	-	-	-	-	-	-	-
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	-	-
14	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		71	72	73	74	75	76	77	78	79	80
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	-	-	-	-	-	-	-	-	-	-
16	4 Spindle Drilling Machines 1/2"	-	-	-	-	-	-	-	-	-	-
17	4 Spindle Drilling Machine 3/4"	-	-	-	-	-	-	-	-	-	-
18	2 Spindle Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
19	Radial Drilling Machine HMT	-	-	-	-	-	-	-	-	-	-
20	Surface Grinders D-700-SO	-	-	-	-	-	-	-	-	-	-
21	Surface Grinders 18"	-	-	-	-	-	-	-	-	-	-
22	Surface Grinder 600 R. K.	-	-	-	-	-	-	-	-	-	-
23	Automatic Belt Grinding Machine	-	-	-	-	-	-	-	-	-	-
24	Milling Machines	5400	4300	2600	5200	7800	10400	7800	7700	4200	1000
25	Strip Bending Machine	-	-	-	-	-	-	-	-	-	-
26	Shot Blasting Plant	-	-	-	-	-	-	-	-	-	-
SHEET METAL SHOP											
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	-	-	-	-
PRESS SHOP											
28	Surface Grinder 24" x 8"	-	-	-	-	-	-	-	-	-	-
29	Tapping Machines	378	378	378	378	378	378	378	378	378	378

S. No.	Description of Machine Group	Products									
		71	72	73	74	75	76	77	78	79	80
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	283	283	283	283	283	283	283	283	283	283
31	Hydraulic Press 100 Ton	-	-	-	-	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	4453	3376	1823	3217	6889	5053	4135	4771	4569	2299
34	Power Press 40 Ton	-	-	-	-	-	-	-	-	-	-
35	Power Presses 63 Ton	-	-	-	-	-	-	-	-	-	-
36	Power Presses 100 Ton	-	-	-	-	-	-	-	-	-	-
37	Guillotine Shearing Machine 6 MM	187	141	49	100	152	126	113	265	256	87
38	Spot Welding Machine 15 KVA	-	-	-	-	-	-	-	-	-	-
39	Tumbling Barrel	-	-	-	-	-	-	-	-	-	-
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	-	-	-	-	-	-	-	-	-	-
41	Bakelite Preform Press	1917	1667	1417	1667	2667	2167	1917	1917	1917	1417
42	Bakelite Preform Presses, 60 & 63 Ton	-	-	-	-	-	-	-	-	-	-
43	Bakelite Moulding Presses 100 Ton	13334	10667	8000	10667	21335	16001	13334	13334	13334	8000
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	129	84	39	78	234	156	117	141	136	39
45	Zinc (Barrel) Plating	164	164	87	164	164	164	164	164	150	164

S. No.	Description of Machine Group	Products									
		71	72	73	74	75	76	77	78	78	80
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	-	-	-	-	-	-	-	-	-	-
47	Nickel (Vat) Plating	-	-	-	-	-	-	-	-	-	-
48	Zinc (Vat) Plating	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY MOTOR STARTERS										
49	Hydraulic Press 1 Ton	-	-	-	-	-	-	-	-	-	-
50	Hydraulic Presses, 5 & 7.5 Tons	-	-	-	-	-	-	-	-	-	-
51	Air Presses 4"	-	-	-	-	-	-	-	-	-	-
52	Rivetting Machine	-	-	-	-	-	-	-	-	-	-
53	Spot Welding Machines	-	-	-	-	-	-	-	-	-	-
54	Electric Drying Oven	-	-	-	-	-	-	-	-	-	-
55	Thermal Relay Winding Machines	-	-	-	-	-	-	-	-	-	-
56	Vacuum Impregnation Plant	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY SWITCHBOARDS										
57	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
	PAINT SHOP										
59	Spray Painting Machines	-	-	-	-	-	-	-	-	-	-
60	Testing Equipment	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		81	82	83	84	85	86	87	88	89	90
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
3	Bench Grinders 8"	-	-	-	-	-	-	-	-	-	-
4	Centre Lathe	-	-	-	-	-	-	-	-	-	-
5	Capstan Lathes, 2D.	-	-	-	-	-	-	-	-	-	-
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	-	-	-	-	-
7	High Speed Turret Lathe	-	-	-	-	-	-	-	-	-	-
8	Single Spindle Automats A 15	-	3459	4187	4187	-	4187	4187	4187	4187	4187
9	Screw Slitting Machine	-	-	-	-	-	-	-	-	-	-
10	Screwing Machine	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP CASTINGS											
11	Band Saw	-	-	-	-	-	-	-	-	-	-
12	Circular Saw 8"	-	-	-	-	-	-	-	-	-	-
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	-	-
14	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group.	Products									
		81	82	83	84	85	86	87	88	89	90
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	-	-	-	-	-	-	-	-	-	
16	4 Spindle Drilling Machines 1/2"	-	-	-	-	-	-	-	-	-	
17	4 Spindle Drilling Machine 3/4"	-	-	-	-	-	-	-	-	-	
18	2 Spindle Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	
19	Radial Drilling Machine HMT	-	-	-	-	-	-	-	-	-	
20	Surface Grinders D-700-SO	-	-	-	-	-	-	-	-	-	
21	Surface Grinders 18"	-	-	-	-	-	-	-	-	-	
22	Surface Grinder 600 R. K.	-	-	-	-	-	-	-	-	-	
23	Automatic Belt Grinding Machine	-	-	-	-	-	-	-	-	-	
24	Milling Machines	-	3000	4000	7600	-	2000	1400	2800	1600 3700	
25	Strip Bending Machine	-	-	-	-	-	-	-	-	-	
26	Shot Blasting Plant	-	-	-	-	-	-	-	-	-	
SHEET METAL SHOP											
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	-	-	-	
PRESS SHOP											
28	Surface Grinder 24" × 8"	-	-	-	-	-	-	-	-	-	
29	Tapping Machines	-	378	378	378	-	378	378	378	378	

