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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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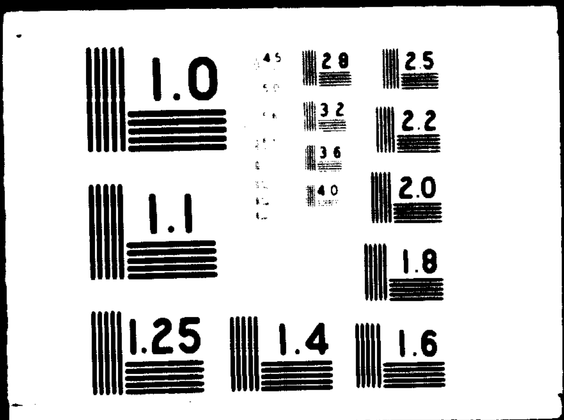

Report of the Interregional Symposium on Metalworking Industries in Developing Countries

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REPORT OF THE INTERREGIONAL SYMPOSIUM
ON METALWORKING INDUSTRIES
IN DEVELOPING COUNTRIES

MOSCOW, UNION OF SOVIET SOCIALIST REPUBLICS
7 September to 6 October 1966

UNITED NATIONS,
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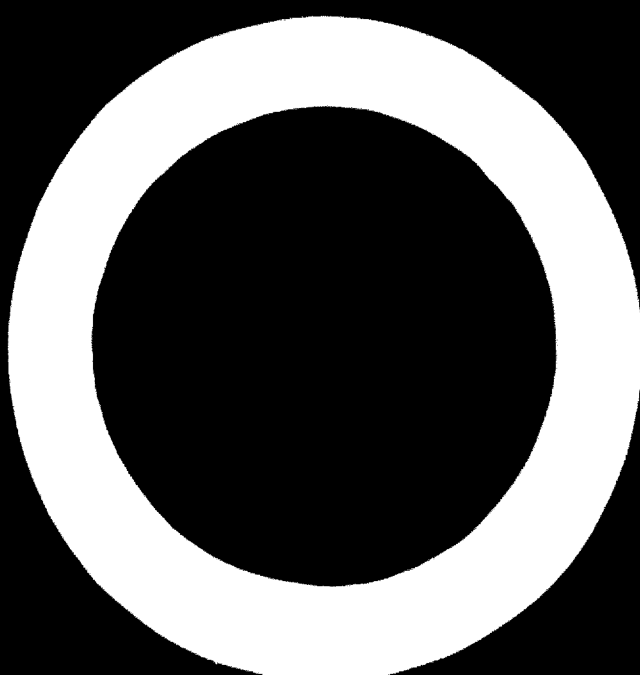

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INTRODUCTION

The Interregional Symposium on the Development of Metalworking Industries in Developing Countries was held in Moscow from 7 September to 6 October 1966, under the sponsorship of the United Nations and the Government of the Union of Soviet Socialist Republics. The Symposium programme was set up jointly by the Centre for Industrial Development of the Department of Economic and Social Affairs of the United Nations, and the State Committee for Science and Technology, the Ministry of Machine Tool Industry, and the Experimental Scientific Research Institute for Machine Tools (ENIMS), of the Union of Soviet Socialist Republics. Participants from 25 developing countries attended.

The purpose of the Symposium was to provide, through the presentation of papers and through discussions, a comprehensive review and analysis of important economic and technical problems concerning the establishment and development of the metalworking sector in the developing countries, and to assure a basis for future constructive action.

The substantive items on the agenda were:

(a) A survey of modern development and trends in machinery production and metalworking practices, and the state of metalworking industries in developing countries;

(b) Trends and problems in the design of industrial machinery and equipment, and in the design of other engineering products in the metalworking sector;

(c) Economic problems of the development of the metalworking industries.

The geographical distribution of the participants was as follows:

Africa	-	6	(5 countries);
Asia	-	12	(8 countries);
Europe	-	7	(5 countries);
Latin America	-	13	(7 countries).

In addition to the above, the Symposium was attended by 26 experts, most of them from industrially developed countries (10), including one expert from the Economic Commission for Asia and the Far East, and two from the Economic Commission for Latin America, as well as by 24 observers from ten countries and an observer from the International Labour Organisation. The attendance of the experts at the Symposium was arranged by the Symposium management.

Forty-one papers from international experts of established reputation in their respective fields were presented. All were followed by intensive discussions on the relevance and application of the subject matter to the circumstances and needs of developing countries in general, and to the specific conditions in the participants' countries.

The complete lists of participants, experts, members of the Symposium management, observers, authors and papers are given in Annex I and Annex II.

To supplement and illustrate the discussions of the Symposium, and to acquaint the participants with a variety of practical aspects of the operations of the metalworking industries, an extensive plant tour was also arranged through the kind offices of the Government of the Union of Soviet Socialist Republics. Tours included visits of exhibitions and of plants in Moscow, as well as a trip to Leningrad, Kiev, and Erevan, in each of which several plants were visited.

The Symposium was opened by Mr. N.K. Grigoriev, Director of the Centre for Industrial Development of the United Nations. Mr. Grigoriev conveyed greetings from the Secretary-General of the United Nations to the participants, thanked the Government of the Union of Soviet Socialist Republics for its hospitality and its efforts in making the Symposium possible, and outlined the format and the purposes of the meeting.

He then proposed that Professor A.E. Prokopovich, Deputy Minister of Machine Tool Industry of the Union of Soviet Socialist Republics, serve as Chairman of the Symposium. Mr. Prokopovich was unanimously elected.

In his address, the Chairman thanked the participants for their confidence in him and welcomed them to the Union of Soviet Socialist Republics. He observed that the example of the growth of metalworking industries in the Union of Soviet Socialist Republics could be beneficial to a number of developing countries in their efforts to build up their own metalworking industries.

Next, the participants were welcomed by Mr. Konstantin V. Ananichev, Director of the Department of International Organizations of the State Committee for Science and Technology of the Union of Soviet Socialist Republics Council of Ministers, and by Mr. O.A. Mikhailov, Chief Specialist of the State Committee for Science and Technology of the Union of Soviet Socialist Republics. A message of welcome from Mr. I.H. Abdel-Rahman, Commissioner for Industrial Development of the United Nations, was also read.

Messrs. A. Ashburn (United States of America), S.M. Patil (India), and R. Matthews (Economic Commission for Latin America), United Nations experts, served as discussion leaders for items A, B, and C respectively, of the Agenda.

The participants elected the following committee to draft a report of the Symposium: A. Adegboye (Nigeria), P.A. Bustos-Soffia (Chile), M.Y. El Hakim (Sudan), R.K. Gejji (India), J.G. Leal de Abreu (Brazil), F. Prades-Sanchez (Spain), K. Shimo (Japan), and M. Trifunović (Yugoslavia).

The Drafting Committee elected Mr. R.K. Gejji as its Chairman.

Mr. I.D. Radović, the United Nations Rapporteur, was also attached to the Drafting Committee. Messrs. A. Ashburn, J. Kaczmarek, M. Kronenberg, R. Matthews, O.A. Mikhailov, A.A. Padogin and S.M. Patil, United Nations experts, served the Committee as advisers.

The Drafting Committee presented its report to the Plenary Meeting of the Symposium on 5 October. With minor modifications, the report was approved and adopted.

In adopting the report, the participants wish to express their gratitude to the United Nations and to the Government of the Union of Soviet Socialist Republics for organizing the Symposium. They also wish to place on record their deep appreciation for the assistance and direction provided by the United Nations experts and the United Nations and Soviet Symposium Management staff.

CHAPTER I. SIGNIFICANCE OF METALWORKING FOR THE NATIONAL ECONOMY[1/]

1. Under present conditions, not even the most developed country can produce the required number, and maintain the necessary technical level, of all machines and other apparatus required for the output of the country. It is therefore necessary to purchase a considerable portion of such equipment from other countries.

2. Organizing the production of industrial equipment in a given country should perhaps be limited initially to those types of machines, instruments and mechanisms that are necessary for the development of the leading branches of its economy, and that are chiefly related to its natural resources. However, there have been numerous instances in which a country, sometimes a developing country, has organized the manufacture of certain products from imported raw materials and competed successfully in the market.

3. It is difficult to give a generalized answer as to what priorities are to be assigned to single branches of the economy in the process of the industrial growth of developing countries. Every case has to be analysed and investigated separately and on its own merits. Several methods of approach are possible. From the point of view of the entire national economy of a country, the main criteria for the choice are based on resources to be allocated to investment, on foreign-exchange earnings and expenditures, and on manpower resources. The capital intensity (capital/output ratio) of the metalworking industries as a whole is near the average of all types of manufacturing, being lower than that of metal-producing or chemical industries and higher than that of most light industries. The foreign-exchange effect depends largely on the proportion of domestic raw materials used. If indigenous production of raw materials is substantial, the metalworking industry ranks high in foreign-exchange earnings or savings. Also, the metalworking

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1/ The metalworking industries produce goods for the various sectors of the engineering industry that are classified as follows by the International Standard Industrial Classification (ISIC):

Manufacture of Machinery, except Electrical Machinery (ISIC 36)
Manufacture of Electrical Machinery (ISIC 37)
Manufacture of Metal Products, except Machinery and Transport Equipment (simple metal products or simple metal manufactures) (ISIC 35)
Manufacture of Transport Equipment (ISIC 38)
Manufacture of Professional, Scientific Measuring and Controlling Instruments (ISIC 391).

The corresponding classes of the Standard International Trade Classification (SITC) are:

Machinery, other than Electric (SITC 71)
Electrical Machinery, Apparatus and Appliances (SITC 72)
Manufacture of Metal, N.E.S. (SITC 69)
Transport Equipment (SITC 73)
Professional, Scientific and Controlling Instruments, Photographic and Optical Goods, Watches and Clocks (SITC 86).

industries are labour-intensive[2]. In less industrialized countries, this is generally considered an advantage, but one which is somewhat counterbalanced by the high demands on the skills and education of the labour force.

Role of the machine-tool industry

4. Within the metalworking industry, the machine-tool industry plays a key role in the expansion of world industrial production, since nearly all other products are manufactured by machine tools or by machinery that has been produced with such tools. This is true for a small pen as well as a giant aeroplane, for typewriters and washing machines, for toys and weapons, for medical instruments and supplies, for agricultural machinery and automobiles. Nations with highly developed metalworking industries enjoy the highest standards of living. Therefore, the industrial development of a country depends to a considerable degree on the number, age, quality and type of machine tools which it possesses.

5. The machine-building industry is fulfilling two basic general functions:

(a) First, the manufacture of means of production, i.e. of equipment and instruments for making various types of products;

(b) Second, production of consumer equipment, such as radios and other means of communication, refrigerators, and other household appliances.

6. One method of assessing the significance of machine tools for the general economy of a given country is to analyse estimates of expenditures for metal-cutting operations in that country. In 1927, about 1.5 million machine tools of all types were in operation in German machine shops. Of these, approximately one million could be classified as metal-cutting machines. Assuming one eight-hour shift per day and 300 working days per year, there were 2,400 million working hours per year spent on machine tools. Using a cost of $US 2 per hour (in 1927), it was estimated that $US 4,800 million was spent yearly in Germany for metal-removing operations. In 1965, expenditures for metal-cutting operations in the United States were estimated in a similar way at $US 34,000 million for the country's metalworking industries - roughly 5 per cent of the nation's gross national product.

State of the metalworking industries: general survey

7. Metalworking industries account for almost 30 per cent of the world's industrial production, measured in terms of value added. Among the major branches of industry, metalworking has shown the greatest increase in production since 1938. The increase has been more significant in the developing countries than in industrialized areas. Nevertheless, the share of the developing countries in the total production of metal products was only 3.9 per cent in 1958, and was the lowest among all major branches of industry.

8. The relative importance of the metalworking industries may be assessed in terms of their percentage share in the total manufacturing output, their contribution to employment, and the value added in the process of manufacture. For example, the percentage production of machinery and industrial equipment of the total industrial output is high in industrialized countries such as Czechoslovakia (34 per cent), East Germany (GDR) (33 per cent), Japan (32 per cent), France (38 per cent), West Germany (FRG) (39 per cent), Union of

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2/ Compared with the average of the manufacturing industries in terms, for example, of the capital/labour and output/labour ratios, or the share of labour costs in the value of output, there are, of course, considerable differences among sub-sections of the metalworking industries.

Soviet Socialist Republics ([illegible] per cent), United Kingdom (40 per cent), United States of America (34 per cent), and low in the less industrialized countries such as Burma (2 per cent), Pakistan (3 per cent), and the Philippines (4 per cent).

9. For the purposes of this report, the developing countries can be classified in three distinct groups, according to the degree of development of their metalworking industries. These categories are:

Group I: Countries whose engineering production is already developed and diversified.

Group II: Countries whose engineering production is in an initial stage.

Group III: Countries without engineering production, or with such production restricted to repairs and simple metal manufacture.

10. The typical structure of the engineering industry in industrialized countries, with percentages estimated for individual branches, is as follows:

Simple metal products	6%
Machinery except electrical	33%
Electrical machinery	24%
Transportation equipment	33%
Instruments, watches and clocks	4%
Total	100%

11. In less industrialized countries where engineering industries have been developed (Group I), the share of simple metal products is substantially higher (20 to 30 per cent can be considered typical), but tends to decrease as engineering production increases. In Groups II and III, available statistics show that the share of simple metal manufacture is still higher (typically, 35 to 40 per cent for Group II, and over 50 per cent for Group III).

12. In developed countries, the production of non-electrical is generally higher than that of electrical machinery (typically by 30 to 40 per cent). In Group I of the developing countries, the production of electrical is twice that of non-electrical machinery. The percentage of the total production of machinery (electrical and non-electrical), which is very low or even non-existent in Group III, increases with the stage of development, and is more than 50 per cent in a typical industrialized country.

13. Industrial machinery and equipment are produced chiefly under the sectors "machinery except electrical" and "electrical machinery". These, of course, produce for other sectors of the economy as well, mainly for agriculture, commerce, and households. The share of industrial machinery is generally higher in more developed countries.

14. As far as the metalworking industries are concerned, the categories can be considered as successive stages of industrial development, each having its special problems which require special measures for the development of engineering industries in general, and for the manufacture of industrial equipment and machinery in particular.

15. Four countries - India, Argentina, Brazil and Mexico - belong to Group I. Each already has an important manufacturing industry, the total number of persons engaged in industry being well over one million for each country. In these four, also, manufacture of industrial machinery and equipment is already diversified. Steel production, already appreciable in these countries, is

expected to increase further at a very rapid pace, so that, except in the case of Argentina, the increasing domestic consumption should be essentially satisfied in the foreseeable future. Thus the most important base of domestic supply of raw materials for the metalworking industries, among others, will be created.

16. This group of countries differs markedly from Group II in regard to meaningful economic indicators, such as value added and/or number of persons engaged (both in total manufacturing and in metalworking industries), steel production and consumption etc.

17. Group II includes Chile, Colombia, Indonesia, Iran, Pakistan, the Philippines, Turkey, Venezuela, and the United Arab Republic. These countries have manufacturing industries engaging between 200 and 500 thousand persons, and a smaller amount of engineering production. Their manufacture of machinery and equipment is restricted to relatively simple products. Steel production is either non-existent or at the beginning stage in these countries. However, their steel consumption of about 400 to 800 thousand tons per year indicates that domestic steel production is economically justified, especially if an anticipated increase in consumption is taken into account. This fact is indeed reflected in the economic planning of several countries in the group. However, it is expected that not more than 70 to 75 per cent of consumption will be satisfied by domestic production during the next ten to fifteen years.

18. Groups II and III are not very clearly distinguishable. The latter is less homogeneous, comprising countries already having appreciable manufacturing activity, together with countries in which there is hardly any manufacturing. Some countries in this group are characterised by a complete absence of engineering production. In others, engineering production is restricted to simple metal manufacturing and repair work. Machinery production is lacking or negligible, steel consumption low, the prospects of a substantial development of domestic steel production are rather remote.

19. Existing practice shows that the maintenance of automobiles, refrigerators, radios, and other equipment by companies of those countries which supply these items may be acceptable during the first stage of development. Industrial progress of a country requires the creation of its own repair facilities and services. This makes possible faster and more economical services both to industry and to the population.

CHAPTER II. REVIEW OF METALWORKING INDUSTRIES IN DEVELOPING COUNTRIES BY REGIONS

Africa

20. The value of the current output of mechanical industries in Algeria can be estimated at 1,000 million francs (new francs) per year. The work force employed in this sector is about 15,000 persons. Basic industries are virtually non-existent: there are no steel plants, no foundries, only several forging shops engaged in simple production operations. However, some larger plants do exist, including one manufacturing electrical cables and three making pumps; there is one boiler shop and several shops for agricultural equipment. Industrial concerns built in the past were engaged chiefly in comparatively simple finishing operations such as assembly of cars, trucks and motors. Some small plants making metallic building components, metal furniture and similar products were also built. The existing mechanical shops were, of necessity, multipurpose in nature.

21. The mechanical industries which were inherited did not satisfy the needs of the country. The situation became worse with the departure of many proprietors of industrial enterprises, and of a large number of skilled workers and specialists, when Algeria achieved independence. It thus became essential to provide for maximum utilization of existing facilities, and to train technical cadres, skilled workers and specialists. The first of these goals has been achieved almost completely, but the second is still far from being realized, although great progress has been made.

22. Plans for the development of mechanical industries in Algeria are well advanced or are already being executed. An increasing amount of equipment is being made in Algerian plants. Work has started on a one-million-ton steel plant which should be in operation by 1969. Plans also include the development of the machine-tool industry, as well as plants for the production of ammonia, phosphates and aluminium, of automotive equipment parts, and plants for mineral processing, among others.

23. The machine-tool industry is almost non-existent in Guinea, except that some plants have machine shops where parts are manufactured mainly for emergency repairs and maintenance. Such shops exist at the Fria Alumina Plant and at the Mack Truck factory in Conakry. Guinea imports most of the equipment, tools and parts which it needs. This raises many serious problems for the country, the most important of which is the need for foreign currency. A substantial portion of the national resources is used for such imports. Nevertheless, many motor vehicles are abandoned because of the shortage of spare parts. The establishment of a national metalworking industry is thus imperative.

24. The prospects for the development of metalworking industries in Guinea are very good. Guinea's deposits of iron ore and high-grade bauxite are among the richest in the world. At present, the country's exports consist of about 560,000 tons of iron ore, 90,000 tons of bauxite, and 430,000 tons of alumina per year. Even without considering other existing metal ores, one can see that Guinea possesses the raw materials for establishing heavy industries.

25. Closely linked to these mineral resources is the hydroelectric capability of Guinea. Preliminary studies show a potential power supply of no less than 6 million megawatts. The Konkoure hydroelectric dam, if constructed, would produce more than one million megawatts. This power could be utilized for the reduction of alumina into aluminium metal, and also for the construction of steel plants. Since steel and aluminium are the most important metals in a modern economy, their availability is a factor that could bring rapid economic development to the country. In the future, Guinea should therefore be able to produce both heavy-duty equipment and precision machines. With this goal in view, the transportation problem is being solved by the building of new railways and the modernization of roads.