S. No.	Description of Machine Group	Products									
		81	82	83	84	85	86	87	88	89	90
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	-	283	283	283	-	283	283	283	283	283
31	Hydraulic Press 100 Ton	-	-	-	-	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	-	4135	5053	5963	-	4295	3376	5371	4277	6449
34	Power Press 40 Ton	-	-	-	-	-	-	-	-	-	-
35	Power Presses 63 Ton	-	-	-	-	-	-	-	-	-	-
36	Power Presses 100 Ton	-	-	-	-	-	-	-	-	-	-
37	Guillotine Shearing Machine 6 MM	-	113	126	348	-	184	137	200	261	284
38	Spot Welding Machine 15 KVA	-	-	-	-	-	-	-	-	-	-
39	Tumbling Barrel	-	-	-	-	-	-	-	-	-	-
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	-	-	-	-	-	-	-	-	-	-
41	Bakelite Preform Press	-	1917	2167	2167	-	1917	1667	2167	1917	2417
42	Bakelite Preform Presses, 60 & 63 Ton	-	-	-	-	-	-	-	-	-	-
43	Bakelite Moulding Presses 100 Ton	-	13334	16001	16001	-	13334	10667	16001	13334	18668
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	-	117	156	192	9	124	84	168	119	214
45	Zinc (Barrel) Plating	1	150	164	150	1	164	164	164	178	164

S. No.	Description of Machine Group	Products									
		81	82	83	84	85	86	87	88	89	90
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	-	-	-	-	-	-	-	-	-	-
47	Nickel (Vat) Plating	-	-	-	-	-	-	-	-	-	-
48	Zinc (Vat) Plating	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY MOTOR STARTERS										
49	Hydraulic Press 1 Ton	-	-	-	-	-	-	-	-	-	-
50	Hydraulic Presses, 5 & 7.5 Tons	-	-	-	-	-	-	-	-	-	-
51	Air Presses 4"	-	-	-	-	-	-	-	-	-	-
52	Rivetting Machine	-	-	-	-	-	-	-	-	-	-
53	Spot Welding Machines	-	-	-	-	-	-	-	-	-	-
54	Electric Drying Oven	-	-	-	-	-	-	-	-	-	-
55	Thermal Relay Winding Machines	-	-	-	-	-	-	-	-	-	-
56	Vacuum Impregnation Plant	-	-	-	-	-	-	-	-	-	-
	ASSEMBLY SWITCHBOARDS										
57	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
	PAINT SHOP										
59	Spray Painting Machines	-	-	-	-	-	-	-	-	-	-
60	Testing Equipment	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		91	92	93	94	95	96	97	98	99	100
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
3	Bench Grinders 8"	-	-	300	-	-	-	900	600	600	-
4	Centre Lathe	-	-	-	-	-	-	-	-	-	-
5	Capstan Lathes, 2D.	-	-	-	-	-	-	-	-	-	-
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	-	-	-	-	-
7	High Speed Turret Lathe	-	-	-	-	-	-	-	-	-	-
8	Single Spindle Automats A 15	4187	4187	268	-	-	-	1710	636	636	-
9	Screw Slitting Machine	-	-	-	-	-	-	-	-	-	-
10	Screwing Machine	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP CASTINGS											
11	Band Saw	-	-	23	-	-	-	23	-	-	-
12	Circular Saw 8"	-	-	-	-	-	-	-	-	-	-
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	-	-
14	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		91	92	93	94	95	96	97	98	99	100
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	-	-	-	-	-	-	1470	-	-	-
16	4 Spindle Drilling Machines 1/2"	-	-	-	-	-	-	-	-	-	-
17	4 Spindle Drilling Machine 3/4"	-	-	-	-	-	-	7170	-	-	-
18	2 Spindle Drilling Machines 1/8"	-	-	-	-	-	-	8400	-	-	-
19	Radial Drilling Machine HMT	-	-	-	-	-	-	-	-	-	-
20	Surface Grinders D-700-SO	-	-	-	-	-	-	-	-	-	-
21	Surface Grinders 18"	-	-	-	-	-	-	2333	-	-	-
22	Surface Grinder 600 R. K.	-	-	-	-	-	-	-	-	-	-
23	Automatic Belt Grinding Machine	-	-	-	-	-	-	-	-	-	-
24	Milling Machines	1600	3200	-	-	-	-	-	-	-	-
25	Strip Bending Machine	-	-	-	-	-	-	-	-	-	-
26	Shot Blasting Plant	-	-	-	-	-	-	27960	-	-	-
SHEET METAL SHOP											
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	-	-	-	-
PRESS SHOP											
28	Surface Grinder 24" x 8"	-	-	-	-	-	-	7834	-	-	-
29	Tapping Machines	-	-	-	-	-	-	9796	388	388	428

S. No.	Description of Machine Group	Products									
		91	92	93	94	95	96	97	98	99	100
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	283	283	-	-	-	-	2182	-	876	-
31	Hydraulic Press 100 Ton	-	-	-	-	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	4409	7481	7823	7001	-	876	24032	882	-	-
34	Power Press 40 Ton	-	-	-	-	-	-	416	-	-	-
35	Power Presses 63 Ton	-	-	37	-	-	-	631	-	-	56
36	Power Presses 100 Ton	179	-	229	-	-	-	1629	-	-	-
37	Guillotine Shearing Machine 6 MM	-	292	152	63	8	6	2197	6	6	14
38	Spot Welding Machine 15 KVA	-	-	-	-	-	-	-	-	-	-
39	Tumbling Barrel	-	-	3	-	-	-	3	-	-	-
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	-	-	300	-	-	-	300	-	-	-
41	Bakelite Preform Press	1917	2667	1583	-	-	666	6584	1166	1166	-
42	Bakelite Preform Presses, 60 & 63 Ton	-	-	1433	-	-	5000	5133	5000	5000	-
43	Bakelite Moulding Presses 100 Ton	13334	-	5700	-	-	-	15233	2466	2466	-
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	129	258	358	108	72	34	658	35	34	-
45	Zinc (Barrel) Plating	150	150	1	12	-	-	473	-	-	-

S. No.	Description of Machine Group	Products									
		91	92	93	94	95	96	97	98	99	100
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	-	-	-	-	-	-	-	-	-	-
47	Nickel (Vat) Plating	-	-	-	-	-	-	-	-	-	-
48	Zinc (Vat) Plating	-	-	-	-	-	-	6100	-	-	951
	ASSEMBLY MOTOR STARTERS										
49	Hydraulic Press 1 Ton	-	-	-	-	-	-	2728	-	-	-
50	Hydraulic Presses, 5 & 7.5 Tons	-	-	1998	860	860	-	3718	-	-	-
51	Air Presses 4"	-	-	1147	-	-	-	1147	-	-	-
52	Rivetting Machine	-	-	504	-	-	-	504	-	-	-
53	Spot Welding Machines	-	-	3076	-	-	-	3076	-	-	-
54	Electric Drying Oven	-	-	-	284	-	-	569	-	-	-
55	Thermal Relay Winding Machines	-	-	3185	1887	-	-	6960	-	-	-
56	Vacuum Impregnation Plant	-	-	-	182	-	-	385	-	-	-
	ASSEMBLY SWITCHBOARDS										
57	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
	PAINT SHOP										
59	Spray Painting Machines	-	-	-	-	-	-	1734	253	253	-
60	Testing Equipment	-	-	1019	-	-	3169	-	-	-	-