26. In order to establish its metalworking industry, however, Guinea would also have to solve two main problems: obtaining the necessary capital and the needed qualified personnel. With close economic co-operation among the West African states, and with help from friendly countries in obtaining capital equipment, technical know-how etc., Guinea should succeed in building up a metalworking industry.

27. Nigeria, with a population of about 56 million and with an area of roughly 350,000 square miles, is rich in mineral deposits. It has potentialities that could make large-scale industrialization possible. At the moment, however, in relation to the size of the country, very few metalworking industries exist to support this industrialization process.

28. Metalworking has already progressed somewhat beyond the stage of mere maintenance and repair of existing plants. There are railways, electricity-generating plants, road and building construction facilities, as well as provisions for maintenance of vehicles generally and of machinery in other industries such as the textile, cement and oil industries. The stage of actual manufacture of simple components and products for local use has been reached. For example, domestic utensils of iron, steel and aluminium of a value equivalent to $US 12 million were manufactured during 1965/1966. For the expanding building and civil-engineering industry, a rolling mill produced bars and rods, valued at about $US 3.4 million in 1965, from local scrap steel, while metal window frames ($US 1.5 million) and corrugated roofing sheets($US 5 million) are manufactured at other plants. Fabrication of metal drums and tanks ($US 6.5 million), and assembly of vehicles, sewing machines and bicycles employ a large number of men.

29. Most of these industries are private enterprises, but without doubt they are aided by the incentives which the Government gives to pioneer industries, such as the Industrial Development (Import Duties Relief) Act, and increased tariffs on competing imported goods. Industrialisation has been mainly on an import-substitution basis.

30. However, the Government has announced its desire to embark on an iron and steel project very soon. This, as well as the Kainji Dam Hydroelectric Project which is in progress, and the presence of oil, natural gas and essential minerals within the country, will give impetus to the development of metalworking industries, lead to the expansion of other industries, and result in the greater welfare of the country's 56 million people.

31. In the Republic of Sudan, industry has developed very steadily since the country gained independence, thus reducing the need for imports. The Approved Enterprises Act (1956) encourages the establishment of industries by means of generous concessions to qualified applicants. "Approved industries" are automatically entitled to relief from business profit taxes, and further concessions may be obtained according to the merits of a project. With the help of the United Nations and developed countries, an industrial research institute, a productivity centre and vocational training centres

were established in the country to help in the improvement and planning of industries. Also, an industrial bank was established with domestic and foreign capital, to help with investments. Many small industries were formed, among them food processing and canning, textile, cement, sugar, plastic, and rubber plants. Extractive industries have not been developed to any great extent, but surveys of mineral resources are now under way, and scrap-iron and steel-smelting mills are under construction.

32. Foreign-trade statistics for 1963 and 1964 show that the annual increase in imports of machinery and metals has been remarkable.

Table 1

Increase in imports of machinery and metals, 1963-1964

	1963	1964
Imported Machinery (units)	325	745
" " (value)	£ 443,000	£ 1,030,000
Ferrous metals for fabrication	29,840 tons	180,000 tons
Non-ferrous metals	1,600 tons	1,900 tons

33. The metalworking industry is now passing from the stage of maintenance of the inventory of industrial and transport equipment to production of simple metal products. The maintenance workshops make simple replacement parts for pumps, engines and machinery. Also, centralized maintenance and overhaul workshops for locomotives and vehicles have been established by the Government.

34. In addition to maintenance shops, the following metal-forming industries are now in operation:

(a) Six aluminium-houseware factories;

(b) Four factories for steel furniture, windows, and construction material;

(c) Two factories producing nails, hinges, pins and clips;

(d) Four factories manufacturing and assembling air and water coolers, air-conditioning units and refrigerators;

(e) One factory producing welding electrodes;

(f) Manufacture of carpentry tools and other metal products.

With the further development of extractive industries, metalworking industries are also expected to advance.

Asia and the Far East

35. The percentage share, in 1962, of the metalworking industries in the total manufacturing output within the ECAFE countries showed wide variations: 16.4 per cent in Australia, 22.5 per cent in New Zealand, 7.1 per cent in China (Taiwan), and 14.4 per cent in India. The percentage share in the total number of persons employed in manufacturing shows similar variations: 24.9 per cent in Japan, 25.2 per cent in New Zealand, 12.4 per cent in China (Taiwan), 16.7 per cent in India, and 24.4 per cent in Australia. In value added, the percentage share of the metalworking industries was: Philippines, 8.8 per cent, Korea, 8.1 per cent, New Zealand, 22.5 per cent, and Australia, 20.3 per cent.

36. The ECAFE region contains more than half the population of the world in less than one-sixth of the earth's land area and has experienced a tremendous rate of population increase. Consequently, the need for increasing the productivity of labour as well as improving the economy of the countries by industrialization is of utmost importance. The proper growth of metalworking industries is one of the key factors in achieving this end. In this region, labour is abundant, but capital scarce; hence the development of labour-intensive metalworking industries is eminently desirable.

37. Employment trends in the metalworking industries in most countries of the region from 1956 to 1963, particularly in the machinery and transport groups, indicate a rapid growth in the more advanced countries (Japan and Australia), and a steady growth in the other countries. The index of employment, based on 100 in 1958, in the machinery industry in Japan rose from 61.5 in 1956 to 137.5 for 1963. In transport equipment, the index rose from 86.4 to 156, and in metal products the increase was from 72.6 to 206 for the same period. In Pakistan, the machinery branch index rose from 102.3 to 171.1 In Australia, the index for metal industries (machinery etc.) increased from 96.9 in 1956 to 121 in 1963. In China (Taiwan), the machinery group increased from 94 to 105, and the transport group, from 85.5 to 105.8; in the Philippines, the machinery index rose from 68 in 1956 to 70.3 in 1963.

38. The metal goods produced in the countries of this region are intended primarily to meet domestic demand, with the exception of Japan, India and Australia. There are, however, consumer goods and machinery items such as sewing machines, bicycles, simple agricultural implements and castings, and metal furniture which can be produced competitively within the ECAFE countries for international markets. It has been possible to manufacture some of these goods at competitive costs because of the relatively low wages in ECAFE areas, coupled with the application of modern technology and the use of efficient machinery. Improved methods of organization and know-how can further reduce production costs.

39. Continued expansion of output can only be achieved with considerable investment both in the improvement of existing facilities and the establishment of new industries. For the immediate future, technological processes must be imported from abroad. Later, as has already been the case in Japan, more and more local designs and production techniques will be developed.

40. Most of the metalworking industries in Asia are of recent origin. In the case of Japan and India, a great portion of the investment has been channeled to capital-intensive metalworking industries. In Pakistan, the Philippines and China (Taiwan), investments have been concentrated in light metalworking industries. However, present and future development plans of the latter countries include investment in heavy metalworking industries.

41. Except for Australia, India and Japan, statistical data on the structure of the metalworking industries and on the demand for and supply of metalworking equipment and products in the region are inadequate. ECAFE is currently engaged in a programme to promote the collection of this information, which is indispensable for planning purposes and forecasting. In the past, forecasts were usually based for the most part on available import figures only.

42. The products manufactured in selected countries in Asia and the Far East may serve to illustrate the various levels of development of metalworking in this region. In Afghanistan, industrialisation, including the establishment of metalworking industries, began only about fifteen years ago. Due to difficulties with financing, availability of skilled labour,

raw materials, etc., progress has been comparatively slow and cautious. Steps that have been taken to provide a sound basis for and to accelerate future growth include increased attention to the training of skilled labour, mineral surveys, plans for a steel plant, and studies of industrial uses of gas as a substitute for coal, in which the country is deficient.

43. The typical pattern of development of metalworking enterprises in Afghanistan has been, as in other developing countries, from repair shops to the progressive manufacture of parts and simple products. Today, metal furniture, simple farm equipment, automotive parts etc. are made locally. Currently, 6,000 bicycles per year are being produced, and the assembly of tractors is under way.

44. Australia is producing a wide range of equipment for food packaging, sugar mills and fibre processing. Prime movers such as diesel engines have been built on a small scale, as well as locomotives, motor vehicles, and bicycles, all of these totalling some 300,000 units yearly. Approximately 70 firms are engaged in pump manufacture, about 700 manufacture agricultural machinery, and 40 produce construction equipment. In addition, scientific instruments, clocks, etc. are being made.

45. No machinery is being produced in Burma at present, but machine-tool manufacturing and the assembly of sewing machines are planned. The production of sheet-metal items and umbrellas is well established. Modern equipment for repairing rolling stock is available, and recently the assembly of bicycles and small trucks was initiated.

46. Hong Kong, though lacking in natural resources, possesses 1,644 metalworking establishments. Small machines as well as diesel engines of up to 80 horsepower are being produced, and lathes, shapers and other machine tools are made by several plants. About 1,000 firms are engaged in the manufacture of various other metal products, including umbrella ribs, fasteners, nails, screws, lanterns and metal furniture. Maintenance shops for aircraft and automobiles are in operation, and recently the manufacture of transistorized clocks was begun.

47. Investment in the industrial sector of India rose from $US 650 million during the First Five-Year Plan (1951-1955) to $US 5,000 million during the Third Five-Year Plan (1961-1965). Of the total industrial investment (equity and long-term loans), that in 66 major undertakings of the Central Government alone stood at about $US 4,300 million at the end of 1964/1965. If current targets are to be reached, the Fourth Five-Year Plan (1966-1970) will require an additional outlay of $US 31,600 million, consisting of government investment in the public sector of $US 18,140 million and from the private sector, $US 1,030 million.

48. Targets for the further advance of the machine-tool industry have not been achieved due to an economic recession. The machine-tool industry is faced with declining production, a high idle capacity of 25 to 30 per cent, and heavy inventories of finished stocks caused by a steep decline in demand by the metalworking industries. This is due to difficulties with the import of raw materials, and in obtaining financing. The metalworking industries may fall short of the production target of $US 63 million for 1965/1966 by some $US 5 million.

49. Over-all economic conditions are expected to improve substantially during the next year or so with the inflow of credit from foreign countries and the improvement of agricultural output. The machine-tool industry should then be able to improve its performance also.

50. Two studies forecasting the demand for machine tools over the period of the Fourth Five-Year Plan (1966–1970) were undertaken with the support of the Government, and resulted in the report of the Working Group on Machine Tools – Group VI, and the study completed by the National Council of Applied Economic Research (NCAER), New Delhi. The Working Group report estimates a demand of $US 1,178 million for the period 1966–1970, and a rate of demand of $US 346.50 million per annum in 1970.

51. Nevertheless, machine tools costing on the order of $US 90 million per annum, about 25 per cent of the total requirement, will still have to be met through imports in 1970/1971, the last year of the Fourth Plan.

52. In spite of the laudable achievement of the Indian machine tool industry in developing indigenous production, the value of imports has increased considerably, from $US 17.58 million in 1956 to $US 70 million in 1965. In order to develop the growth needed to bridge the gap between domestic supply and demand, it will be necessary to increase exports of machine tools, for which an excessive productive capacity presently exists. Exposure of India's products to the world market, it is felt, would not only benefit foreign exchange, but would also bring a host of other indirect advantages, such as the raising of standards of design, quality and efficiency.

53. A steel plant is being established in Western Java in Indonesia; here some 50 manufacturing units produce components for machinery used in the sugar, textile, food processing, and mining industries. Production of aluminium ware is able to meet the domestic demand. Nails, bolts, and screws are also made for domestic use. Each year about 15,000 sewing machines and 200,000 umbrellas are produced, and 15,000 bicycles, 2,000 trucks, 900 jeeps and 100 passenger cars are assembled. Motor-vehicle bodies are made by ten companies. Local production of instruments for medical and dental use averages about 60,000 pieces annually.

54. The metalworking industries in Israel may be divided into five sectors:

(a) Iron, steel, and non-ferrous metal products; structural steel; forgings; aluminium, copper and lead extrusions (pipes and various profiles); cold-rolled aluminium; laminated and welded steel pipes and welded aluminium pipes; a variety of other steel and alloy products;

(b) Food-processing and chemical-processing equipment; farm machinery; machine tools such as lathes (six type-sizes), drilling machines (five type-sizes), eccentric presses (from one to 100 tons), hydraulic presses, mechanical saws, and woodworking machinery;

(c) Small tools necessary for drilling and milling machines and lathes; various tools; high-precision dies for metalworking, plastics and rubber industries; wire products, cans;

(d) Electric motors, transformers and a variety of measuring instruments; communications equipment; electronic equipment; a broad range of electric cables; home appliances; and

(e) Production and assembly of automotive equipment (automobiles, trucks and buses); automotive equipment parts; shipbuilding (up to 5,000 tons).

55. In Japan, according to the estimates by the Metalworking Industry Council commissioned by the Ministry of International Trade and Industry, the demand of metal-cutting machines over the period from 1966 to 1970 will be $US 1,100 million. Imports during the corresponding period will amount to

$US 208.3 million, i.e. 17 per cent of the total demand. Export is expected to be the same, or a little higher than, import, so that domestic production is envisaged to mark $US 1,111 million. Thus, the average percentage of the total import demand during these five years will be around 20 per cent, which incidentally equals the value of exports for the same period.

56. No plant exists in Pakistan for the production of heavy machinery, but plans to establish factories for steam turbines and machine tools are under consideration. In West Pakistan, production of locomotive frames, road-building machinery, and boilers is also contemplated. Over 32 establishments are engaged in the production of textile machinery and 54 in making agricultural machines. Sewing machines are manufactured at a rate of 83,000 per annum. Other products include diesel engines, pumps, compressors, nuts, nails, bolts, hurrican lanterns, hardware, etc. About 300,000 bicycles and 60,000 sewing machines are needed yearly. Surgical instruments are manufactured in great variety, with two thirds of them exported. The country is almost totally dependent on imports of the machinery required for establishing light-metalworking industries, but this situation should be alleviated soon with the construction of modern plants for machine-tool production.

57. Over 400 metalworking establishments exist in the Philippines, employing some 17,000 persons. The products of these firms include steel wire, wire products, bolts, nuts, screws, pipes, castings, welding electrodes, metal drums for food-canning industries, safes, vaults etc. Rolling stock is imported, as are motor vehicles, while bicycles are assembled from imported parts.

Latin America

58. In 1964, the mechanical industries as a group, including manufacturers of metal products, machinery and equipment, as well as electrical and transport products, represented almost 17.0 per cent of the total manufacturing industry in Latin America. With an aggregate value of $US 4,000 million, the contribution of the mechanical industries to the gross national product (GNP) is slightly more than four per cent. In terms of employment, the mechanical industries maintain a labour force of nearly a million persons, or 15.6 per cent of the total employed in the industrial sector of the area.

59. The different levels of development of the Latin American countries, and the particular conditions existing in each, account for the great differences shown by the figures in Table 2. These figures are self-explanatory, but consideration must be given to the fact that, in many cases, particularly for medium and smaller countries, they represent services and mechanical maintenance rather than production proper. The scarcity and unreliability of available data is explained in part by the relatively short history of industrial activity in the region and the low degree of specialisation existing in many mechanical plants.

Table 2

The Mechanical Industries and their Composition in Selected Latin American Countries in 1964

(Percentages)

	Participation of the mechanical industry		Composition of the mechanical industries a/			
	In the gross domestic product	In the manufacturing industry	Metal products	Machinery, other than electrical	Electrical machinery and equipment	Transport equipment
Argentina	8.5	26.3	25.1	24.3	12.8	37.8
Brasil	4.3	17.4	14.5	19.8	22.4	43.2
Colombia	1.7	9.4	38.1	9.3	25.8	26.8
Chile	2.4	12.5	37.3	19.3	19.3	24.1
Ecuador	0.9	5.8	37.5	12.5	12.5	37.5
Mexico	3.4	13.8	28.6	9.0	32.5	29.8
Peru	1.2	6.7	40.0	10.0	16.6	33.3
Uruguay	3.7	17.4	20.2	20.2	27.7	31.9
Venezuela	1.2	9.1	25.3	3.4	14.9	56.3
Others	0.6	3.6	31.1	12.6	8.4	47.9
Latin America	4.0	17.0	23.7	18.7	20.2	37.4

a/ Source: International Standard Industrial Classification

60. On the whole, the mechanical industry of Latin America has reached considerable size and importance. This is due chiefly to the larger Latin American countries - Argentina, Brazil and Mexico - which together account for 90 per of the mechanical industries of the region. In these countries, import substitution of durable consumer goods has attained high levels, and great progress has been made in the production of capital goods. In other countries, however, the limitation of national markets and other factors which will be mentioned below have been serious obstacles to the expansion of this activity, which in many cases does not reflect the possibilities offered by the national markets.

61. Latin America constitutes a market for machine tools that is estimated for 1970 at $US 250 million per year, compared with a production level of about $US 50 million. The lack of great quantities and types of machines offers sufficiently attractive possibilities for the future to justify a detailed analysis.

62. The structure which the Argentine machine-tool and tool-manufacturing industry should try to develop in the next ten years in response to predicted demand is currently under study. Funds for this study were provided by the Banco Industrial de la República Argentina, the Chamber of Machine Tool Manufacturers and the National Development Council (CONADE).

63. The investment required for perfecting the machine tools now being manufactured in Argentina, based on criteria of the Argentine Machine Tool Institute, is nearly $US 14.35 million. This amount would be used principally for the construction of prototypes of new machine-tool models, and for the acquisition of both imported and locally-made machine-tools, to complement the inventory now available to manufacturers.

64. It is estimated that the inventory of machine tools in 1975 will total about 280,700 units, a figure 74 per cent higher than the demand in 1961. This corresponds to an average annual growth of the number of machine tools of 4.5 per cent against 5 per cent for the gross national product and 7 per cent for the metalworking industries. Correspondingly, the number of maintenance machine tools in 1975 should reach 46,700 units. As for replacement needs, it has been estimated that only 20 per cent, i.e. 15,600 of the machines existing in 1963 (machines over ten years old) would be replaced by 1975. Hence, the demand for machine tools for 1965-1975 would amount to 107,000 units for production, 18,100 for maintenance and 15,600 as replacements, giving a total of 141,300 units.

65. Machine tools in the hands of manufacturers amount to 2,000 units, most of them relatively new, with more than 70 per cent less than ten years old. They include an adequate proportion of boring, gear-cutting and grinding machines, owned chiefly by the larger machine-tool manufacturers. The smaller companies possess an incomplete range of machines and therefore subcontract specialized machining jobs, with the consequent disadvantage of lack of control over quality.

66. Between 1954 and 1963, the Argentinean machine-tool industry supplied almost 85 per cent of the number of machine-tool units needed locally. In weight of machinery, the national share fell to 59 per cent, and in cost, to 45 per cent. These latter figures indicate the difficulty of keeping up with technological developments; they also indicate the necessity of perfecting the machine tools now being supplied by the local industries.

67. During and after World War II, the industrialization of Brazil was considerably stimulated by an increasing need for import substitution. The evolution of the mechanical industries led to the construction of plants for durable consumer goods. Capital goods were imported; their production in large quantities began only during the next stage of development. Today's national output of capital goods is equivalent in value to imports, i.e. 50 per cent of the consumption is met by domestic production and the remaining 50 per cent by imports.