S. No.	Description of Machine Group	Products									
		101	102	103	104	105	106	107	108	109	110
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	-
3	Bench Grinders 8"	-	-	300	900	900	300	900	900	900	900
4	Centre Lathe	-	-	-	-	-	136400	-	-	-	-
5	Capstan Lathes, 2D.	-	-	-	-	-	29600	-	-	-	-
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	548333	-	-	-	-
7	High Speed Turret Lathe	-	-	-	-	-	18300	-	-	-	-
8	Single Spindle Automats A 15	606	606	874	1104	1104	1260	2316	5295	2316	5295
9	Screw Slitting Machine	-	-	-	-	-	-	-	-	-	-
10	Screwing Machine	-	-	-	-	-	-	-	-	-	-
MACHINE SHOP CASTINGS											
11	Band Saw	-	-	23	23	23	23	23	163	23	163
12	Circular Saw 8"	-	-	-	-	-	-	-	-	-	-
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	-	-
14	Single Spindle Drilling Machines 3/4"	3127	3127	3127	3127	3127	3127	9381	9381	9381	9381

S. No.	Description of Machine Group	Products									
		101	102	103	104	105	106	107	108	109	110
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	-	-	-	-	980	10285	3290	-	-	3290
16	4 Spindle Drilling Machines 1/2"	-	-	-	-	4900	-	-	-	-	-
17	4 Spindle Drilling Machine 3/4"	-	-	-	-	-	-	7090	-	-	7990
18	2 Spindle Drilling Machines 1/8"	-	-	-	-	14100	69239	10575	-	-	10575
19	Radial Drilling Machine HMT	-	-	-	-	-	-	-	-	-	-
20	Surface Grinders D-700-SO	-	-	-	-	-	-	-	-	-	-
21	Surface Grinders 18"	-	-	-	-	2333	80520	2333	-	-	2333
22	Surface Grinder 600 R. K.	-	-	-	-	-	-	-	-	-	-
23	Automatic Belt Grinding Machine	-	-	-	-	-	-	-	-	-	-
24	Milling Machines	-	-	-	-	-	105500	-	-	-	-
25	Strip Bending Machine	-	-	-	-	-	-	-	-	-	-
26	Shot Blasting Plant	-	-	-	-	22300	63450	49500	-	-	49500
SHEET METAL SHOP											
27	Spot Welding Machine 25 KVA	-	570	-	570	-	-	-	-	-	-
PRESS SHOP											
28	Surface Grinder 24" x 8"	3917	3917	3917	3917	3917	3917	11751	11751	11751	11751
29	Tapping Machines	4043	5295	5753	7363	5753	5753	13673	15985	14655	15003

S. No.	Description of Machine Group	Products									
		101	102	103	104	105	106	107	108	109	110
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	1091	1561	1091	1561	1091	1091	3273	3273	3273	3273
31	Hydraulic Press 100 Ton	1048	1048	-	1223	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	8096	8816	15435	16378	15497	16751	32572	35047	33466	35449
34	Power Press 40 Ton	208	803	208	803	208	208	624	624	624	624
35	Power Presses 63 Ton	297	600	334	1024	664	334	928	928	928	928
36	Power Presses 100 Ton	460	1697	689	1286	1001	714	2089	1609	1609	2089
37	Guillotine Shearing Machine 6 MM	767	1948	921	1580	1016	985	2997	2738	2587	3156
38	Spot Welding Machine 15 KVA	-	3445	-	4404	-	-	-	-	-	-
39	Tumbling Barrel	-	-	3	3	3	3	3	3	3	3
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	-	-	300	300	300	300	300	300	300	300
41	Bakelite Preform Press	2084	2084	3667	4500	4500	3667	8668	8668	8668	8668
42	Bakelite Preform Presses, 60 & 63 Ton	1850	1850	3283	3283	3283	3823	6983	6983	6983	6983
43	Bakelite Moulding Presses 100 Ton	2867	2867	8567	12366	12366	8567	18100	18100	18100	18100
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	150	160	484	503	503	668	895	965	893	1015
45	Zinc (Barrel) Plating	226	284	227	285	237	806	709	803	801	711

S. No.	Description of Machine Group	Products									
		101	102	103	104	105	106	107	108	109	110
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	-	-	-	-	-	-	-	-	-	
47	Nickel (Vat) Plating	-	-	-	-	-	-	-	-	-	
48	Zinc (Vat) Plating	3050	3050	3050	3050	3050	3050	-	9150	9150	9150
ASSEMBLY MOTOR STARTERS											
49	Hydraulic Press 1 Ton	1364	1364	1364	1364	1364	1364	4092	4092	4092	4092
50	Hydraulic Presses, 5 & 7.5 Tons	860	860	2858	2858	2858	2858	4578	4578	4578	4578
51	Air Presses 4"	-	-	1147	2955	1147	1147	1147	1147	1147	1147
52	Rivetting Machine	-	-	504	504	504	504	504	504	504	504
53	Spot Welding Machines	-	-	3076	3076	3076	3076	3744	3744	3744	3744
54	Electric Drying Oven	284	284	284	284	284	284	853	853	853	853
55	Thermal Relay Winding Machines	1887	1887	5072	5072	5072	5072	8848	8848	8848	8848
56	Vacuum Impregnation Plant	182	182	182	182	182	182	548	548	548	548
ASSEMBLY SWITCHBOARDS											
57	Single Spindle, Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
PAINT SHOP											
59	Spray Painting Machines	-	400	-	1000	1534	6965	2900	-	-	2900
60	Testing Equipment	1075	1075	2094	3681	2094	2094	4244	4244	4244	4244

S. No.	Description of Machine Group	Products									
		111	112	113	114	115	116	117	118	119	120
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	-	-	
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	-	
3	Bench Grinders 8"	1800	1800	1800	1800	1800	600	600	600	300 300	
4	Centre Lathe	-	-	-	-	-	-	-	-	-	
5	Capstan Lathes, 2D.	-	-	-	-	-	-	-	-	-	
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	-	-	-	-	
7	High Speed Turret Lathe	-	-	-	-	-	-	-	-	-	
8	Single Spindle Automats A 15	2208	2208	2814	2208	2814	3744	3744	3744	1336 1336	
9	Screw Slitting Machine	-	-	-	-	-	-	-	-	-	
10	Screwing Machine	-	-	-	-	-	-	-	-	-	
MACHINE SHOP CASTINGS											
11	Band Saw	46	46	46	46	46	3	3	3	- -	
12	Circular Saw 8"	-	-	-	-	-	-	-	-	-	
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	-	
14	Single Spindle Drilling Machines 3/4"	6254	6254	9381	6254	9381	-	-	-	-	

S. No.	Description of Machine Group	Products									
		111	112	113	114	115	116	117	118	119	120
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	1470	-	5470	1470	-	-	-	-	-	-
16	4 Spindle Drilling Machines 1/2"	-	-	-	-	-	-	-	-	-	-
17	4 Spindle Drilling Machine 3/4"	7170	-	11320	7170	-	-	-	-	-	-
18	2 Spindle Drilling Machines 1/8"	8400	-	10575	8400	-	-	-	-	-	-
19	Radial Drilling Machine HMT	-	-	-	-	-	-	-	-	-	-
20	Surface Grinders D-700-SO	-	-	-	-	-	-	-	-	-	-
21	Surface Grinders 18"	2333	-	2333	2333	-	-	-	-	-	-
22	Surface Grinder 600 R. K.	-	-	-	-	-	-	-	-	-	-
23	Automatic Belt Grinding Machine	-	-	-	-	-	-	-	-	-	-
24	Milling Machines	-	-	-	-	-	-	-	-	-	-
25	Strip Bending Machine	-	-	-	-	-	-	-	-	-	-
26	Shot Blasting Plant	27960	-	21480	27960	-	-	-	-	-	-
SHEET METAL SHOP											
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	-	-	-	-
PRESS SHOP											
28	Surface Grinder 24" x 8"	7834	7834	11751	7834	11751	-	-	-	-	-
29	Tapping Machines	11507	12489	15550	11507	16532	1435	1863	2281	374	802

S. No.	Description of Machine Group	Products									
		111	112	113	114	115	116	117	118	119	120
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	2182	2182	3273	2182	3273	167	167	547	167	167
31	Hydraulic Press 100 Ton	-	-	-	-	-	-	-	1198	-	-
32	Fly Press	-	-	-	-	-	-	-	-	-	-
33	Power Presses, Light Duty.	31127	32021	39901	31127	40195	5441	5441	7881	3059	3059
34	Power Press 40 Ton	416	416	624	416	624	-	-	-	-	-
35	Power Presses 63 Ton	668	668	965	668	965	-	56	305	-	56
36	Power Presses 100 Ton	1858	1378	2318	1858	1838	-	-	220	-	-
37	Guillotine Shearing Machine 6 MM	2344	1934	3123	2344	2773	86	100	396	62	76
38	Spot Welding Machine 15 KVA	-	-	-	-	-	-	-	5997	-	-
39	Tumbling Barrel	6	6	6	6	6	8	8	8	8	8
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	600	600	600	600	600	-	-	-	-	-
41	Bakelite Preform Press	9000	9000	11084	9000	11084	1084	1084	1084	1084	1084
42	Bakelite Preform Presses, 60 & 63 Ton	6566	6566	8416	6566	8416	950	950	950	950	950
43	Bakelite Moulding Presses 100 Ton	24732	24732	27599	24732	27599	2350	2350	2350	2350	2350
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	1001	1001	1156	1001	1156	116	116	131	78	78
45	Zinc (Barrel) Plating	474	570	710	474	802	86	138	75	75	75