68. In 1957, the creation of an automotive industry constituted a great incentive for the development of mechanical plants. The following statistical data evaluate the production for 1965:

Table 3

Production in Brazil in 1965

Steel production	3 million tons (ingots)
Consumption of heavy steel plate	185,000 tons
Consumption of iron and steel foundry	70,000 tons
Consumption of forged steel	53,000 tons
Value of mechanical production $US 1,500, equivalent to	1.3 million tons

69. During the first six months of 1966, 110,000 cars and trucks were manufactured. These and the other data clearly demonstrate the degree of maturity attained by Brazil's mechanical industry. One is led to conclude that the existing limitations on the development of production are mainly of an economic and financial nature.

70. The first stage of development of Venezuela's industries was characterized by the establishing of petroleum, vehicle-assembly and construction industries; and the second, by the decline of Venezuela's external purchasing power, when imports dropped abruptly. In terms of national currency, however, the increasing cost of imports observable from 1960 onward persisted, largely as a result of the devaluation of the bolivar.

71. In 1962, imports of the products of metalworking industries amounted to 309,000 tons, with a value of 1,731.4 million bolivars and an average price of $US 1.5 per kilogram. In determining the priority of new industrial development activities, the National Plan had specified that the policy to be pursued primarily be one of import substitution and that "in this connexion the sectors producing intermediate and capital goods hold out the best prospects".

72. The year 1962 was chosen as the base year for the analysis of substitution possibilities. A preliminary selection of products to be included in the programme was made, taking into consideration not only those cases in which import substituion would be possible almost at oncc, but also those in which it would be desirable because of the technical processes and know-how that would be brought into the country through the manufacture of the articles concerned. To facilitate the selection, imports in 1962 were reclassified into the following ten groups:

(a) Containers and tinware;

(b) Hot-forged and metal products;

(c) Wire products;

(d) Small products primarily stamped;

(e) Small products and parts primarily machined;

(f) Boiler shop products and metal structures;

(g) Sheet-metal work, with or without metal spinning;

(h) Light machinery and machine parts;

(i) Medium-weight and heavy machinery and machine parts; and

(j) Other products.

73. The preliminary selection of products from these classifications was then made as follows:

(a) Comparatively simple metal-transforming products that can be manufactured by relatively labour-intensive procedures;

(b) Products for which manufacturing processes are used that are not yet familiar in Venezuela or that require perfecting, to the extent that such techniques can be introduced through medium- and small-scale enterprises;

(c) Products that are more difficult to manufacture, but are essential for the integration of other activities, i.e. as inputs in more complex metal-transforming processes.

74. In terms of the International Standard Industrial Classification (ISIC), the import levels in 1962 and possible substitution levels appear as follows:

Table 4

Venezuelan Import and Possible Substitution Levels in 1962 (ISIC)

	Imports		Possible Substitution		
	Tons	Value in bolivars	Percentage by weight	Tons	Value in bolivars
Metal products	139,660	338,001	29.4	41,104	140,289
Machinery except electrical	79,077	596,039	24.7	19,544	140,833
Electrical equipment	27,572	275,794	21.4	5,912	52,308
Transport equipment	59,702	417,155	18.4	10,900	63,381
Total	309,014	1,731,209	25.1	77,540	398,101

75. As seen in the table, the extent of possible substitution considered desirable amounts to 77,540 tons, and their value to 398.1 million bolivars giving a unit value of about $US 1.30 per kilogram. This potential output would correspond to about 25.1 per cent in weight and to 23 per cent, or about $US 100 million, in terms of the value of metal products.

Europe

76. The development of the Bulgarian metalworking industries would not have been possible without considerable efforts made in the areas of training, research and development. Today, there are four engineering schools and numerous secondary technical schools in the country. Various institutes concerned with research and development problems in metalworking employ approximately 1,000 professionals.

77. The Bulgarian machine-tool industry was able to achieve its growth partly with technical assistance from abroad, particularly from the Union of Soviet Socialist Republics. The year 1947 can be considered as the one in which the machine-tool industry in Bulgaria began. The growth of this industry has been particularly impressive in the last decade. Today, there are twenty factories that manufacture metalworking machines. These employ over 20,000 workers, the largest having approximately 3,000. The production of machinery, while still centred on comparatively simple types, is being expanded gradually to include specialised and automated machinery, which is currently being imported. Plans for future growth aim for an increase in production output of 200 per cent by the year 1970.

78. Each machine-tool plant has its own design office, concerned mainly with actual production problems. In-plant training courses, in which about 2,000 workers participate every year, also exist in all of these plants.

79. At present, Bulgaria produces more than 120 type-sizes of machine tools, with a total output of over 13,000 units. Plans for 1970 call for an increase to 200 type-sizes and an output of 37,000 units. Currently, 35 per cent of the machine tools manufactured are exported. An increase in exports has been accompanied by increased imports of machine tools, particularly of the complex types.

80. The production of machine tools in Yugoslavia began with the manufacture of simple universal machines of local design. Through the development of the domestic market and the formation of technical cadres, it has been possible gradually to produce more complex and more productive machines. At present, approximately 300,000 workers are employed in the mechanical industries of the country. The yearly output of a total of 400 such industries is $US 1,400 to 1,500 million. Mechanical industries contribute approximately 20 per cent of the total gross national product, and 28 per cent of the total industrial output of the country. The average number of workers per enterprise is 700 to 800, and the annual output per worker is more than $US 5,000 (up from less than $US 2,500 ten years ago).

81. Exports of products of the mechanical industries in 1965 reached $US 300 million, which represents about 20 per cent of the total output. Imports of metalworking products in the same year reached $US 420 million. According to an input-output analysis made in Yugoslavia, the optimal efficiency will be reached in the mechanical industries if the share of exports in the total output of these industries increases to 30 per cent. The main obstacle which exists is the international tariff structure, which does not favour developing countries.

82. The average price per kilogram for domestically produced mechanical products is $US 0.80, and for imported mechanical products $US 1.50. To accelerate the transfer of necessary design and production know-how, it has been the policy of Yugoslav industry to make considerable use of foreign licenses. To date, more than 130 foreign licenses in the field of mechanical engineering have been acquired, with contract terms devised so as to assure the best interests of the Yugoslav economy. Parallel with this, maximal efforts are being made to develop local design and production capabilities. Yugoslavia today manufactures machine tools of the most advanced designs.

83. The experience of Yugoslavia indicates that those of its industrial products are most competitive on the international market which require production in medium-sized or small quantities or in individual units, rather than those made by mass-production methods. This, however, does not preclude large-scale production, especially that of simple products or widely-used assembly parts.

84. Machine tools are manufactured in about 20 Yugoslav plants, approximately fifteen of which are making machine tools exclusively. The annual output of machine tools amounts to 15,000 tons, with a value of $US 25 million. Most of the machines made are universal machines. The total output of machine tools consists of a value of about 75 per cent of metal-cutting tools. Approximately 6,000 workers are employed in the machine-tool industry.

85. Current annual Yugoslav exports of machine tools to about 40 countries, among others the Federal Republic of Germany, Sweden, the Union of Soviet Socialist Republics, Canada, Switzerland, Poland, and Great Britain, amount to $US 5 million. It is estimated that the Yugoslav machine-tool industry could currently support exports of up to $US 10 million.

86. In order to overcome trade difficulties with Western developed countries, which are the largest buyers of Yugoslav machine tools, joint ventures have been undertaken with Swiss and British firms. The parts of several types of machine tools are made in Yugoslavia, and the machines are then assembled in Switzerland and Great Britain. Similar arrangements are now being negotiated with United States firms. Developing countries are also buyers of Yugoslav machine tools. Purchases are made possible for the most part by giving favourable medium-term credits.

87. Plans for 1970 call for an increase in the output of machine tools to $US 50 million and 28,000 tons. Employment in the industry should increase by 15 per cent, and exports to 30 per cent of the total produced. This growth will be based both on the use of foreign licenses and on the development of domestic designs.

88. The world supply of the products of the metalworking industries has increased rapidly in the period since World War II. Production is concentrated, as is to be expected, in the industrialized countries. The share of the developing countries in 1958 in the total production of metal products was 3.9 per cent by value. The typical production-consumption pattern among the industrialized nations in 1958 was to import from 10 to 50 per cent of domestic consumption; in those developing countries which have diversified engineering production, imports range from 50 per cent to 75 per cent of needs; and countries with metalworking industries in an initial stage tend to import from 80 per cent to 90 per cent of their requirements.

89. It is difficult to specify what metalworking products should be manufactured first in developing countries. The technological conditions, the availability of materials, and the structure of demand are different for each country. The only statement which can be made with certainty is that no country, particularly no developing country, should attempt to make all types of metalworking products. From the economic standpoint, it is most advantageous to produce those products which have the greatest value added. This, however, is not always feasible technologically because such goods are often complex and require a larger base of capital and skill than is available in a developing country.

Share of developing countries in world machine-tool production

90. During the last decade, Europe and the United States have continued to consolidate their position as the world's leading machine-tool producing areas. In 1965, the total value of machine-tool production was estimated at $US 5,200 million, an increase of 8 per cent over the 1964 total of $US 4,700 million, and double that of 1955. As in previous years, three countries accounted for over 50 per cent of world machine-tool production in 1965: United States, 28 per cent; Union of Soviet Socialist Republics, 15 per cent; and Federal Republic of Germany, 15 per cent.

91. The share of all the developing countries in world machine tool production in terms of United States dollar value remains only about 4 per cent, and the share of individual developing countries is still very small (for example, India 1.1 per cent, Brazil 0.6 per cent). In contrast to the relative stability of other countries, Japan's production has grown rapidly from 0.55 per cent of world production in 1955 to 5.7 per cent in 1965. During this period, Japan has moved in rank from the fourteenth to the fifth largest machine-tool producer.

Participation by developing countries in machine-tool trade

92. In view of the small share of developing countries in world machine-tool trade, only imports of machine tools into developing countries can be discussed, as their exports are negligible (less than 0.03 per cent of the total world exports). Their share of world imports is also comparatively small, however. The industrialised countries absorbed between four fifths and three quarters of world exports during the period from 1955 to 1962. The average annual rate of increase of imports by the Latin American and Asian countries was higher than that of the industrialized countries during this period (Asia, 19 per cent; Latin America, 16 per cent; industrialized areas, 15 per cent), but their share of world imports did not increase perceptibly. In 1962, the percentage of world imports of machine tools reached 9.5 in Latin America

and 6.4 in Asia. The average annual increase of machine-tool imports into Africa was only 8 per cent over the period, but Africa's share of total world machine-tool imports was only 2.4 per cent in 1962.

93. Annual machine-tool imports into developing countries were not stable from 1955 to 1962. Also, the accumulation of imported machine tools in the developing countries was smaller than the accumulation in industrial countries (in Latin America one seventh, in Asia one ninth, and in Africa one twenty-seventh).

Share of developing countries in world consumption of machine tools

94. The low rate of production and import of machine tools in the developing countries has led to a very low rate of consumption of machine tools as compared to that in developed countries. This gap has widened during the last five years. While world machine-tool production has increased at an average rate of 12 per cent per annum, the developing countries have not only reduced their imports which form the main share of their consumption, but have even decreased their own production in some years.

95. Imports into Asia and Latin America were lower during 1960-1964 than during the 1955-1959 period. The annual increase of imports into Latin America was only 3 per cent during 1960-1962, compared with 26 per cent during 1955-1959. For Asia, these figures were 8 per cent and 28 per cent, respectively, and for Africa, 13 per cent and 6 per cent. Africa has shown a relative increase, but its share of the total imports of machine tools into developing countries is only about 12 per cent. The total consumption of machine tools in the developing countries, though increasing, is only about ten per cent of world consumption. Such a high concentration of supply in the industrialized countries leads to a high volume of international trade, and to the total dependence of a large number of developing countries on imports for their machine-tool requirements.

96. It is not necessary or even desirable that any country plan for 100 per cent self-sufficiency in its machine-tool requirements. However, an effort to bridge the gap between domestic supply and demand of productive equipment is particularly important for resolving the foreign-exchange problems of the great majority of developing countries.

97. This does not imply that the development of machine-tool industries in the less industrialized countries will necessarily lead to a decline in their imports of machine tools from the more advanced nations. Indeed, statistics bear out that the industrialized nations are also the largest importers of machine tools for their own markets. However, the level of imports compared to the total requirements should be considerably lowered.

Machine-tool requirements in developing countries

98. The process of industrialization cannot be accelerated unless the stock of efficient machine tools at the disposal of developing countries is increased. Approximately one machine tool is required for every two persons engaged in the metalworking industries.

99. The determination of the number of machine tools required by a developing country during a given period is a very complicated problem which involves the analysis of the whole programme of industrialization of that country. Regardless of the procedure and method used, a census of the metalworking industry and an inventory of the machine tools available in the country should be undertaken. The following chapter describes in more detail the subject of machinery censuses.

CHAPTER IV. MACHINERY CENSUSES

100. The findings of a machinery census provide valuable information which can help to determine the machine-tool requirements of a given country. A study of the consumption of quantities and types of various machine tools used in the different manufacturing industries of developed and developing countries should also be undertaken in order to provide a basis for an estimate of machine-tool requirements for the industrial development of a country.

101. Starting with a simple count of particular types of productive equipment, machinery censuses can be broken down into classifications by age group, industry, geographic area and size of plant. Given a sufficient amount of detail, such reports can provide the figures needed for effective planning and control by a great number of groups involved in industrial development.

102. In their most direct application, inventories allow plant managers participating in a census to

(a) Gauge the performance of their plants by direct comparison with finished inventory totals and with plants of similar operation on the basis of
   (i) Measured ratios of new to old equipment;
   (ii) Distribution among various types of machinery;
   (iii) Ratios between workers and machines;

(b) Determine the standing of their plants compared to those producing similar equipment in other countries, with whom they compete for international markets.

103. Inventories on the micro level can be utilized by firms that manufacture machine tools, or products such as cutting tools which are used in conjunction with machine tools. Detailed classifications enable firms to obtain information on the nature and location of markets for their goods, and to provide sales arguments to ultra-conservative buyers.

Survey of empirical studies

104. Relatively recent inventories have been taken in ten countries, and practices of procedure have been adopted which a country about to undertake a census for the first time can benefit from studying. The existing censuses have concentrated on the metalworking industries. The view has been that inventories of equipment used for making a product are of greater usefulness than inventories of equipment used for maintenance in other industries or in service shops. The tendency since the original American Machinist study in 1925 has been to use age breakdowns based on five- and ten-year intervals as standards of machine life.

105. In several countries a census is taken on a regular basis. In Canada, Great Britain and the United States of America, the data are collected and analysed by a private publishing company. In France, India, Italy and Japan, this is done by a government agency. The remaining three countries which follow this practice (Argentina, Brasil and Chile) have a census made through co-operation between an agency of the United Nations and agencies of their own governments. The experience gained from these studies suggests that censuses made by government agencies yield a better response to plant questionnaires, whereas those done privately are faster and less expensive.

Organization for machinery inventory

106. Any country planning to conduct a census of metalworking equipment must start with a current list of plants using such equipment.

107. The next step is to select the types of equipment and the industries which are to be included, and to decide in what detail the information will be reported. This may involve obtaining suggestions from government agencies, marketing consultants, and from users and builders of machine tools.

108. The specification of geographical areas within a country whose trading habits are determined by local conditions can also be added to give information about the location of industrial activity.

109. The exact methods of collection and tabulation of data should be fully worked out, and the form and spacing of the questionnaire should then be designed to suit the procedures to be used. Data collection can be made by mail or direct contact; however, the cost of interviewing, both in terms of money and man-hours required, may be prohibitive. A balance will have to be arrived at between the amount of detail which is acceptable and the desired ease of data collection.

110. It is usually desirable to extend the sample results to obtain national figures approximating 100 per cent returns from industries. This is done by assuming that there is a reasonably consistent ratio between number of workers and type of machines throughout all the plants in a particular metalworking industry.

Methodological and operational aspects of machine-tool studies

111. The studies carried out by the Economic Commission for Latin America in the Latin American countries serve as an example which is particularly relevant to the determination of the demand for machine tools. They include applications as well as conclusions drawn from a review of the various data assembled.

112. In general, demand is conditioned by so many different factors that analysing them is a highly complex task. For machine-tool studies, three special considerations related to the demand for capital goods must be included, for they stem from machine-tool characteristics which are highly relevant to the demand in this field. The first is interchangeability of many machine tools for the fulfilment of one and the same function. The second is the dependence of demand on the quality and precision of the products to be manufactured, which means that machine performance must be evaluated. The third concerns the frequency with which technical innovations are introduced, and the emergence of new machining and metal-forming processes.

113. The developing countries need to adopt a methodology which is slightly different from that normally used in the more highly industrialized areas in their study of demand for machine tools.

114. Information for an analysis of demand has to be obtained by means of a survey of the consumer sectors. Some aspects have to be considered with special attention, particularly those related to the size of the sample and its representativeness. Here, the average size of the plants covered by the survey and of those constituting the universe have to be taken into account, since the number of machine tools per person employed varies with the size of the plant, i.e. it is high for small plants and low in the case of larger ones. Plant size is not only an important factor in establishing the total number of machine tools in the inventory, but is also significant for the composition of the inventory. In bigger plants, the types and characteristics of the machines installed are much more varied than in those of more modest size, where the predominant items are usually lathes, shapers, drilling and sawing machines, and a few machine tools for simple forming operations.

115. An important decision that must be made before a survey is begun is whether its scope is to be nation-wide or limited to certain major centres. In developing countries, a high proportion of the metalworking industries is generally concentrated in two or three such centres.

116. The extension of the sample finding to the universe, in order to estimate the total number of machine tools installed, is an important step in preparing the inventory. The extent to which a sample is representative of the universe cannot be measured in over-all terms, but must be evaluated according to the composition of the universe by plant sizes. If the composition of the sample differs greatly from that of the universe, extrapolation must be based on size categories. A direct proportion between the machine tools installed and the man-power employed in the sample and in the universe is possible only when the average plant size is the same in the former as in the latter.

117. In developing countries, an important preliminary step is to find out what proportion of total employment is represented by personnel working in establishments that do not need to use machine tools. Information on the existence of such situations and on their significance, especially in the lower size categories, was gathered in the course of the surveys.

118. To ensure that the survey can be completed successfully and speedily, it is important to reduce the inquiries to a minimum and to prepare the simplest possible questionnaire, which will be easy to answer in the environment under study. In developing countries, using direct interviews has obvious advantages over sending the questionnaires by post, although the latter procedure is less burdensome. The following are the main arguments in favour of the former method:

(a) The certainty of obtaining replies is greater, especially in the case of small and medium-sized establishments;

(b) There is a greater likelihood that the information requested will be given correctly;

(c) The homogeneity of the replies is safeguarded inasmuch as errors derived from wrong classification of the machines or from difficulties with terminology or concepts is minimized; and

(d) The inventories can be inspected and evaluated at first hand.