S. No.	Description of Machine Group	Products									
		111	112	113	114	115	116	117	118	119	120
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating										
47	Nickel (Vat) Plating										
48	Zinc (Vat) Plating	6100	6100	9150	6100	9150	911	1862	911	911	1862
	ASSEMBLY MOTOR STARTERS										
49	Hydraulic Press 1 Ton	2728	2728	4092	2728	4092	817	817	817	-	-
50	Hydraulic Presses, 5 & 7.5 Tons	5716	5716	6576	5716	6576	-	-	590	-	-
51	Air Presses 4"	2295	2295	2295	2295	2295	-	-	-	-	-
52	Rivetting Machine	1008	1008	1008	1008	1008	2383	2383	2383	-	-
53	Spot Welding Machines	6152	6152	6152	6152	6152	3155	3155	3155	1344	1344
54	Electric Drying Oven	569	569	853	569	853	-	-	-	-	-
55	Thermal Relay Winding Machines	10145	10145	12033	10145	12033	4642	4642	4642	-	-
56	Vacuum Impregnation Plant	365	365	548	365	548	-	-	-	-	-
	ASSEMBLY SWITCHBOARDS										
57	Single Spindle Drilling Machines 3/4"	-	-	-	-	-	-	-	-	-	-
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	-
	PAINT SHOP										
59	Spray Painting Machines	1734	-	2900	1734	-	-	-	750	-	-
60	Testing Equipment	4188	4188	5263	4188	5263	-	-	-	-	-

S. No.	Description of Machine Group	Products									
		121	122	123	124	125	126	127	128	129	130
		Millihours for a Batch of Hundred Units									
SWITCHGEAR LABORATORY											
1	Single Spindle Drilling Machine 1/2"	-	-	-	-	-	-	-	3106	9	32
MACHINE SHOP SMALL PARTS											
2	High Speed Drilling Machines 1/8"	-	-	-	-	-	-	-	-	1328	353
3	Bench Grinders 8"	300	300	300	300	4800	4500	3576	3987	5567	4445
4	Centre Lathe	-	-	-	-	-	-	-	-	-	-
5	Capstan Lathes, 2D.	-	-	-	-	-	-	-	-	3675	273
6	Turret Lathe, No. 8 Preoptive	-	-	-	-	-	-	-	-	-	-
7	High Speed Turret Lathe	-	-	-	-	-	-	146	536	13414	12535
8	Single Spindle Automats A 15	1336	1336	1336	1336	45048	38592	29963	60530	23014	31560
9	Screw Slitting Machine	-	-	-	-	21012	4500	8010	4793	10690	13301
10	Screwing Machine	-	-	-	-	-	2332	3393	4050	21005	13183
MACHINE SHOP CASTINGS											
11	Band Saw	-	-	-	-	92	4950	5343	9018	1966	1520
12	Circular Saw 8"	-	-	-	-	-	6250	6333	11465	12728	9172
13	Automatic Cut-off Grinders	-	-	-	-	-	-	-	-	25	9
14	Single Spindle Drilling Machines 3/4"	-	-	-	-	20998	2767	3129	12238	23435	22214

S. No.	Description of Machine Group	Products									
		121	122	123	124	125	126	127	128	129	130
		Millihours for a Batch of Hundred Units									
15	Single Spindle Drilling Machine 1/4"	-	-	-	-	13170	6870	8791	10231	12362	10805
16	4 Spindle Drilling Machines 1/2"	-	-	-	-	4440	12110	19400	23055	30016	30530
17	4 Spindle Drilling Machine 3/4"	-	-	-	-	42690	44130	29223	33981	50615	45722
18	2 Spindle Drilling Machines 1/8"	-	-	-	-	36336	48550	59400	74619	92604	62787
19	Radial Drilling Machine HMT	-	-	-	-	-	-	-	467	5774	1112
20	Surface Grinders D-700-SO	-	-	-	-	-	8917	12555	8468	22350	9885
21	Surface Grinders 18"	-	-	-	-	33666	4833	3169	3961	8178	21508
22	Surface Grinder 600 R. K.	-	-	-	-	14366	7283	6006	1209	19668	19728
23	Automatic Belt Grinding Machine	-	-	-	-	-	8400	5310	8567	27907	10945
24	Milling Machines	-	-	-	-	24588	3300	4154	10722	105637	46778
25	Strip Bending Machine	-	-	-	-	-	-	-	-	1335	388
26	Shot Blasting Plant	-	-	-	-	193120	70400	66430	118545	144194	112317
SHEET METAL SHOP											
27	Spot Welding Machine 25 KVA	-	-	-	-	-	-	-	-	-	-
PRESS SHOP											
28	Surface Grinder 24" x 8"	-	-	-	-	15668	19015	-	-	676	1321
29	Tapping Machines	1220	374	802	1220	35303	19015	14337	32370	6687	10927

S. No.	Description of Machine Group	Products									
		121	122	123	124	125	126	127	128	129	130
		Millihours for a Batch of Hundred Units									
30	Hydraulic Press 30 Ton	547	167	167	547	9452	6861	5550	12775	1621	3630
31	Hydraulic Press 100 Ton	1198	-	-	1198	-	-	-	-	-	-
32	Fly Press	-	-	-	-	-	-	208	-	6465	10244
33	Power Presses, Light Duty.	5499	2087	2087	4519	82776	43104	33000	64742	25395	28836
34	Power Press 40 Ton	364	-	-	364	832	-	-	-	36	70
35	Power Presses 63 Ton	305	-	56	305	4324	4717	4145	8998	1680	2952
36	Power Presses 100 Ton	220	-	70	220	9500	9388	8065	16127	6609	6660
37	Guillotine Shearing Machine 6 MM	372	56	-	365	6400	4163	3304	6213	6173	38013
38	Spot Welding Machine 15 KVA	5397	-	-	5397	-	-	-	-	-	7
39	Tumbling Barrel	8	8	-	8	12	24	-	-	2	-
BAKELITE MOULDING SHOP											
40	High Speed Drilling Machine 1/8"	1174	-	-	-	1200	3252	-	-	45	70
41	Bakelite Preform Press	1084	1084	1084	1084	18000	-	-	72	986	2105
42	Bakelite Preform Presses, 60 & 63 Ton	950	950	950	950	13132	2850	-	63	764	1679
43	Bakelite Moulding Presses 100 Ton	2350	2350	2354	2350	49464	7050	-	157	2497	5034
ELECTROPLATING SHOP											
44	Nickel (Barrel) Plating	93	42	42	54	2127	527	404	553	931	618
45	Zinc (Barrel) Plating	127	75	75	127	3437	5488	5844	10808	10181	6355

S. No.	Description of Machine Group	Products									
		121	122	123	124	125	126	127	128	129	130
		Millihours for a Batch of Hundred Units									
46	Silver (Vat) Plating	-	-	-	-	-	-	430	443	24676	6987
47	Nickel (Vat) Plating	-	-	-	-	-	18443	15604	18420	15348	13957
48	Zinc (Vat) Plating	911	911	1862	911	12200	12509	9415	9768	13970	10941
ASSEMBLY MOTOR STARTERS											
49	Hydraulic Press 1 Ton	-	-	-	-	5456	-	-	-	235	460
50	Hydraulic Presses, 5 & 7.5 Tons	-	-	-	-	11432	-	-	-	451	755
51	Air Presses 4"	-	-	-	-	4591	-	-	-	174	267
52	Rivetting Machine	-	-	-	-	2016	-	-	-	76	117
53	Spot Welding Machines	1344	963	963	963	12304	2889	-	64	711	1540
54	Electric Drying Oven	-	-	-	-	1138	-	-	-	49	96
55	Thermal Relay Winding Machines	-	-	-	-	20291	-	-	-	807	1376
56	Vacuum Impregnation Plant	-	-	-	-	731	-	-	-	32	62
ASSEMBLY SWITCHBOARDS											
57	Single Spindle Drilling Machines 3/4"	-	-	-	-	2338	-	-	-	458	576
58	Single Spindle Drilling Machine 1-1/4"	-	-	-	-	-	-	-	-	-	20
PAINT SHOP											
59	Spray Painting Machines	750	-	-	750	14837	8051	9130	9752	18238	14025
60	Testing Equipment	-	-	-	-	8376	-	-	-	340	600