119. The many and varied problems raised by the projection of demand derived from a large number of factors affect the demand for machine tools. Many of these factors are relatively easy to identify in theory, but their incidence and implications are very difficult to evaluate accurately in quantitative terms. Tentative solutions for this problem must be sought, so that over-all effects can be analysed properly, making use of information on the situation under study as well as information on other countries.

120. The influence of the determinants of demand is reflected mainly in the total number of machine tools and the composition of the inventory. This influence can be interpreted and evaluated by means of certain indicators such as productivity (measured in terms of value added per worker), value added per machine, and the number of machines per person. For the purpose of the studies under consideration, it was thought sufficient to subject these magnitudes to a series of adjustments in order to make them, by means of successive approximations, consistent with one another, in respect to the total projection and the additions to the base-year inventory.

121. Assumptions as to the percentage composition of the new machine-tool inventory were deduced from the following points of reference:

(a) The structure of the inventory in the base-year;

(b) Changes in the apparent consumption of machine tools;

(c) Specific manufacturing projects and development programmes, particularly in certain branches of the metalworking industries; and

(d) Breakdowns of inventories in other countries at different stages of their economic development.

122. The difficulties of estimating demand for machine tools in qualitative terms, and specifying the required models, types and characteristics so as to define this important aspect of future demand, are considerable. It was therefore decided that an over-all qualitative evaluation should be based on the average weight of the machines and their average price per kilogram.

123. Thus, machine-tool requirements were established in terms of the number of units and the types of machines, with the indication of quality expressed in weight and average price.

CHAPTER V. SOME SPECIAL CONDITIONS RELATED TO ESTABLISHMENT AND PROMOTION OF METALWORKING INDUSTRIES

124. Detailed and comprehensive investigations of prevailing conditions are necessary in order to give substantial and immediate help to developing countries in the establishment of engineering industries. These investigations must cover both the technical and the economic problems. Abstract generalizations of the experience of industrialized countries and excessive simplifications in the description of local problems of technological development should be avoided. Instead, extensive information on the experience of at least some of the developing countries has to be gathered.

125. It must also be kept in mind that metalworking industries in many developing countries, for instance in those of equatorial Africa, are only in formative stages. Here, organizational problems seem greater than technical ones, and assistance is more often needed in solving the former than the latter.

126. If use is made of available information on the promotion of manufacture of industrial machinery and equipment in less-industrialized countries, together with experience gained in industrialized countries, it is found that appropriate scientific and technological knowledge and an increased scale of operations must be considered as important pressing needs. Information on capital output and capital labour ratios indicates that the burden of investment costs is less crucial than, e.g. in chemicals or metal-producing industries. A smooth and organic growth, requiring only small investment resources at the beginning of the development period, is possible. The labour force of the industry, from the skilled or even semi-skilled worker to the engineer or scientist, contributes most to the factor of knowledge. Technological (or industrial development) institutes, a widely discussed national means for providing external scientific and technological information, and patents or licensing, utilized to provide such information from abroad, also need to be promoted.

127. These activities should go hand in hand with a study of equipment and processes in foundries and forges which are often under-utilized and could serve a great number of machine-building companies. Also, in some cases the possibilities should be investigated of using techniques which do not require highly-skilled manpower, and numerically-controlled machine tools.

128. An important part of the manufacture of industrial equipment, of complicated machinery in particular, in developing countries is carried on through extensive co-operation with some industrialized countries, ranging from contracts to provision of blueprints, know-how and training of personnel, to the establishing of subsidiary companies. Technological knowledge thus obtained from abroad is very useful, and often constitutes the only possibility open to a developing country. However, excessive dependence on foreign sources of technological information may also have adverse effects at a higher level of development, e.g. in slowing down the process of adaptation of product design and production methods to local conditions, or in lessening the possibilities of competing in foreign markets.

129. The experience accumulated by the Union of Soviet Socialist Republics in a number of metalworking technical-assistance projects (machine-tool plants, mechanical factories, foundries etc.) leads to the following conclusions:

(a) Machine-building projects in a given developing country cannot be considered separately, but only as a part of general plans for industrialization;

(b) A modest universal mechanical workshop is indispensable for beginning the industrialization of a developing country. The purposes this serves are:

  (i) Repair of industrial equipment;
  (ii) Production of parts and simple machines to satisfy the needs of other industries;
  (iii) Transportation and farming operations; and
  (iv) Training of skilled workers;

(c) Initially, only a limited number of general-purpose machines should be made. These have broad applications as well as possibilities for export;

(d) Supporting industrial facilities, foundries in particular, must also be provided for;

(e) Feasibility and working plans for metalworking plants in developing countries must be based on sound technical and economic premises and take into account all relevant considerations. Local professional capabilities should be used as much as possible in the formulation and development of various projects, in order to develop local cadres and accelerate project implementation;

(f) All metalworking projects must provide for production technologies, necessary instrumentation, and the training of specialists and workers. These problems should be solved with the co-operation of the countries giving technical assistance;

(g) Conditions should be created for the training of designers and technologists who could be engaged in the beginning in designing simple tools and fixtures and, when they become more experienced, could start designing their own machine tools.

130. During India's First Five-Year Plan (1951-1955), indigenous production of machine tools was very low and confined to the manufacture of low-priced tools intended mainly for repair workshops and training institutions. Requirements of the engineering industries, about $US 42 million, were met mainly through imports.

131. The machine-tool industry showed a capacity for accelerated growth in the Second and Third Five-Year Plans (1956-1965). Indigenous production rose from about $US 2.27 million to $US 55.59 million, an almost 25-fold increase over ten years. The percentage of local production in total requirements increased for the same period from 11.44 per cent to 38.54 per cent, and capital investment in the industry, which stood barely at $US 2 million in 1956, advanced to $US 77 million in 1965.

132. The over-all effect of this rapid growth has been that the country has become nearly self-sufficient in the production of general-purpose machine tools, and has begun to manufacture more sophisticated types of machine tools of higher productivity suitable for use in mass production of automobiles, scooters, electric motors etc. In the transition toward quantity production and production of more sophisticated machines, considerable capital, skilled labour, and engineering design know-how will be required.

133. The reasons for the rapid growth to date include:

(a) Rapid expansion of the capital base of investment in industry, rising from $US 650 million in the First Plan to $US 5,000 million in the Third Plan, due to

   (i) Very heavy government support of the industrial sector, and the success of public undertakings, e.g. the significant contribution of Hindustan Machine Tools Ltd., which has accounted for roughly 47 per cent of indigenous production of machine tools since 1956, and

   (ii) Increased investment in the private sector;

(b) The policy of the machine-tool industry to enter into agreements for designs by and technical collaboration with well-known foreign firms, thus substantially

   (i) Aiding diversification of the product range, and

   (ii) Aiding the development of India's own design and manufacturing skills;

(c) The high priority and consideration which the machine-tool industry holds in the Government's planning, industrial licensing, allocation of scarce foreign exchange, issue of import licences etc., through

   (i) Direct liaison with ministerial-level agencies concerned with the development of the machine-tool industry, and

   (ii) Co-operation with the Indian Standards Institution and Development Council for Machine Tool Industry in setting up standards and formulating broad policies;

(d) Creation of a protected market for indigenous production, resulting from the ban on imports of certain types of machine tools which are produced in sufficient numbers internally, thus

   (i) Enabling the industry to establish itself firmly while easing the drain of foreign reserves, and

   (ii) Generating a spirit of internal competition which has served to raise design and production standards and to check the rise in prices of machine tools.

134. Investments in machinery and equipment in metalworking sectors generally average more than half of total investments in fixed assets. The foreign exchange required to satisfy the substantial import requirements of these sectors can be raised through drawing on foreign-exchange earnings or reserves of the countries concerned, or through grants and loans obtained from abroad.

Import restrictions

135. Expanded import-substitution programmes for metalworking products, especially of the more simple types, are within the capability of many developing countries. Such programmes have already been undertaken in some areas either by banning imports of goods which can be produced internally, or by applying high tariffs on imports. This generally has enabled nascent indigenous industries to establish themselves. Too often, however, import substitution has had an adverse effect for the user, namely, reduction in quality, or the inability to obtain precisely that machinery which makes his own production most economical. Non-selective protection also does not assure that new industries will develop with the infrastructure that will form a sound basis for future industrial expansion.

136. The specific steps taken to protect the development of local industries by restricting imports vary from country to country. Some, like Brazil and India, have a register of machinery and equipment which cannot be imported and must be purchased locally. In other countries, no such lists exist, and every import application is judged on its individual merits.

Exports

137. It must be pointed out that the importance of machinery exports cannot be evaluated only by the foreign-exchange earnings. Exporting always raises the industry's effectiveness regarding costs as well as its technical capabilities, besides indicating to equipment users within the exporting country that the quality of machinery being produced internally has reached the level of international acceptance. Export has to be viewed, *in toto*, as a major incentive for the development of production of industrial machinery and equipment. The importance of exports is not measured only by its size, but also by its impact on the whole course of industrial development.

138. Trade, whether at the national or international level, raises the question of acceptance standards. An attempt to solve this problem for machine tools was made some 40 years ago with the application of Schlesinger Acceptance Tests. The principles behind these tests are still valid, but the concept must be updated to take into account a variety of new technological and economic developments. At this time, the International Organization for Standardization would seem to be the appropriate body to undertake such a task. It should be kept in mind that the strict and injudicious application of international acceptance standards could seriously handicap or even cause the elimination of many small and medium-sized plants in developing countries whose levels of technology are relatively low, and would thereby slow down the development of local industries.

139. A possible solution would be to adopt homogenous acceptance standards for an entire region, and to organize centres for inspection of machinery and equipment, as has been suggested by ECAFE.

Experience of selected countries

140. The Government of Cambodia has encouraged industrial production in the private sector by granting exemptions from customs duties on imports and materials necessary for metalworking and other manufacturing industries. Under the current Five-Year Plan, a National Development Fund Organization has been created to extend financial assistance to small manufacturing industries.

141. Restrictions on imports and the complementary measures for the protection of domestic industries have furthered the growth of industrialization in Ceylon.

142. In Malaysia, a Malayan Industrial Development Finance Organization was established, and tax relief is awarded to pioneer industries. Anti-dumping legislation has also been enacted.

143. An acute shortage of foreign exchange appears to be the main reason for the Indian Government's restrictive policy on imports of machine tools. In addition, an incentive is given to the domestic machine-tool industry by the Government through its banning of imports of certain types of machine tools which are being produced in sufficient numbers in India. These factors explain the creation of a protected market for machine tools. In many respects, this is not a healthy situation for the industry; it must nevertheless be admitted that it has given considerable stimulus to the Indian machine-tool industry, and has helped to generate a spirit of internal competition that has served to raise design and production standards and to curb price increases of machine tools.

144. India is one of the very few developing countries trying to export their machine tools. Most of its trade is with Eastern European countries, since the value of India's imports from and exports to these countries is approximately equal. In the case of the United States of America and Western Europe, the balance of trade is heavily weighted against India, and the promotion of sales is far more difficult. The experience of India, on balance, disproves the opinion that there is no scope for exports of metalworking equipment and other products from developing to industrially advanced countries.

145. To encourage industrial development in Thailand, an Industrial Promotion Investment Act was published. This Act grants examption from business taxes on machinery under certain conditions, irrespective whether the tax-exempt person is a trader, producer or importer. A tax holiday for a period of five years is granted, starting at the time when the individual or company first sells its products or gains an income.

CHAPTER VII. INVESTMENT POLICIES - FINANCING AND FOREIGN INVESTMENT

Capital budgeting at the national level

146. To assure optimal utilization of scarce capital resources, expenditures for plants and equipment should be carefully analysed. This is true equally for government and for private expenditures. As the metalworking sectors are the main suppliers of durable capital goods in an industrializing economy, emphasis must be placed on the problems of capital accumulation, on growth and on replacement in those sectors.

147. For a decision on priority of investment within the sector and within specific projects, it must be possible to rank the available alternatives by some measure of effectiveness or by a merit rating showing the contribution of each alternative to over-all investment goals. With such a measuring device, that alternative would usually be selected which, over a given period of time and per unit of capital invested, produces the greatest marginal increase in the chosen measure of effectiveness. A somewhat simpler criterion would be to eliminate all those alternatives that produce less than a threshold or cut-off value in the measure of effectiveness. This might be a minimum on investment of X per cent, or a minimum increase in productivity of Y per cent.

148. The recognized technique which makes such cost-benefit calculations possible is the discounted-cash-flow (DCF) or present-worth procedure. However, this method, while giving the over-all yield of a specific investment when interest, project life, capital investment and operating expense, are specified, does not show the effect that an investment will have upon the internal structure of the economy. Thus, the DCF approach reveals whether it is more profitable in money terms to invest in a tractor or passenger-vehicle plant, but does not indicate how many additional bushels of grain can be produced if this plant exists, or how many more lathes need to be imported. This kind of answer is vital to the growth of an economy. Therefore, input-output analysis may be used effectively instead.

149. This technique traces the effect of an investment in one sector upon the other sectors in the economy and the effect on imports and on the final bill of demand available to consumers. For example, in the United States of America, isolating the metalworking sector shows that nearly one third of the total combined output of this sector involves transactions within it, e.g. among machine-tool builders purchasing from component producers and manufacturing for automobile makers. If the desired final demand for a product, for example, electrical machinery, is specified, input-output analysis can reveal the capital investments needed in the other manufacturing sectors, such as transportation, basic metals, agriculture, services, imports etc., to make that output possible.

150. Preparation of input-output tables over a number of years can also reveal technological changes in particular sectors and their effect at the macro level. The main obstacle to input-output analyses in most developing countries is the lack of necessary statistical data. This difficulty can be partially overcome, however, by taking information available for other countries with similar conditions of development, and adapting them to local requirements.

Foreign investment and its significance for the metalworking industry

151. The capital required as an initial investment in industrial equipment may represent a substantial commitment for a developing country in terms of a percentage of the total reserves available. This fact, coupled with political considerations, raises questions about the stable growth of the developing country. Possible local or international instabilities present risks for both the seller and the purchaser of equipment. In this respect, the metalworking industries may be in a slightly better position than some other industries to encourage foreign investment, since the available information on capital output and the capital/labour ratios indicates that the burden of investment costs is less in the manufacture of industrial machinery than in the case of chemical or metal-producing industries. A possible alternative, also, is a smooth and organic growth, requiring only small investment resources at the beginning of the development.

152. Sufficient technical know-how has often been lacking in the developing countries even when capital has been available. As a result, collaboration with foreign companies in the use of designs and manufacturing techniques under licence has been widely practiced in the metalworking industries to the point of almost complete dependence. It is well recognized that it is often cheaper and easier to import technological knowledge than to develop it in the country. On the other hand, there are current indications that plants being set up mainly to surmount tariff or foreign-exchange barriers (these plants being subsidiaries or licensees of a foreign enterprise) have no plans for exporting goods. Thus, the policy of the foreign investor toward export needs to be clearly understood before contracts are concluded, especially when several foreign companies are interested in setting up subsidiary plants.

Financing

153. Automated machinery is usually acquired by developing countries either through a co-operative joint venture with an international corporation, or through a government loan or guarantee. In the first case, the developing economy may induce the corporation to build and operate an automated plant by providing trade, tax, or other concessions. Thus the equipment is not purchased directly, but by concession, i.e. through partnership or other form of payment in lieu of immediate cash. In the second approach, a government may be induced to provide the purchaser with a loan, or the seller with a guarantee, usually through banking channels.

154. While lower acquisition cost may make the purchase of second-hand industrial equipment more attractive where a shortage of capital exists, it is more difficult to obtain credit for such purchases than for new equipment. Financing is usually tied to the more general problem of shortage of foreign exchange and the need for credit. If this problem exists, most imports are financed by inter-governmental long-term credit arrangements or through private foreign investment. To reduce the strain on the exporting manufacturer, it is also customary to make supplementary banking arrangements which enable the manufacturer to receive cash for the bulk of the value of the export order at the time of shipment. The problems of financing are greatly reduced when governmental arrangements exist to provide the developing country with foreign exchange, as is the case in the United States Agency for International Development (USAID) programme for excess property.

Experience of selected countries

155. Continued expansion of output has been achieved with considerable investment both in the establishment of new industries and in improvement of existing facilities. The trends of investment vary from country to country. In the case of Japan and India, the major portion of the investment has been

channeled to capital-intensive metalworking industries. In Pakistan, the Philippines and China (Taiwan), investments have been concentrated on light metalworking industries. However, the present and future development plans of these countries include considerable investment in heavy metalworking industries as well.

156. One factor which has contributed greatly to the growth of the Indian machine-tool industry is the assistance which it has received from the Government. In the economic planning of the country, the machine-tool industry had a high priority, particularly during the Second and Third Five-Year Plans. However, no special tax concessions are given to the Indian machine-tool industry.

157. The contemplated goals of the development of the Brazilian machine-tool industry include an increased volume of production and improvemente in quality. Attaining these goals will require incentives and facilities from the Government, as well as a considerable investment in imported machines. To enable the machine-tool industry to solve the financial problems associated with its development, the following would have to be made available: long-term financing for the purchase of heavy machinery, all of which must be imported; medium- and short-term financing for the purchase of lighter machines, most of which would also be of foreign origin; and financing for studies and construction of prototypes of new machine tools to be made locally.

158. With collaboration between international credit organizations and domestic and foreign resources, a fund for the acquisition of industrial machinery has already been established. The fund covers up to 60 per cent of the amount needed for a period of two to five years. On the other hand, the Inter-American Development Bank has issued a ruling on the financing of interregional exports of capital goods designed to make Latin American exporters competitive with suppliers from other areas.

159. Investment requirements for the expansion of metalworking activities in Venezuela are estimated, at 1960 prices, at $US 143 million, which is more than half the figure for the entire manufacturing industry of the country. This proportion is explained by the influence of the markedly capital-intensive basic and petroleum industries on the over-all figure.

160. Plans for the financing of investments drawn up by the Venezuelan Development Corporation are in accord with the requirements of the present import-substitution programme, particularly with the method of renting fixed assets. The latter may well become one of the most effective instruments for promoting industrialization, especially by forming small- and medium-scale industries. It is advisable, however, to study a credit system that would meet working-capital requirements and would provide for the metalworking industries an amount equal to or exceeding that of the value of the fixed assets.

CHAPTER VIII. THE ROLE OF REGIONAL CO-OPERATION

161. In machine building in general (except in mass production), some of the specialized equipment, such as machine tools producing large and heavy parts, is never utilized to full capacity when operated for one particular factory only. In order to make more effective use of such equipment, which is often very expensive and complicated, different factories may co-operate through a system of sub-contracting. This can be developed as a very useful and general method to ensure effective utilization of plant facilities and skills within the industry. Many of the parts, components, raw materials or accessories utilized in machine building are identical, similar, or produced by identical processes, while the amount required by a single factory is below the limit which permits operation of the plant facilities by advanced and highly productive methods.

162. It may therefore be advisable in such cases, principally for castings and forgings, to concentrate production in a few well-equipped plants which serve a large number of factories as suppliers of industrial equipment and machinery. Such specialized machine-building plants must be designed to handle an adequate volume of production. They should utilize modern technology and organization, rather than being designed as small-scale shops which would obstruct technical and economic progress.

163. Research on the experience of developed countries in the field of maintenance of machine tools carried out by the Experimental Scientific Research Institute for Machine Tools (ENIMS), Moscow, since 1959 shows that establishing centralized rebuilding shops in a country has significant advantages over maintaining individual repair shops in a plant. In a specialised rebuilding plant, complete machine overhaul requires only 40 per cent of the labour time necessary for the manufacture of a comparable new machine. In addition, production costs are about 20 per cent lower than in individual rebuilding shops. In developing countries where industry tends to be concentrated in selected areas, conditions are favourable for establishing such centralised plants. This would not only reduce costs, but would also allow the use of more modern methods, and require a smaller number of highly-skilled personnel. Negative aspects are the fear of damage to equipment used on the basis of regional co-operation, and the elimination of the pride of personal ownership of the artisan who refuses to let others use his tools.

164. Even with optimal application of the methods indicated above, it is improbable that engineering industries of developing countries could attain a satisfactory scale of operations without active participation in the international division of labour, i.e. without exports. A start towards this goal could be made by regional division of labour, consisting of the manufacture of different parts, units and aggregates for general machinery, among neighbouring developing countries. The size of the engineering industries of developing countries belonging to Group I 1/ is comparable, at least in regard to the number of employees, to that of the smaller industrialised countries. However, while exports of the former are insignificant, the latter export about 50 per cent of their engineering production and import as much or more, which results in economies made possible by the resultant narrower specialisation of the domestic production. For countries belonging to Group III 1/,

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1/ See Chapter I, paragraph 9.

pooling of resources and planning on a sub-regional or regional scale can be considered as a pre requisite even in the initial stages of the manufacture of industrial equipment.

Experience of selected countries

Asia and the Far East

165. Several countries within this region have made arrangements for an exchange of study teams in metalworking industries. It would be particularly valuable if arrangements for regional co-operation could also be made for the purpose of training labour in less developed countries by means of exchange with newly-established metalworking factories in better-developed countries. This would provide the workers with well-rounded experience in some of the practical problems encountered in the establishment and operation of new factories.

Latin America

166. A study by the Economic Commission for Latin America on "The Metalworking Industries in Latin America" reviews the equipment required for the projected expansion, from 1961 to 1970, of the petroleum, electric, steel, cement and paper and pulp industries. This study showed that the share of equipment that could be made by domestic industry is about 80 per cent of the total, at prices competing fairly well with imported equipment.

167. According to another ECLA study on the "Manufacture of Machine Tools in Developing Countries: The Case of Brasil", machine tool consumption for the period 1967-1971 includes 65 per cent domestic production, against 38 per cent for the period 1955-1961. The industries in question are representative of the heavy industries as a whole. Machinery and equipment for light industries are obviously easier to produce. If the Brazilian figures are accepted as an indication of the share of feasible domestic production, and if increasing co-operation between developing countries is assumed, it seems reasonable to admit the possibility of a share of domestically-produced industrial machinery and equipment of about 60 to 70 per cent for 1975. However, such forecasts may have to be relaxed in view of the industry's performance during 1963/1964. These years saw a marked reduction in apparent consumption of machine tools, mainly because of drastic cuts in imports from the 1962 level of 16,118 tons to 3,995 tons in 1964, and a decrease in the rate of expansion of domestic production in 1962 and 1963, with the production level in 1964 of 15,778 tons somewhat lower than that in 1962.

168. <u>Venezuela's</u> long-range projects for exports and integration in a regional plan for the manufacture of the more complex products of the metal-transforming industry depend on the successful implementation of the present import-substitution programme, and on the development of the required technical infrastructure and skilled manpower over the next several years. Only after this stage of industrialization has been reached is it fruitful to consider the implementation of a programme for the manufacture of heavy machinery and equipment as envisaged for the Guiayana area, and to begin complementary activities such as the production of motor-vehicle parts.

169. The idea of regional co-operation should be extended to include other common facility centres, comprising tool rooms, equipment for heat treatment, electro-plating, inspection and testing of materials, in relatively densely industrialized areas. Regional co-operation could also include the following:

(a) Production of castings and forgings;

(b) Manufacture of general industrial equipment;

(c) Establishment of companies which could provide design and engineering services for a number of industrial enterprises.

Such facilities would be of great value in strengthening the industrial base of a country, and in improving the quality of the products.

170. Co-operation of developing countries seems to be an easier way to promote exports of machinery than to export to industrialised areas. In regard to competition with industrialised countries, the high labour intensity of machine building is an advantage for developing countries in importing machinery. The potential demand in developing countries, taken as a whole or by regions, is important enough to permit a sharp increase in the production of industrial machinery in these countries.

CHAPTER IX. QUALITY OF PRODUCT

171. There is an ever-increasing demand for higher precision in the fabrication of parts, surface finish, stability and reliability of operation of technological equipment. The characteristics of technological quality, which will be referred to below simply as quality, are dimensional accuracy, surface finish and physical properties of the upper layer. Needless to say, no metalworking industry can long succeed and prosper without constantly striving for improvement of these characteristics.

Dimensional Accuracy

172. Accuracy must be built directly into a machine. Surfaces must be flat and perpendicular or parallel to each other; slides must move along straight lines and spindles rotate about defined axes. Among the many factors affecting the accuracy of modern machinery, one of the most important stems from the fact that the quality of the majority of component parts depends on cutting processes.

173. As movements of components are often amplified several times during the process of arriving at the finished product, small dimensional errors in the machining of individual parts tend to cause greater inaccuracies in the final product. Even in equipment not requiring substantial movement in its operation, individual errors in components tend to be additive rather than to cancel each other. For machine tools, inaccurate semi-finished products can almost double the normal material losses in chips in the cutting process. The observance of technically-justified machining tolerances may reduce material losses by 20 per cent to 50 per cent.

174. In spite of the development of increasingly more precise machining tools and measuring techniques, accuracy is often an elusive characteristic. This is not only a matter of having well-trained mechanics operating well-maintained equipment. Every skilled machine tool operator is well aware of the fact that his machine may perform differently in the morning and in the afternoon, rendering it necessary to reset his tools, adjust gibs, and carefully watch the accuracy of his workpieces. This is due to thermal expansion, which affects the accuracy and surface finish of the workpieces, and therefore cannot be disregarded. This applies to plants where high accuracy is required, and also to plants located in climates where there is considerable temperature variation during a working day. A machine tool left standing idle overnight warms up and attains thermal equilibrium only after one to two hours. Automatic size control minimizes the amount of scrap caused by thermal effects; nevertheless, it is very important to know how a machine tool reacts to changes in temperature.

175. Vibration, with its adverse effect on tool life and accuracy, is also often due to thermal effects. Metal-to-metal contact may occur in the bearings when the machine is cool and the oil supply insufficient, but vibration caused by such contact subsides when an adequate quantity of oil reaches the bearing, although the spindle may rise due to thermal expansion of the housing. Front and rear walls of machine tools may expand at different rates, causing distortion of tool beds and other elements.

176. Checks of dimensional accuracy have been improved considerably with the development of the laser principle; light waves are used to measure table displacements, and these are converted into linear dimensions by a computer.

Surface finish

177. Surface finish also plays an increasingly important role in modern production methods of the metalworking industries. The demand for better methods of producing and measuring surface finish is increasing. Some of the difficulties involved in making quantitative comparisons of surface finishes on an international basis are due to a lack of standardized definitions. Surface designations in micro-inches or micro-millimeters may mean different amounts of deviation in different countries. Sometimes the difference between the greatest depth and the greatest peak (roughness valley) is used as a measure, and sometimes the average of a number of measurements.

178. One method in current use for producing high-quality surface finishes is that of super-finishing by means of oscillating grinding stones. It has been found essential to complete all operations on the same machine, including drilling and boring, leaving only the grinding as the final operation.

Upper-layer quality

179. No less important from the point of view of quality are the geometric and physical properties of the upper layer. This subject has received comparatively little attention. A special method is necessary for the selection of optimal machining conditions. The requirements for the upper-layer properties ought in the future to be specified by the designer, together with the requirements for the surface finish.

Organisation of quality control

180. Traditionally, the basic means of quality control is a dimensional check of all parts made while work is in progress. Before a piece of equipment leaves the final assembly bays, it undergoes a thorough visual inspection and checking of dimensions against specifications. In addition to this static test, a functional test in which the machine completes a standard test piece that covers the principal machine movements must be performed to the satisfaction of the chief quality inspector. Since this inspector is solely responsible for ensuring the continued functional quality of completed machine tools, he should not be responsible to any production official.

Exposure of products to world market and quality improvements

181. Exposure of the products of a country to the world market brings many indirect gains for industrial development. To be competitive, a product must be of high quality, and must be the result of efficient manufacture and superior design. If the machine-tool industries of developing countries want to keep pace with more advanced countries, they must remain progressive, aggressive, and cost- and quality-conscious. Efforts to export machine tools to industrialized countries will stimulate the development of these essential requirements.

CHAPTER X. DEVELOPMENTS AND TRENDS IN METALWORKING

182. Initially, the developing countries must be concerned primarily with the basic types of machine tools and production techniques. However, they should also keep abreast of advances being made in connexion with more highly-developed equipment and processes, and use these whenever practical. In many instances, the most modern machine tools and metalworking methods will enable such countries to make effective use of scarce raw materials and, even more important, of the limited number of skilled engineers and technicians.

183. While taking into account the rapidly changing nature of the metalworking industries, this chapter seeks to review the main technological developments and production trends; to present some general conclusions as to the implications of these trends specifically for the design and production of machine tools; and to discuss the directions in which some developing countries want their industries to grow.

184. The distinguishing feature of the present stage of technical progress is a rapid introduction of scientific discoveries into industrial production. Whereas hundreds of years elapsed formerly between scientific discoveries and their wide-scale industrial application, these periods have now been reduced to a few years. For example, the principle of generating focused beams of light (lasers) was discovered slightly more than ten years ago. At present, laser methods have already found industrial application in communications, medicine, and processing of materials.

185. The rate of economic development of any country, and especially of the developing countries, at present depends primarily on the speed with which the new scientific discoveries are transformed into workable methods, technological processes and equipment, and on the extent to which they are employed in the country.

Technological trends and developments

186. The application of numerical control to machine tools, and the provision of improved facilities for setting and changing tools, are two of the most important developments that have occurred in connexion with metal-cutting equipment during the past ten to fifteen years. At the same time, other significant, although less spectacular advances which have taken place in the whole field of metalworking, should be investigated by any country embarking on a programme of industrial expansion. These developments may conveniently be classified into several broad groups, concerned with:

(a) Raw materials;

(b) Casting processes;

(c) Machining methods; and

(d) Welding.

These innovations, although quite recent and a result of sophisticated research, are standard practice in industrially advanced countries today, and can be applied in developing countries.

Materials

187. The variety of metals used is continuously expanding, with stronger, more heat-resistant and chemically stable materials and their alloys.

188. More intensive use is made of high-strength ceramics and other hard materials. Plastics substitute for metals as facing and finishing materials, especially in household equipment.

189. Certain current innovations in the production of steel are directed towards reducing the cost of the metal by facilitating continuous casting and other processes. A technique known as spray steelmaking has been developed, in which hot metal coming directly from the blast furnace is refined continuously, to provide a base material for the production of a wide range of steels, including alloy steels. The technique has been applied on a pilot scale to produce a variety of steels, and a production unit is now being constructed.

190. Another development has been continuous vacuum degassing, which is now used commercially for the production of high-quality alloy steels. Molten metal is drawn into a vacuum chamber containing the steel, and the degassed steel is then delivered into a ladle or ingot mould. Both of these processes have great potential for the future, since they can supply metal to continuous-casting plants. The metal can be cut into billets and extruded by a process making use of glass as a lubricant. Lengths of steel in a modified H section, which are subsequently rolled to produce structural girders, are being made by continuous casting.

191. The control of rolling mills is being carried out by computers, and fully-automated installations for press forging have also been installed.

Casting processes

192. In the field of conventional casting, increasing use is being made of expanded foam plastics for the production of castings required in small quantities. In connexion with conventional foundry work, glass-fibre patterns are now in use, the applications of which are likely to extend far into the future, particularly for the production of large castings.

193. For die casting, a material for the production of soluble cores has been introduced and is being used, for example, for the manufacture of water-cooling passages in cylinder heads. This core material can be dissolved readily after the casting has cooled, so that the production of complex internal forms is greatly facilitated.

194. Die casting under vacuum conditions is being applied increasingly to the production of various components, particularly those requiring high density, good surface finish and thin walls. A new die-casting process holds considerable promise for the future production of castings which are non-porous and have a high surface finish. During the casting cycle, a counter-pressure is applied to the metal entering the die, to prevent the trapping of gas and to ensure that the casting has the required high density.

Machining methods

195. Since the beginning of this century, progress in machine-tool design and production methods has been stimulated at intervals by the application of research findings to workshop practices. The need to increase productivity has been one of the main incentives for this progress. As a result, the definition of machine tools has been broadened and now includes machinery for alternative production methods such as electrical machining, hot machining, explosive forming, magnetic forming and plasma forming. For some of these methods, further developments will be needed before the results of research can be applied to the improvement of production equipment for a rapidly growing economy.

196. A special advantage of recently designed machines is that operatives and engineers can be training in a relatively short time to produce highly

complex items on them. For example, it takes several years to train highly-skilled pattern makers for mechanical dies and moulds. The necessary personnel can be trained in a matter of months to make the same items by the new methods.

197. The most important recent development in metal cutting has been in the field of numerical control. Applications of this field are expected to broaden rapidly, and to have a great influence on the trends in design and production methods of machine tools. With the use of numerical control, time studies in shops will gradually become superfluous, since tapes will control handling time as well as cutting time.

198. One of the deciding factors in favour of machining by numerical control was the elimination of fixtures that had to be built for the manufacture of a new product. Further, more freedom in the design of machine parts was gained, as changing some dimensions only requires changing a tape instead of rebuilding a fixture.

199. Studies show that the numerical machine tool has a considerable time advantage over the tracer-controlled type, provided the lot size does not approach mass-production quantities, for use of the numerical-control machine is particularly efficient for small lot sizes. Such machines are intended for job shops and other plants in which the production of a few pieces of a part of complicated contour is the predominant activity. They are also used for drilling and boring holes at predetermined distances. The method of numerical control used in such cases is the point-to-point one, which is much simpler than the contouring system.

200. In the United States, the development of numerically-controlled tools shows a trend towards utilisation of simultaneous multiple movements. This method permits simultaneous machining in various directions for the production of complex contours, thus freeing the designer from certain limitations caused by production problems. He will be able to use special contours which lead to optimum performance of vehicle and other machine parts such as helicopter rotor blades, impellers, and others.

201. In Europe, greater interest is being shown in the application of numerical control to copying and multi-tool lathes rather than to lathes with control systems of the continuous-path type. Numerical control has been applied in an interesting manner to one type of lathe, which incorporates a conventional profiling slide and an independent tape-controlled tool slide with a four-station turret. Very intricate components can be rough-machined under tape control, and then finished to fine limits under template control. Another company has developed a complex family of programme- and tape-controlled lathes of unit construction. These can be provided with various drive arrangements, one or more profiling slides, and an independent drum-type turret.

202. Some companies have found it necessary to build numerically-controlled machine tools which are heavier than corresponding manually-controlled units. The guideways were widened and antifriction bearing and rollers incorporated. These changes are necessary to counter the so-called "stick-slip" effect of slowly moving tables, carriages and saddles before they come to an accurate stop at a predetermined position. Motors must be dimensioned to avoid overheating, and the lubrication systems must be well designed. Lead screws must have a good fit, and carriages must be able to travel to within fractions of a thousandth of an inch. The design of the machines requires not only good machine-tool practices, but good theoretical knowledge of deflections, thermal expansion and vibration of machine tools and of their elements as well. Research into the structure and distribution of masses to minimise or eliminate these disturbances is playing an increasing role in the design of all machine tools.

203. The trend in recent designs of numerically controlled machine tools has been in the direction of the so-called "machining centre". This consists of multi-purpose machine tools permitting milling, drilling, boring, tapping etc., in one or a small number of set-ups. The workpieces may have several surfaces. Considerable savings are realized, particularly in handling and set-up time.

204. On the basis of published sources and the analysis of the operation of numerically-controlled machine tools, the following average figures describing their operation can be outlined:

(a) Productivity increase: 2-6 fold;

(b) Return of investment:

(i) Up to 2 years in 20% of cases;

(ii) Up to 3 years in 67% of cases;

(iii) Up to 5 years in 3% of cases;

(c) Technical and economical efficiency of the use of numerically-controlled machine tools is attained (according to published data from American experience) as the effect of:

(i) Labour cost decrease by 70%;

(ii) Tool cost decrease by 67%;

(iii) Productivity increase by 51%;

(iv) Improvement of product quality by 42%;

(v) Improvement of utilization of means of production by 26%; and

(vi) Decrease of other expenditures by 31%.

205. The need for and technological justification of simplified programme-control systems can be determined by studying production times. The production time for the machining of one workpiece is composed of the following elements: preparation time, main machining time, auxiliary time, time for technical and organizational servicing of the working area, and lost time.

206. Only 20 to 25 per cent of the production volume in the developed industrial countries consists of large lots or mass production. The remaining three quarters of metalworking production consist of individual items, and small to medium lots. This fact underlines the necessity of automating the machine tools used in individual, small- and medium-sized production, as well as of creating machine tools adapted to such production conditions. In the case of universal-type machine tools, 20 to 40 per cent of the total production time is employed for the machining process itself, while 50 to 70 per cent is auxiliary time. If the auxiliary operations are automated and performed simultaneously with the machining work, productivity can be considerably increased. Examining the time fractions employed for the different elements of auxiliary time, we obtain the following data:

Operation	Per cent of auxiliary time
Control of the machine	30-70
Clamping and unclamping of workpiece	10-45
Tool change	10-15
Measuring	6-25

These data provide some information on the problems to be solved and on the technological as well as economical need to automate auxiliary time elements.

207. The most rapid development in recent years, in addition to the trend towards numerical control of machine tools, has been in electrical machining. At present, the metal-removel capacity in electrical machining procedures is still very small in comparison with conventional machining; yet the advances already made are indicative of the trend. Among the new methods are electron-beam machining, used for producing tiny holes; lasers for cutting and welding sheet metal; electro-chemical honing of holes; and electro-contact machining for turning, with a metal disk replacing the lathe tool. Metal-removal rates are low (1/1000) compared with mechanical methods.

208. Research and development of new metal-forming processes have been encouraged because of difficulties in machining new, harder and tougher materials in conventional ways, and because of the need of reducing waste in the form of swarf or scrap, reducing production time, and developing machine tools with better mechanical propertiss. Work on high-energy rate forming is being done in many parts of the world, and several H.E.R.F. machines are now commercially available. The magnetic forming process has passed beyond the experimental stage, and magnetic-forming machines are commercially available for use in expanding and shrinking tubular components, forming flat workpieces, and for assembly operations.