S. No.	Description of Machine Group	Products	
		Right Hand Side Elements	
		Millihours for a Batch of Hundred Units	
		R.H.S. 1	R.H.S. 2
	SWITCHGEAR LABORATORY		
1	Single Spindle Drilling Machine 1/2"	79,900	79,900
	MACHINE SHOP SMALL PARTS		
2	High Speed Drilling Machines 1/8"	1,59,800	1,59,800
3	Bench Grinders 8"	1,59,800	1,59,800
4	Centre Lathe	79,900	79,900
5	Capstan Lathes; 2D.	1,59,800	1,59,800
6	Turret Lathe, No. 8 Preoptive	79,900	79,900
7	High Speed Turret Lathe	79,900	79,900
8	Single Spindle Automats A 15	3,19,600	1,91,760
9	Screw Slitting Machine	79,900	79,900
10	Screwing Machine	79,900	79,900
	MACHINE SHOP CASTINGS		
11	Band Saw	79,900	79,900
12	Circular Saw 8"	79,900	79,900
13	Automatic Cut-off Grinders	1,59,800	1,59,800
14	Single Spindle Drilling Machines 3/4"	1,59,800	87,890

S. No.	Description of Machine Group	Products	
		Right Hand Side Elements	
		Millihours for a Batch of Hundred Units	
		R.H.S. 1	R.H.S. 2
15	Single Spindle Drilling Machine 1/4"	79,900	43,945
16	4 Spindle Drilling Machines 1/2"	2,39,700	1,31,835
17	4 Spindle Drilling Machine 3/4"	79,900	43,945
18	2 Spindle Drilling Machines 1/8"	12,78,400	7,03,120
19	Radial Drilling Machine HMT	79,900	43,945
20	Surface Grinders D-700-SO	1,59,800	71,910
21	Surface Grinders 18"	1,59,800	71,910
22	Surface Grinder 600 R. K.	79,900	35,955
23	Automatic Belt Grinding Machine	79,900	35,955
24	Milling Machines	3,19,600	3,19,600
25	Strip Bending Machine	79,900	79,900
26	Shot Blasting Plant	79,900	79,900
	SHEET METAL SHOP		
27	Spot Welding Machine 25 KVA	79,900	79,900
	PRESS SHOP		
28	Surface Grinder 24" x 8"	79,900	75,905
29	Tapping Machines	5,59,300	3,35,580

S. No.	Description of Machine Group	Products	
		Right Hand Side Elements	
		Millihours for a Batch of Hundred Units	
		R.H.S. 1	R.H.S. 2
30	Hydraulic Press 30 Ton	79,900	47,940
31	Hydraulic Press 100 Ton	79,900	47,940
32	Fly Press	79,900	51,935
33	Power Presses, Light Duty.	8,78,900	5,71,285
34	Power Press 40 Ton	3,19,600	2,07,740
35	Power Presses 63 Ton	79,000	51,935
36	Power Presses 100 Ton	1,59,800	1,03,870
37	Guillotine Shearing Machine 6 MM	79,900	47,940
38	Spot Welding Machine 15 KVA	79,900	47,940
39	Tumbling Barrel	79,900	79,900
	BAKELITE MOULDING SHOP		
40	High Speed Drilling Machine 1/8"	79,900	79,900
41	Bakelite Preform Press	79,900	47,940
42	Bakelite Preform Presses, 60 & 63 Ton	3,99,500	2,99,625
43	Bakelite Moulding Presses 100 Ton	4,79,400	3,59,550
	ELECTROPLATING SHOP		
44	Nickel (Barrel) Plating	1,59,800	1,51,810
45	Zinc (Barrel) Plating	1,59,800	1,51,810

S. No.	Description of Machine Group	Products	
		Right Hand Side Elements	
		Millihours for a Batch of Hundred Units	
		R.H.S. 1	R.H.S. 2
46	Silver (Vat) Plating	79,900	75,905
47	Nickel (Vat) Plating	79,900	75,905
48	Zinc (Vat) Plating	1,59,800	1,51,810
	ASSEMBLY MOTOR STARTERS		
49	Hydraulic Press 1 Ton	79,900	55,930
50	Hydraulic Presses, 5 & 7.5 Tons	1,59,800	1,11,860
51	Air Presses 4"	5,59,300	3,91,510
52	Rivetting Machine	79,900	55,930
53	Spot Welding Machines	2,39,700	1,67,790
54	Electric Drying Oven	79,900	55,930
55	Thermal Relay Winding Machines	1,59,800	1,11,860
56	Vacuum Impregnation Plant	79,900	55,930
	ASSEMBLY SWITCHBOARDS		
57	Single Spindle Drilling Machines 3/4"	3,99,500	3,75,530
58	Single Spindle Drilling Machine 1-1/4"	79,900	79,900
	PAINT SHOP		
59	Spray Painting Machines	5,99,200	2,99,625
60	Testing Equipment	3,99,500	2,79,650

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