209. Explosive forming is now in commercial use for such diverse operations as forming stainless-steel plates for dentures and the production of large pressings for aircraft and space vehicles.

210. Other alternative production techniques include electro-erosion, electro-chemical and ultrasonic machining, plasma machining, and hydroforming. A number of these alternative manufacturing methods are still in the research stage, awaiting development into production equipment for a rapidly expanding technology.

211. In grinding, the application of controlled force to the feed has been introduced, functioning so that the feed rate depends upon a preset pressure rather than on a constant rate. It is claimed that this method ensures repeatability, and that sparking-out can be eliminated. Other developments are related to grinding small parts from solids at high production rates and close tolerances, and to the application of hydrostatic bearings in grinding spindles. A copying system for gear hobbing has been developed to permit the production of crowned, spherical or tapered gears.

212. The following features are common to all of the electro-methods:

(a) They can be applied particularly to hard and brittle materials;

(b) The shape of the tool can be reproduced over the entire surface of the workpiece by using a simple reciprocating motion of the tool. The simple kinematics used in such shaping processes permit operations which cannot be performed by mechanical machining;

(c) The workpiece is subjected to almost no loads;

(d) The machining process can easily be automated, so that one operator can tend to several machines at one time.

213. Electrospark machining is based on utilisation of short pulsed spark discharges. The maximum rate of metal removal is 600 cu. mm per minute for steel, and 100 cu. mm per minute for sintered carbides (rough machining). The maximum surface finish produced on sintered carbides is Class 7 (roughness 3.2 to 6.3 microns).

214. Electro-pulse machining utilizes low- and high-frequency arc discharges. The maximum rate of metal removal actually obtained on steel was 25,000 cu. mm per minute, and on sintered carbide, 70 to 120 cu. mm per minute. The maximum surface finish of steel articles with this process was Class 5 (roughness 10 to 20 microns) or Class 6 (6.3 to 10 microns); that of sintered-carbide articles was Class 6 or 7. The method is mainly used for three co-ordinate machining of shaped cavities of steel-forging dies, casting moulds, turbine blades etc.

Welding

215. Electron-beam welding is assuming increasing importance as a production process, particularly in the manufacturing of components for aircraft and aero-engines.

216. Friction-welding machines, which operate on the principle of generating heat by bringing two surfaces into contact at a high relative speed, are now being built by a number of manufacturers. Friction welding permits the joining together of dissimilar metals, such as aluminium to stainless steel or copper to aluminium, on a completely automatic cycle.

217. For making joints in very thick steel plates, particularly where large amounts of filler metal are required, electro-slag welding is widely employed. Metal can be deposited more quickly by this process than by any other known technique; moreover, the electro-slag process is readily adaptable to automatic operations. It is now being used for joining plates with thicknesses exceeding fifteen inches, but is considered unsuitable for materials less than one-and-a-half inches thick.

Implications of technological developments for design and production of machine tools

218. Experience in the manufacture of machine tools indicates that the essential element in creating an economically efficient production programme is a sound design policy. Attaining this goal is made particularly difficult in the metalworking industries by:

(a) The wide range of operations which particular machine tools are expected to undertake;

(b) The inability to accumulate repair and maintenance experience on a particular design due to limited production;

(c) The tendency for weaknesses in construction to be obscured since tools are rarely engaged in similar types of activities over extended periods.

219. In order to take account of these factors, and also to take advantage of the latest research, it is important to analyse the production process in relation to machine features which have considerable influence on design. In addition, the design trend in machine tools is affected not only by the increase in productivity, horsepower and metal removal rates which have accompanied recent technological developments, but also by the life of new machines in comparison with older designs. The service life often influences management decisions as to buying or not buying a new machine to replace an older one. Service life is tied on the one hand to design features such as rigidity, wear resistance, absence of vibration, and on the other, to financial considerations.

220. Concerning vibration control in machine tool design, the following practical rules are recommended:

(a) Design for rigidity;

(b) Develop high damping capacity; and

(c) Design for ligh weight and high natural frequency.

221. Typically, manufacturers in developed countries have tried to simplify the design task somewhat by specializing in one particular line rather than producing all machine types. Such concentration may be useful as a guide to developing countries.

222. In relating the design of high-precision engineering equipment to production and sales requirements, one must keep in mind the following considerations:

(a) Ease of manufacture;

(b) Reduction of the number of components required to perform a function to a minimum whenever possible, e.g., the number of motors, high-speed gearing and shafts in machine headstocks;

(c) Design flexibility, e.g., complicated machines should be capable of accepting the simplest vernier measuring systems while being able to accommodate, with a minimum of alteration, the latest numerical control system.

223. Concentration on efficient pattern design is also important if original material costs and costs of subsequent machining are to be kept low. Attempts should be made to produce casting outlines which are easy to clean, fill and paint, so that treatment costs will be as small as possible.

224. The requirements for higher mating tolerances between components in the more complicated horizontal boring and milling machines also call for an increased level of technical innovation and individual workmanship, to determine the best methods of perfoming difficult machining operations. The use of refined heat treatment processes, new washing methods, and specially-adjusted lapping techniques, for example, may be called for at any point during production.

225. In spite of the demand for great flexibility and ingenuity in production methods, the following efforts to organize the production process to achieve savings wherever possible are considered good practice:

(a) A carefully-planned system of unit construction or modular design that not only serves as a means to keep work in progress and stocks to a minimum, but is a fundamental solution to the problem of satisfying the demand for machines of a substantial range of table work-holding capacities and metal-removing abilities. This rather new technique of designing a machine as a system of nearly-finished construction units also allows gear boxes and other items to be manufactured during the time when the main bed is in production, so that the over-all time until machine completion is reduced;

(b) Production of shafts, driving gears and other parts used in building units in quantities designed to raise stocks to specified levels. Parts required to meet speed, feed and power requirements of construction units are then recalled for batch assembly with the appropriate purchased components;

(c) Reducing the treatment of castings, which can amount to up to five per cent of the total manufacturing costs, to a set of standard procedures and a limited number of finishes; and

(d) Keeping stocks of patterns, castings and steel requirements to a minimum by arranging for a definite number of increments in the traverse length of machine beds.

Experience of selected countries

226. The development of machine tools already being manufactured in Brazil can be expected to include numerous improvements. Plans for future development include increasing the weight of the machines used, in order to increase productivity by supplying them with higher-powered drives. In 1961, the average weight of a Brasilian-made machine tool was less than one ton; this should be raised to about 1,250 kilograms by 1971. It is advisable to equip the machine tools built in Brazil with higher spindle sppeds than those presently available. Similar considerations should be given the feed drives in order to improve the work cycle.

227. Development of semi-automation of all kinds should be promoted. Although this complicates the manufacture of machine tools and raises their cost, the increase in productivity will fully compensate for these drawbacks by reducing idle time during the operations. Surface hardening of machine-tool beds is recommended in order to improve the machining precision and to maintain it for the longest possible time over the useful life of a machine.

228. Improved accuracy standards will be attained if better materials are used, particularly cast-iron types of higher quality and stability. The design of cast-iron parts should also be improved. Machine-tool accessories should be more complete than those presently available. Few manufacturers have taken sufficient care to provide complete equipment for their machines. Special attention should be given to the selection of electrical equipment to ensure greater safety and protection against overloading.

229. The machine tools should be tested according to standards recognized by all machine tool manufacturers. At present, only very few manufacturers are using such standards. This is extremely important in view of the exacting requirements of the market, for it serves as a means of offering consumers a guarantee of the quality of the machines produced. To keep pace with the development of the Brazilian metalworking industries during the coming decade, numerous machine-tool types are planned for future production.

230. The Indian machine-tool industry has in the past purchased designs from abroad and produced machines under licence. It is now necessary that domestic designs be developed and machine-tool designers trained for this purpose. The country will have to import more and heavier types and more modern designs of machine tools. The trend is towards single-purpose machine tools, and production of machine tools with programme control. The domestic machine-tool industry has to think in terms of producing these designs soon in order to meet the demand in the country without having to depend upon large-scale imports.

CHAPTER XI. SOME SPECIAL TECHNOLOGICAL CONSIDERATIONS FOR METALWORKING INDUSTRIES IN INDUSTRIALLY DEVELOPING COUNTRIES

231. The industrial development of machine building and the use of equipment under contemporary conditions in the developing countries may be divided into three basic stages. The first is the purchase of equipment manufactured in other, more developed countries which is necessary for the development of the national economy. The second is the organization of maintenance and repair facilities for the machinery in the country. The third stage consists of the establishment of facilities for the domestic production of equipment necessary for the development of the country's economy.

Organization of machine-tool production and selection of types of machine tools for manufacture

232. The degree of industrial development of a country determines the form of organization of machine-tool production, as well as the volume and range of output at the projected factories. There is a common tendency to move from batch production to continuous production processes, as is clearly seen in the chemical industry; it is occurring more and more widely in metallurgy and in the food-processing industry.

233. Achievements of modern science, techniques, and processing methods determine the development of machine-building technology and, though to a smaller degree, affect the design and development of the machines themselves. For example, electro-erosive processing made it possible to manufacture curved and shaped apertures and to create the necessary machines. The use of ultrasonic, electron and light-beam techniques led to high-precision machining of materials of practically any strength, thus creating conditions for the use of new designs of machines.

234. If the mechanical engineering industry of a country is underdeveloped or non-existent, it is advisable to establish a small multi-purpose engineering plant which can produce miscellaneous replacement parts for such branches of industry as the country possesses. This plant provides a base for the training of personnel, and a nucleus for the growth of a mechanical-engineering industry. In the second stage, the factories themselves produce all components, except for special parts which are imported. To manufacture heavy parts, modern foundries must be established.

235. When a programme of machine-tool production for a projected plant in a developing country is drawn up, the following requirements should be considered when the types of metalworking machines to be produced are determined:

(a) Compliance with domestic needs; this should make efficient and economic production possible; and

(b) Availability of indigenous raw materials, basic and intermediate products - cast iron and steel, electrical-drive motors, hydraulic elements, etc.

236. The analysis of these and other factors for Bulgaria indicated that the introduction of standard machines was economically feasible in the initial stage of its development. The machine types and basic parameters selected were:

(a) Universal lathes, maximum turning diameter up to 630 mm;

(b) Drilling (column and bench type) machines, maximum drilling diameter up to 50 mm;

(c) Universal, horizontal and vertical milling machines, width of table up to 320 mm;

(d) Shaping machines, maximum traverse up to 630 mm;

(e) Hacksaw machines, diameter of the cut material up to 400 mm;

(f) Surface-grinding machines, tool and cutter grinders, etc.; and

(g) Plain boring and other machines used mainly for engine overhauls.

In deciding the scale of production of such machine tools, one should consider collaboration of two or more developing countries in building a plant.

237. On the basis of analyses of past experience with machine-tool production, it is possible to draw up a comparison of typical inventories of machines installed in a developing and a developed nation (see table 5).

238. In <u>Latin America</u>, it is evident that metal-forming machines play a more predominant role in the development of the machine-tool industry than do metal-cutting tools. In countries with a developing metalworking industry, the simplest types of metal-forming machines constitute an attractive market due to the fact that metal-forming operations are the basis for the production of a number of simple items. With these machines it is possible to attain reasonable quality levels more quickly than with metal-cutting machines. For the Latin American countries, the number of metal-forming machines represents from 10 to 20 per cent of the national production. By weight, they reach a figure of approximately 40 per cent.

239. The following types of metal-forming machines are recommended for manufacture in the first stages of development of a machine-tool industry:

(a) Hand and power drive shears up to 3 mm;

(b) Hand and power drive bending rolls up to 3 mm;

(c) Hand and power drive folding machines up to 2 mm;

(d) Combination machines (bending, punching and shear of bars, sheets, angles, etc.);

(e) Executive presses up to 60 tons pressure; and

(f) Hand metal-forming machines of small capacity, such as hand-driven screw presses, punching, riveting and other similar machines.

240. It should be kept in mind throughout the industrialization process that the time required for developing special types of machine tools can be considerably reduced by concentrating all manufacturing facilities of an individual plant on the manufacture of particular families of products, and by employing a carefully-planned system of modular design. For example, turret lathes, automatic lathes etc., can be included with the production of centre lathes, rather than starting production of totally different types of machine tools.

Table 5

Comparison of metal-cutting machine tools in a developing and a developed country

Type	Bulgaria		USA	
	Percentages			
Lathes	44.0		21.0	
Capstan (turret)		2.0		20.0
Engine (universal)		95.5		54.0
Automatic		-		24.0
Other		2.5		2.0
Milling machines	8.0		10.7	
Knee type		96.7		58.2
Planer type		0.3		1.7
Profiling and duplicating		2.5		5.9
Other		0.5		34.2
Drilling and boring machines	25.0		24.7	
Vertical drilling		95.5		65.6
Radial drilling		2.5		9.1
Horizontal boring		1.5		4.7
Jig boring		0.5		2.3
All other		-		18.3
Grinding machines (except tool, cutter, bench, snag)	4.0		12.4	
External cylindrical		43.0		18.0
Internal		22.0		8.4
Surface		35.0		29.1
Other		-		44.5
Honing, lapping, tool and cutter grinding machines	1.5		4.1	
Honing		60.0		18.5
Lapping		5.0		12.7
Tool and cutter grinding		35.0		68.8
Shaping, slotting, broaching machines	9.0		2.4	
Planing		30.0		21.2
Shaping		50.0		46.6
Slotting		20.0		9.6
Broaching		-		22.6
Gear cutting and thread cutting machines	3.0		3.1	
Cutting-off machines		5.0		7.0
Other metal-cutting machines		0.5		14.6

Tropicalization

241. Attention must be given to the particular conditions existing in a developing country, such as variations in temperature, humidity and other climatic factors which may affect the accuracy of machine tools, their thermal expansion, the effectiveness of hydraulic and lubrication oils, etc. Such conditions, for example in a tropical country, may require adaptations of existing designs and processes as well as original machine designs and production methods for these conditions. Alternatively, the working environment may be modified, e.g. through air conditioning, and suitable machinery and techniques selected.

Material substitution in production

242. Substitute materials such as plastics are not used extensively for the load-bearing members of machine tools, but are being employed increasingly for non-load-carrying components. It would be well for countries lacking mineral resources or facilities for their application to study further substitution possibilities for materials which can be produced locally. Clearly, advantage should be taken of all research geared in this direction, as for example, the use of impregnated and laminated plastic inserts as slideway materials.

Flexibility of design

243. The range of sizes of machines has become particularly marked in recent years. Besides machines, instruments and mechanisms of average dimensions handled predominantly in service shops (passenger cars, refrigerators, domestic electric devices), there is a strong tendency towards increases in dimensions of individual machines in metallurgy and transportation (railroads and aviation, freight and passenger) on the one hand, and on the other hand, a tendency towards miniaturisation, as seen in electronics, communications and medical equipment.

244. The position of machine-tool users in India has changed recently due to the recession in the machine-tool market. The buyer can now dictate his requirements and select the machinery he wants. This illustrates the fact that the manufacturer should have sufficient flexibility to change from production of one type of machine to others which are in greater demand.

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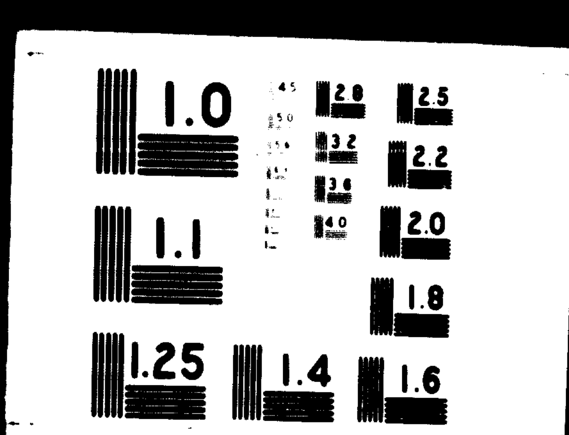

CHAPTER XII. RESEARCH AND DEVELOPMENT

245. Research, for an industrially developing country, is sometimes thought of as an activity bringing little immediate return, involving considerable risk, and burdening already tight capital budgets. This is unfortunate, since it is through the innovations resulting from successful research that great economies and improvements can be made, first at the plant level and subsequently in the entire national economic growth. Moreover, the opportunities for rapid technological progress are greater today than ever before.

246. For these reasons, countries with developing metalworking industries should carefully study current research and developments, and should be prepared to support and implement the most modern designs and techniques where these seem practical, rather than making expenditures on outmoded machinery. Much stress has been placed, and with good reason, on the adaptation or development of machinery designs and production techniques to the needs of developing countries. This, however, does not take the place of the assistance which developing countries should receive in selecting the correct machinery and techniques of the common types, which still satisfy most production needs in both developing and industrially advanced countries.

Research for the machine-tool industry

247. In the area of machining, research investigations deal with the relations between feed, depth of cut, chip cross-sectional area, and the cutting speed as related to tool life. Cutting forces are determined for conventional and newer materials, considering their hardness, tensile strength etc. as functions of the feed and depth of cut, of the microstructure and a number of other pertinent factors. The combined effect of cutting speed and cutting force determines the horsepower required for a machining process; this, in turn, affects the metal-removal rate and hence the productivity of machine tools. These and similar problems are the subject of research in the numerous fields of machining operations such as turning, milling, drilling, grinding, broaching, planing, reaming, and honing.

248. In machine-tool research, attention must be given to the rigidity of the individual components of the tools and to the total rigidity of an assembled machine. Deflections under load and vibrations occurring under cut are studied, as are the problems of thermal expansion, which appear to be of particular significance for many developing countries in connexion with climate. Not only is the accuracy of the product affected by these distortions, but also the tool life, and this has a direct effect on productivity. In addition, research is proceeding on the motion of machine-tool elements, and on the stick-slip problem which is of great significance for the accurate positioning of numerically-controlled machine tools.

Accuracy of machine-tool structures

249. The main contributions of recent research in machine structures have been to the techniques of achieving accuracy and of measurement. Developments in the following areas are significant:

(a) As standards of accuracy have increased, particularly on larger machine tools, with increased use of numerical-control systems, it has become more and more difficult to measure the performance of the completed machine tool with an accuracy comparable to the resolution of the measuring scales of the machine. This problem has been eased by the development, since 1[illegible], of portable gas laser interferometers. The high degree of coherence of light emitted by this device enables fringes to be formed between two light beams; with suitable corrections for temperature and pressure, lengths up to [illegible] metres can be calibrated under workshop conditions to an accuracy of one part in $10^{[illegible]}$ - an accuracy hitherto obtainable only under standards-room conditions.

(b) Numerically controlled machines are capable of a higher degree of repeatability than those operated manually. If they are to be more accurate, it must also be possible to control them by the actual machined dimensions of the workpiece rather than by the relative positions of the toolholder and worktable, as is the normal procedure. This requires some form of in-process measuring of workpiece dimensions immediately behind the cutting tool. To this end, pneumatic gauging systems, electronic systems employing lasers, and the more automatic adaptive control systems are in use or under investigation.

(c) The growing use of hydrostatic bearings for slideways and spindles is answering the need for a machining accuracy greater than that of the machined surfaces in the machine tool itself. This offers the possibility of eliminating accurate machining of machine-tool surfaces and instead using additional optical devices and servo-systems.

<u>Stiffness of machine-tool structures</u>

250. Research into minimizing high chatter and vibration has concentrated on methods of achieving:

(a) Greater damping;

(b) Increasing static and dynamic stiffness by incorporating different structural materials;

(c) Eliminating resonance effects through improved designs.

251. Two areas of research seem particularly fruitful. In one of these, tests on models which have been traditionally useful in pointing up weak spots are giving way to the use of lumped-parameter computer models which can simulate in detail the use of different shapes and the sizes of various structural elements, and also account for the behaviour of joints. In another area, integration of the design of the machine tool and foundation by making the machine bed of concrete is being considered. This would reduce material and transportation costs, while increasing stiffness and damping.

<u>Spindle and feed drives</u>

252. Economic adaptive-control systems are seen as the long-range solution to the problem of providing optimal cutting conditions continuously. Meanwhile, there is considerable interest in the use of continuously variable speed drives for machine tools. The growing use of silicon-controlled rectifiers for speed regulation of electric motors, and utilization of hydraulic and direct-current types, should increase the range of power/speed characteristics possible for machine tools. Lead-screw feed drives for numerically-controlled tools appear best suited at present to meet the requirements of high natural frequency, stiffness, absence of backlash and low friction.

<u>Ergonomics and utilization of machine tools</u>

253. Aspects of the design of machine tools to which ergonomics, the science of man-machine relationships, can contribute include:

(a) Positioning;

(b) Shape of control levers and knobs;

(c) Design of control panels and scales;

(d) Layout of legend plates; and

(e) Design of symbols.

More research, with greater co-operation between production workers and designers, needs to be undertaken.

254. There is a growing body of evidence today that, in many instances, general-purpose machine tools are not suited for the purposes for which they are being used. It is estimated that, if machine tools could be matched properly to the requirements, the equivalent capital value of the plant necessary for the machining operation could be considerably reduced. Detailed studies are being conducted to determine sizes, shapes and uses of components, with the aim of achieving a greater degree of standardisation and the introduction of machining of the family-group system.

Automatic control

255. The range of automatic-control devices is very broad. It includes electronic and pneumatic systems such as the programme-sequence control lathe. Numerical-control devices have become virtually synonymous with the notion of automatic control. This may be due in part to the fact that such devices offer greater potential than do the programme-sequence units. The former control workpiece dimensions by use of transducers, in addition to monitoring speed, feed and other process data. The major developments of current research on control seem to be in the following areas:

(a) Multi-axis machines and suitable programming languages and techniques to facilitate use for procedures such as die-sinking;

(b) Photogrammetry as a means of supplying the machine tool with information about a prototype component;

(c) Extension of programme-sequence control to full numerical control of tools, to systems enabling one control device to operate a number of machine tools, and to adaptive or "in-process" feedback control systems;

(d) Combination of numerical control with electro-erosion or electrochemical machining for difficult-to-machine alloys;

(e) Use of numerically controlled drawing machines and computer-aided design systems of the "Sketchpad" type.

Manufacturing processes

256. As mentioned earlier, the machining of new materials has led to new manufacturing processes such as high-energy rate forming and electrochemical machining. Much research must still be done before these processes are in common use.

257. Other problems which have not yet received sufficient attention include, for instance, the effect of climate on hydraulic and lubricating oils. These effects differ for the various types of machine tools such as lathes, drilling machines, milling machines, boring machines, grinders, and broaching machines. Further study in this area is warranted.

Research in maintenance

258. Research need not be limited to the development of new production methods and equipment, but should include machine-tool maintenance. It is necessary to know the reasons why a machine tool loses its efficiency, and the methods by which its reliability and durability can be increased. The classical sciences, such as mechanics, idealized the conditions in which machines functioned. Errors and inaccuracies caused by component wear, temperature deformation, defective materials etc. were viewed as aberrations from the perfect machine and as accidental phenomona.

259. Modern science, particularly cybernetics, takes a different view of errors; they are regarded as a natural feature of any real system. Hence the need arises to investigate the sources and causes of adverse influences acting on machines, and to study their reactions. Vibrations transmitted by other equipment act on the machines. Thermal energy in the form of temperature fluctuations disturbs machine parts as well. Chemical energy causes corrosion when the air contains moisture, and electromagnetic energy in the form of radio waves may affect the electronic equipment. These and other processes reduce the quality of performance and require periodic overhauls.

Implementation of research programmes

260. All possible efforts should be made for the incorporation of technical advances in new designs which have market potential. This is particularly important because of the long time interval of three to five years between development and production of the first model of a new type of machinery.

Centralised research and development system

261. The structure of a centralised machine-design and research organisation must, of necessity, be determined by the level of development of mechanical engineering in the country in question. The needs of the country in this sphere of activity must be served at minimum cost, and with efficient use of scientific and design personnel. As mechanical engineering develops within the country, specialisation should be intensified, with the result that the single mechanical-engineering research and design centre may gradually be split into several specialised, independent research organizations serving the branches of mechanical engineering which have been built up.

262. A major component of this process is the training of native scientific and design personnel, and the gradual specialisation of such persons in particular fields of mechanical engineering. Advanced training must be provided for them, as well as a continuing flow of technical information,and, eventually, the introduction of separate training for the engineering staff of the mechanical-engineering industry. Close links must accordingly be established between the country's research centres and establishments of higher technical education. As production grows, a transition must be made from a single research centre to a stage at which some portion of the research staff is transferred to the actual plants in order to establish the closest and most direct possible link between science and production. The single research centre will be maintained to carry out long-range and highly complex projects, to inform the industry about the latest advances, and to co-ordinate the production development of the individual enterprises.

263. The development of research and design services which are geared to the development of the mechanical-engineering industry may be broken down into the following stages:

(a) Stage 1. Technical training institute whose research laboratories and specialised staff assist and advise the industry on particular problems.

(b) Stage 2. A single mechanical-engineering research centre separate from the training institute. This centre may design machinery for the mechanical-engineering industry, conduct research on processes and specific mechanisms at the request of factories, render technical assistance in bringing into use complex imported equipment and technological processes, and supply the industry with information concerning the latest advances. The staff of the research centre takes part in the work of technical training establishments.

(c) Stage 3. A single metalworking centre, and separate centres for the different branches of mechanical engineering, to develop equipment for the processing and extractive industries. At this stage there is greater specialisation in types of machinery; the laboratories are concerned both with technology and with the development and study of the necessary equipment, in addition to rendering assistance to industry.

(d) Stage 4. Research centres for particular branches of mechanical engineering, and design and research services at the manufacturing plants. The centres work on long-range problems of industrial processes, regulating systems, machinery units and components, assist in solving the more complex problems facing plants, and provide the industry with technical and economical documentation and information. Practical work on the development of machinery and the day-to-day supervision of its production are carried on by the design services of the enterprises themselves.

264. According to the level of development which it has attained, each country selects the most suitable form of organisation for its scientific and design services.

Decentralised research and development systems

265. In applied research, the transfer of results from laboratory to workshop is a constant, delicate and complex problem. The transfer takes place either when the research programme ends or when a coherent set of results has been obtained. It is at this stage that research work finds its justification.

266. Three stages of utilizing the results of research in industry are apparent: First, the establishment of the pilot plant, when the transfer of pilot-plant technology to production, and finally, commercial applications of research.

267. The pilot plant should be located as near as possible to the research department, permitting close co-operation of the two divisions. The pilot plant is an extrapolation of the laboratory, which tries to convert research procedures into production methods. It is the task of the production engineers, who are responsible to the production department, to prepare the transfer from research to the workshop, and to disseminate scientific ideas in the latter. The engineers are chosen from the research staff and trained in production technology. They are generally university-educated, and form an important link in the organisation. Problems encountered in the design and building of machine tools are gathered from discussions with customers, personal observations, and testing of machinery. They are also examined in relation to manufacturing costs. Problems concerning operational convenience of the machine, the safety of the operator, and improvements in productivity and accuracy are also investigated. The engineer must weigh the relative significance of various problems. He must record pertinent facts and make measurements in order to determine the significance of the problems, and the advisability of initiating new development projects. The engineer of the

future will have to extend his knowledge constantly. Owing to the difficulty of obtaining technical perfection and scientific exactitude, the engineer must be capable of selecting solutions which are often compromises between contradictory requirements.

268. The preparation of prototypes and their rigorous testing should be carried out in rooms separated from the main production shops, in order to avoid conflict over use of equipment and interference with the regular production activity.

Experience of selected countries

269. The Indian Government has set up a machine tool research institute, namely, the Central Machine Tool Institute at Bangalore, with assistance provided by the Czechoslovak Government. This is only the beginning; many more machine-tool research institutes could be used. It is expected that the present Institute, which was inaugurated in December 1965, will, among other things, do research on machine-tool problems such as cutting, tool technology, materials and their treatment, metrology and type testing of machine tools. It will also develop new designs, improve those already existing, and train designers for the industry.

270. The Indian Government has also established the Central Mechanical Engineering Research Institute in Durgapur, which likewise deals with problems of the metalworking industries. In addition, a Research Institute for Scientific Instrument Technique has been established at Chandigarh (Punjab).

271. A fundamental role could be played in the development of machine-building industries if a machine-tool institute were established in Argentina, dedicated to the study and research of techniques related to the construction and functioning of machine tools. Getting such an institute started would bring important benefits to the makers as well as the users of machines. For the former, it would be an important aid in meeting technical manufacturing requirements. For the latter, the tests carried out by the institute would constitute a guarantee of product quality and give prestige to products manufactured for the domestic or export markets.

272. Aside from its mainly technical functions, the institute should actively participate in guiding the development of the industry, and advise the appropriate agencies regarding credit which should be given to manufacturers for the acquisition of machinery and production equipment, as well as for the study and building of prototypes.

CHAPTER XIII. COST CONSIDERATIONS

273. Costs can be classified under three headings: direct cost of labour and materials, standard overhead charges (e.g. rent, heat, light, maintenance, administration), and the amortisation of capital equipment. During the first ten years of service, the productivity of a machine decreases, leading to an increase in the cost of labour and overheads. The cost of the new machine, which will become higher in successive years, must be allowed for. Maintenance is a major financial concern in the metalworking industries.

Purchase costs of metalworking equipment

274. One of the most important production problems for the metalworking plant manager is to determine what his equipment needs are. The capital value of the plant required for machining operations can be reduced by 30 per cent if machine tools are properly matched to the actual requirements. For instance, there is little merit in using a machine with a holding capacity of one metre if the largest piece to be worked on it is only one third of that length. The 30 per cent figure takes into account the reduction in complexity and size of machine tools, the reduced workshop area and the reduced cost of overhead charges.

275. Plant managers in developing countries should also keep in mind the real savings in terms of original cost and operating expense made possible by the use of second-hand equipment. The fact that the market for such equipment is supply- rather than demand-oriented causes prices to fluctuate widely, and requires that the purchaser be sufficiently familiar with market conditions to be able to make purchases at the most attractive prices.

Overhead costs

276. Overhead costs play an important role in the case of automatic machines, tending to rise with changes in machine efficiency. Complicated work for which jigs and fixtures are required aggravates these conditions and gives a definite advantage to numerically controlled tools. This is particularly true of milling, drilling, tapping and boring of pump bodies, casings, connexions and similar components.

Cost-reduction techniques in machine-tool production

277. The production cost of machine tools can be reduced substantially by adopting the principles of modular design. It was found in the case of a three-axis drilling machine that the cost of a modular-design unit was about half that of a conventionally built machine of this type. Modular design also has the advantage of keeping to a minimum the amount of capital required for the inventory of parts, patterns, castings etc., which is normally quite considerable. For example, a medium-sized factory recently reported that, even with a carefully planned system of unit construction, stocks worth about $US 840,000 were required for work in progress amounting to $US 280,000. The saving differs, of course, with the type of modules built into the machinery, and could be increased when the users become more familiar with the principles of modular design.

278. Improvements in the design or manufacturing methods of machine tools often result in cost and price increases. The question then arises whether the increase is worth the higher performance. It may be necessary to postpone a technical improvement in favour of lower cost until design simplifications lower the prices.

279. In order that metalworking industries in developing countries can become more self-sufficient and competitive with those in the industrialized nations, ancillary industries providing raw materials and components need to be developed. A higher priority in government planning, and specific incentives or tax relief measures to entrepreneurs are vital in this connexion, and must be provided for if a lowering of costs in metalworking industries is to be achieved.

280. Standard costs. Company standards are used in factory accounting for controlling and measuring the efficiency of manufacturing operations. Before production is started, a standard estimate of the total cost of producing an item is prepared. This estimate is later compared with the actual cost.

281. Break-even analyses. By separating total costs of a product into fixed and variable costs at a given level of output, and by assuming linear relationships in the range of operation, one can develop a graph of total cost versus output. This plot is useful in determining the profit expected from an increase or decrease in production, the effects of a substitution of production techniques, change of lot size, or the introduction of labour-saving machinery.

282. Marginal productivity of labour. The concept of value added to the labour-cost ratio is a useful guide for analyses of efficiency of operations. In the United States, this ratio has remained at 2.5 since 1914 in spite of all economic changes. The competitive position of a company can be judged against this figure, and the production engineer can assess through it whether his techniques are effective.

Experience of Asia and the Far East

283. No detailed figures are presently available for the countries of Asia and the Far East. However, it may be estimated that wages have increased by 40 per cent in the developing countries since 1955. In the most industrialised country (Japan) of the region, the increase amounted to 50 per cent. Second in importance to labour costs are the costs of transportation, distribution, investments and interest rates. The price structure is also greatly affected by the cost of imported steel and other materials and components.

284. Although the costs of production in the region are relatively higher than in the major producing countries in the world, particularly when mass-production techniques can be used, it has already been possible to manufacture some goods at competitive cost. This is due to the lower wages, and to the application of modern technology. Among the goods most frequently and competitively manufactured in this region are sewing machines, bicycles, simple agricultural implements and metal furniture.

CHAPTER XIV. STANDARDIZATION IN METALWORKING

285. If developing nations are to achieve the degree of industrialization in metalworking that is required to provide goods for both internal and external consumption, they must provide for a system of standards as soon as possible. Experience has shown that production methods become harder to change as the industry becomes more complex. Inefficient methods can become ingrained habits. A careful comprehensive study in the beginning phases of industrial development pays off in fewer mistakes in the future.

286. Standards in the metalworking industries are requisite to three basic phases of industrial production, namely:

(a) To modern methods because they provide interchangeability and economy;

(b) To trade within a country because they enable consumers to use a given part in all areas of the country; and

(c) To international trade because they provide a common basis for purchases and sales.

287. Several kinds of standardization need to be distinguished in metalworking. These range from standardized classifications of part names and practices of design and production to standardization in the production of machine-tool units through the concept of modular design. The major elements discussed below must be considered in relation to the needs of developing countries.

Standardization of part sizes

288. The early adoption of standard sizes of metalworking materials allows the design of many products based on a limited number of sizes of rounds, squares, and other standard shapes; a limited number of thicknesses and widths of sheet, strip, and plate; and a limited number of finishes. Early standardization would save time and money for everyone involved. An engineer in Company A need not spend time developing a screw that will fit a part provided by Company B, if both companies adhere to a common standard for screw threads. Establishing and using a system of national standards ensures that a bolt will match a nut, that an electrical plug will fit an outlet, and that a bulb will screw into a socket, no matter who manufactured the product or where and how it is used in the country. Engineering time can be utilized more efficiently to provide better products and product uses, and the minimized duplication of effort will result in economy for all concerned.

Examples of standardization in the machine-tool industry (numerical control)

289. The use of control systems in machine tools has led to development of various means of instruction input. In the case of numerically-controlled machine tools, punch cards have gradually been replaced by punched tape, standardized in the United States of America to one-inch width and eight channels. In Standard RS 244, which is the *de facto* United States standard, the code requirements are spelled out for designating numbers, letters and symbols to be placed on the tape. RS 227 specifies the tolerances of the medium and the holes, RS 267 applies to tape for positioning and RS 274 to tape for contouring numerically-controlled machine tools. These standards are preliminary, however, and are currently the subject of controversy.

Classification of machine tools

290. Classifications of machine tools have been adopted in some industrialised countries. These usually come from a code which assigns numbers to classes, groups and sub-groups of machine tools. As a first step, a national standard is essential, but the creation of an internationally-accepted standard classification would be of considerable benefit to all nations, as would standards of testing and quality.

Standardisation in production of machine tools

291. Standardisation of machine-tool production is necessary if the minimum number of sizes of a given model of machine is to serve the entire range of applications of that machine. The favourable results thus obtained are:

(a) Similarity of design, technology, operation and overhaul;

(b) Possibility for vertical and horizontal unification of some structural elements;

(c) Eventual application of the modular principle to general-purpose machines; and

(d) Efficient production and all consequent economical advantages.

292. These results can be achieved in several ways. For example, limits are being established for a whole range of metalworking machines. The limits correspond to a basic size parameter or a graded range of necessary sizes, and the main technological data (e.g. geometrical dimensions of the machined work and of the mating and fixing surfaces) are being specified.

293. Parameters and sizes have to be selected to suit the preferred number ranges of equipment in accordance with the appropriate standards. When a new range of machines is to be developed, it is advantageous to begin with a small number of models within the given range, allowing for a gradual increase of this number together with augmentation of the parameters. Thus, any defects can be eliminated and improvements, based on experiments, carried out on a small number of items.

Modular design

294. The modular-design principle belongs in the category of machine-tool standardisation. It goes beyond the mere standardisation of individual machine parts, however, because it covers the standardisation of assembled units which can be used in various types of models. Consequently, optimal utilisation of plant equipment is made, yielding the capital savings which are so important for an industrially developing country.

295. The first step in modular design is to establish a system for the machine-tool production programme. Typical parameters are selected for each class of machine tools, such as the maximum work diameter for lathes and the maximum hole diameter for drilling machines. With the aid of these parameters, it is possible to develop a series of machines with sizes arranged in a geometric progression which, in turn, permits a substantial reduction in the number of sizes of machine tools.

296. The second step is the classification of machine tools into design groups. This term applies, for instance, to the main spindle assembly of a lathe or to the copying device of a milling machine. It is useful to limit the number of design groups, which can be compared to building blocks, to those that are used very frequently. They are divided into three catefories, namely, basic, general, and supplemental design groups.

297. It is possible to build a large variety of machine tools employing only comparatively few design groups. It even becomes feasible to build special machine tools, and also gradually to automate them in the future by applying the indicated principles. It will be possible to build transfer lines from design groups; they can be disassembled when no longer needed and used for a different transfer line or in a different machine combination. Using the design-group principle, one can assemble up to sixteen different multiple-spindle machines by using only four frame sizes. Substantial savings can be realized through the application of modular design to multi-spindle automatics.

298. The optimum repeatability of design groups is established by the designer, who calculates so-called "characteristic numbers" during his work. Several such characteristic numbers can be computed by means of simple formulae.

299. The third step consists of the development of design units that represent a higher degree of standardisation. The difference between design groups and design units lies in the field of application. While design groups apply to an individual plant, design units apply to a great number of plants or to an entire country. The difference can be compared to the difference between a factory standard and a national standard. Mechanisms for the motion of machine parts, tool carriers, and loading devices, for example, belong into the category of design units. Some are special machine tools used for only one type of operation or workpiece, using, however, the principle of modular design. Machine tools of the future may be built by assembly of prefabricated standard parts rather than on the basis of individual design.

300. The fourth and last step is scientific research into the diverse applications of design units to optimum conditions. Research on uprights is typical. Here, the scientific investigation should cover the ratios of the length of sides, height, location of stiffeners, the centre of gravity, etc. It should be determined under what conditions maximum rigidity can be obtained at least cost when incorporating design units in various types of machine tools such as lathes, planers, and milling machines. Cost comparisons should be based on a geometric progression of these dimensions.

301. The results of experience with standardisation at all levels - company, industry, national and international - are available to developing countries. Much can be gained from a thorough study of the standards in effect in the industrialised nations. These were worked out with great care, and the developing nations can benefit greatly from adopting them. National standards for the metalworking industries can be obtained from developing nations with help furnished by international organisations such as the United Nations and the International Organisation for Standardisation.

302. Care should be exercised, however, because each country, and often each area within a country, has special conditions, such as voltage requirements for electric current, which must be taken into consideration. Requirements for bearings in machines used in a temperate climate would prove useless if the parts were to be manufactured or used in tropical surroundings.

CHAPTER XV. MAINTENANCE AND REPAIR OF METALWORKING MACHINERY

303. Metalworking machine tools occupy a central place in the entire complex of industrial equipment and machinery. The experience of the developed countries shows that machine tools can have a long, useful lifetime. In jobbing shops, the average life may be up to 40 years, and in cases of small-lot production, about 25 years. It is slightly shorter in the production of vehicles and other industrial equipment on a large-batch basis, and reduced to eight years in the case of mass production. Therefore, a well-organized repair and maintenance system is essential for every stage of industrial development, and is perhaps the first constructive step to be taken in the early phases of industrialization.

304. Research on technical equipment has shown that approximately 10 per cent undergoes major overhauls each year, 20 to 25 per cent intermediate overhauls, and almost 100 per cent some minor overhaul. Before receiving a major repair, a machine tool has usually passed through two intermediate and six minor overhauls. Each intermediate overhaul takes about two thirds as much labour as a major overhaul, and each minor overhaul 17 per cent. The standards developed in the Union of Soviet Socialist Republics for maintenance and repair of machine tools show that a major overhaul of a lathe takes eleven days, six minor ones 16.5 days, and two intermediate overhauls 13 days. The lathe is thus out of operation for a period of 40 days (24 hours each) between two major overhauls.

305. The loss of time and resources needed to keep the stock of machine tools in good order is substantial, though depending to a great extent on methods of operation and servicing and on the technology and organization of maintenance. For example, in a small- or average-sized enterprise, the cost of a major overhaul of a medium-sized universal machine tool is normally 50 to 60 per cent of the cost of a new machine, and in the case of a heavy machine tool, 25 to 30 per cent. In addition, machine tools are periodically checked for accuracy, lubricated, and given preventive treatment. Thus, the cost of maintaining and servicing a machine tool of medium size during one maintenance cycle (i.e. up to and including the major overhaul) is greater than the cost of a new machine. If maintenance and repair are not well organized, the cost can be several times greater.

306. In order to keep equipment in permanent working order with a minimum expenditure of time and resources, it is necessary to institute a maintenance system with strict rules concerning the basic procedures.

307. In the Union of Soviet Socialist Republics, a uniform planned preventive-maintenance system has been especially worked out for, and is applied in, all branches of industry. Now thirty years old and steadily undergoing improvement, this system has shown its great possibilities and the correctness of the underlying organisational principles. The system of preventive maintenance includes not only overhauls, but also a set of preventive operations. The operator and the maintenance staff (fitters, greasers, belt-drive servicement, electricians) participate in the inter-overhaul servicing, which includes checks to ensure that the equipment is in good condition, that it is properly operated and lubricated, and that minor troubles are corrected. Cleaning, oil changes and rigidity checks are included in this process. Surfaces must be protected from dirt, abrasives and chips, particularly in surroundings where polishing and similar machines are in operation. The maintenance system also fixes the pattern of the cycle, i.e. the number of planned overhauls and the order

in which they are carried out. Indicating a minor overhaul by I, an intermediate by II and a major one by III, most machine tools now undergo a cycle of nine planned overhauls in the order I - I - II - I - I - II - I - I - III.

308. For the purpose of advance planning of maintenance, the machine tools are classified in different categories according to their degree of complexity. Each is assigned a complexity coefficient, such as three to eight for vertical drilling machines, which are the least complex, to 20 to 35 for open-side jig borers, which are the most complex types with respect to maintenance. In addition, standard time rates are developed for calculating the labour force required. Multiplying these rates by the complexity coefficient results in figures indicating the hours required for a particular overhaul.

309. The length of the maintenance cycle is calculated from formulae in which the type of operation is expressed by another series of coefficients, such as one for mass production, 1.3 for series production, and 1.5 for small-series and single-item production. Another set of coefficients covers the type of work material machined (1, structural steel; 0.75, aluminium etc.) A third relates to operating conditions, such as 0.7 for dusty and humid workshops, and a fourth covers the type of machine tool (1, light; 1.7, particularly heavy machine tools etc.) All pertinent coefficients are multiplied by 24,000 to give the maintenance cycle in hours.

310. A minor overhaul includes the reconditioning or replacing of a small number of parts, adjustments, checks of oil flow, etc. An intermediate overhaul entails truing up and restoration of accuracy, without removing the machine from its foundation. During a major overhaul, the machine tool is usually completely dismantled and examined according to detailed rules, which include formulae for permissible wear, service life of the parts etc. The correct choice of the technical processes to be used for repairing is complex. Various suggestions for handling this problem, based on the experience gained in this regard, are available.

311. The principle underlying this system has been that, by establishing a maintenance cycle with a permanent pattern, preserving average ratios between the volumes of work involved in the different types of overhaul, and comparing different types of equipment by placing each in a maintenance complexity category, it is possible to plan maintenance in advance and to calculate the labour, equipment and time required.

Organization of maintenance and repair

312. Various organizational systems for equipment repair can be adopted:

(a) A decentralized system, characterised by concentration of all repair and maintenance operations in workshop repair units and by specialization of repair teams;

(b) An in-plant system of centralization of repair work within enterprises, with spare-parts production, major repairs and modernization concentrated in a mechanical repair s... and the remaining work carried out by repair units;

(c) A centrally-directed system of concentrating major repairs of equipment in workshops or plants specially set up for the centralized repair and modernization of equipment on either a small-scale or large-scale assembly-line basis.

313. At the plant level, the organization of maintenance work must provide for the execution of all technological processes necessary for maintenance operations, receipt of spare parts from the machine-tool factory, and overhaul of individual assemblies or machine tools at special maintenance centres. The type of organization depends upon the varieties and number of machine tools at the plant.

314. In the Union of Soviet Socialist Republics, it was found that the organization of central repair shops and plants has significant advantages over the practice of repairing machine tools at the plant where they are used in production. The labour time used in specialized central-repair plants for complete machine overhaul is about 40 per cent of that used in the production of a comparable new machine. The production cost in the centralized repair shops of the Union of Soviet Socialist Republics is 20 to 25 per cent, which is lower than that of existing practice under decentralized systems.

315. Developing countries may be guided by this example. In situations where industry is concentrated in specific geographic areas, conditions for establishing central repair shops are especially favourable; not only can the cost be reduced, but also more modern methods of repair can be employed, requiring a smaller number of highly-skilled workers.

Maintenance of second-hand equipment

316. The repair of second-hand equipment is of particular interest to developing countries. There is no clear-cut difference between maintenance problems for new and second-hand equipment. Maintenance of the latter has both advantages and disadvantages. Up-to-date knowledge of electrical circuits, hydraulics, electronics etc. is necessary for the maintenance of modern machine tools. Even in the industrialized countries, these skills are often in short supply. They are often required to a lesser degree in older machines; however, the older the machine, the greater the risk of breakdown. Also, in many cases instruction manuals for maintenance and repair of second-hand machinery are unavailable.

317. Increases in maintenance cost are not proportional to age. Some existing data show that the maintenance cost may rise from one per cent of the original cost after one year of use to only two per cent after ten years of use.

318. Spare parts are more easily available for new than for second-hand equipment. However, many manufacturers stock repair parts for many years, and this can be of considerable value to developing countries. Local manufacture of spare parts has advantages over importing them from the developed countries, and is often feasible since second-hand equipment may be of simpler design and made of less sophisticated material than new machinery.

319. The spare-part problem differs in industrialised and developing countries. In the first, spare parts for new equipment are usually available within a day, and within a week to a month for older machines. In developing countries, ordering, transportation, customs procedures and foreign-exchange difficulties may extend delivery time to three or more months. Hence, it is essential to ensure at the time of purchase that a satisfactory source of supply parts is available. The useful life of second-hand equipment is variable. It is recognised that rebuilt machinery in which no improvements have been introduced, can last as long as new machinery of the same type and can provide considerable savings in initial cost.

CHAPTER XVI. DEGREE OF MECHANIZATION

320. The metal-product industry is basically a labour-intensive industry; therefore, mechanization and automation are more limited than in certain other industries. Equipment with different degrees of mechanization exists, but in many cases an optimal choice is not made. Such a choice should not necessarily be for the most highly-mechanized equipment, but depends on various factors, including the wage and interest rates, the size of the market, and the size of lots produced. Sometimes, automated equipment must be selected not on the basis of economic factors alone, but for technological reasons as well, when production by alternative equipment is not possible. The instrumentation industry is a case in point.

Selection of machine tools

321. The question of selecting machine tools for developing countries cannot be answered in a general way because conditions differ in each particular case. Experience has shown, however, that the structure and growth of a machine-tool inventory are closely associated with the level of mechanization of a country. As the country develops, it makes increasing use of precision machine tools, automation, specialized tools for particular branches of mechanical engineering, and heavy machine tools for large parts. In the Union of Soviet Socialist Republics, for example, the greatest increase during 1937-1965 was in the number of heavy machine-tool types, which jumped from five to 420 types and sizes, and precision tools which increased from four to 130 types and sizes.

322. In the industrially-developed countries, only 20 to 40 per cent of the total production time per workpiece is used for actual machining. The remaining time is spent in tooling, setting up, taking trial cuts, making measurements etc. Such unproductive subsidiary time, especially when related to manufacture of small- and medium-size batches, is disproportionately expensive where wages are high, since it means incomplete utilization of the productive capacity of the machine tool. Consequently, the primary aim in the development of tools has been the automating of subsidiary operations while maintaining or even improving the quality of workpieces.

323. Generally speaking, the following stages of development in the types of machines used can be observed in industrialized nations:

(a) Universal machines;

(b) Production-type machines;

(c) Sequence-controlled machines;

(d) Automatic machines;

(e) Transfer lines;

(f) Numerically-controlled machines.

324. Universal machines combine precision, versatility, relatively low price and rather reliable operation. These machines are operated by hand and are well suited for a large variety of jobs. Because of their great flexibility of use, they are obviously well suited for developing countries. However, they must be operated and maintained by well-qualified workers, and these are available only in a few developing countries.

325. The production-type machines are also hand-operated; however, their automatic workpiece transport and loading can greatly accelerate the flow of production. An advantage of a production-type machine for the operator is the comparatively short time required to adapt it for a new series of workpieces, so that he is soon able to apply his initial experience to the manufacture of new parts. This type of machine may well be operated by a semi-skilled worker; it must be set up by a skilled worker, however. Another advantage of production-type machines especially valuable for developing countries is their adaptability. It is unlikely that labour shortages, which would necessitate the selection of automated machines, will arise in the near future in industrially-developing countries.

326. Due to their simple operation, quick adaptability to a new work programme, and high continuous accuracy, sequence-controlled machines may eventually be tailored to the needs of developing countries. Since there is a sufficient supply of non-specialized workers in these countries, there are no obstacles to single-machine operation; semi-skilled workers can easily be taught to operate a sequence-controlled machine tool. Thus, single-machine operation would seem to be suitable for batch production in developing countries.

327. Automatic machines possess a satisfactory degree of flexibility in the parts which they are capable of producing. The possibility of their operation by non-skilled workers would favour their use in industrially-developing countries. However, the expenditure for a good production-planning department, which is needed for these machines, is economically justified only if numerous machines are in use. This type of machine will therefore be suitable only under certain conditions for utilisation in developing countries. Besides, the economical use of even a single automatic machine could lead to a product quantity which would, in many cases, be too large for the domestic demand of a developing country.

328. A prerequisite for the economic application of transfer lines is the production of a large number of pieces. This, in turn, requires that the products be standardised. Technical unification and restriction of models contribute considerably to such standardisation. The practicability of transfer-line utilisation also depends on the labour situation in the developing country where such a machine is to be set up. A transfer line not only permits faster production of parts at lower costs, but also reduces the labour required even as the total output is increased.

329. Numerically-controlled machines in general do not require specially-trained operators, but present very demanding tasks for the maintenance and supervisory personnel. A centrally co-ordinated service facility for all numerically-controlled machines would be of great advantage in a developing country. The excellent flexibility of the machine in regard to products, its profitable use even in small-batch production, and the possibility of integrating it into a manually-oriented work flow can be of advantage for an industrially developing country.

330. The key to effective automation of an industry or of a process is to select from a wide range of possibilities the degree of automation that will provide the greatest returns for the effort expended. This selection process represents an essential planning step, particularly in an emerging economy. Random automation is seldom beneficial, and may be ruinous where capital is limited, due to the resultant unproductive consumption of scarce resources.

331. A developing country has the ability to use automated tools at a faster rate than a developed economy, due to the size, age, and greater flexibility of its industrial plant. Although there are major obstacles to automation of both social and economic origin in developing countries, selective automation at the correct stage of industrialisation not only can be

beneficial, but may be necessary. Automation of the metalworking industries may be the only route to economical survival for developing countries, and may even be necessary for successful competition in a technologically developed world market. However, great care and serious economic and social analyses must take precedence over considerations of prestige production if automation is to be a real benefit.

332. The maintenance of productive efficiency in a manufacturing organization is one of management's perennial problems. Machines wear out and techniques change against a background of changing product designs and market requirements. Careful maintenance and other procedures directed towards long service life of machines have been considered good practice. Attempts at cost reduction and problems of taxation have always tended to make management view the replacement of machines as a long-term procedure. In the past, the prevalent attitude has too often been to consider how long a machine should be kept in operation in its existing condition, rather than how long it should be used in order to yield the best financial returns.

333. Developing countries should assess the possible effect of rough-and-ready policies on ultimate factory efficiency when considering the replacement of machinery by equipment of a similar technological type. When replacements are being contemplated, it is particularly recommended that the interaction of all current machinery and processes be reviewed in order that the over-all plan of operation and the replacement orders be considered in relation to actual future requirements. An enterprise may decide to diversify its operations, embracing new markets with products not previously manufactured. It may introduce new technological developments in a field which it has already exploited, or increase the production of goods that it has already manufactured. For all this, a forward demand prediction or marketing plan is fundamental. Production capabilities of current equipment can then be paired off with expected demand.

334. Thus, it is advisable to consider whether other types of machinery or entirely new processes can do the required job more efficiently. The optimal capital policy is not always apparent. In multi-product situations, for example, linear programming or simulation models, even if they are simple, can be used to advantage.

335. In the formulation of replacement policy, the effectiveness of a machine is all too often measured merely by its age. It is not easy to determine when the efficiency of machinery has reached its limit. Inaccuracies beyond the control of the skilled operator can be assessed and, to some extent, corrected by routine maintenance. However, an increased tendency to chatter and tool wear can only be changed by removing the machine from production and giving it a complete overhaul.

336. Over-all policy should include a prudent mixture of replacement by new machines of improved design, new techniques applied to old machines, and the renovation of old machines. In all probability, new techniques could be applied to a large number of older machines without too great an increase in capital cost. Older machines have to be replaced on a basis consistent with the available funds.

Service life as a criterion for choice of equipment

337. The need for replacement of machinery is affected not only by increases in productivity, but also by the service life of new machines in comparison with older designs. Service life is tied to rigidity, wear resistance, absence of vibration, and also to financial considerations. In American industry, the formulas of the Machinery and Allied Products Institute (MAPI) are often used to determine whether acquisition of a new machine would improve production. A simplified equation for determining replacement is

$$d = c \left(\frac{i}{1.4} + \frac{2n - 1}{n^2} \right)$$

where d is the adverse minimum, c the acquisition cost, and i the interest rate over the estimated length of the service life n of the machine tool under consideration. The adverse minimum is the time-adjusted annual average capital cost of the equipment.

338. Service life is a dominant factor for comparing the economical profitability of two machine tools. If it is assumed that the purchasing and operating costs of two new machines are the same (say, $US 33,000), and that one of them has a service life of fifteen years and the other, one of nine years, the cost to operate them, at an interest rate of five per cent, would be as follows:

(a) 15 years' service life: $d_1 = 33{,}000\ (0.05/1.4 + 29/225)$ = $US 5,478;

(b) 9 years' service life: $d_2 = 33{,}000\ (0.05/1.4 + 17/81)$ = $US 8,118.

Hence, with a difference in service life of only six years, the annual saving is the difference of $US 5,478 and $US 8,118 = $US 2,640 when the machine with the better service life is purchased. Over a period of nine years (i.e. the service life of the second machine), the total saving would amount to $US 23,000. The better-quality machine may even cost more initially and still be more profitable than one with a shorter service life. At a cost of $US 40,000 for the longer-lived machine, the nine years' saving would amount to $US 13,250.

339. Some care must be used in applying formulae of this type, for they do not include factors such as operating expenses and unreliability which are likely to arise with age and technological obsolescence. The point comes when machinery, even though still operative, is no longer an asset.

340. In the Union of Soviet Socialist Republics, the service life of metal-working equipment is determined by economical considerations. It is continuously compared with the cost of replacement by new machines, which may differ with the progress of technology, and with the productivity of a new machine. It may, under certain circumstances, be appropriate to replace an old machine by a new one, even if the initial cost is higher.

CHAPTER XVIII. MANPOWER PROBLEMS

341. The successful implementation of a plan for industrial development needs not only a large amount of capital for investment, but also a supply of qualified technical and managerial personnel, at both the macro and plant levels. Adequate staffing is essential in the metalworking industries if this sector is to become independent of foreign equipment and designs. Manpower requirements are perhaps most critical in the machine-tool industry, since production of items other than the simplest tools requires a highly skilled labour force. In the absence of such a body of technically qualified people, the manpower problem is not only one of allocation but also of training. Of course, in any branch of science and technology, the higher the quality of training of specialists and the greater the number of highly rated persons, the larger the output of the products required for the welfare and further progress of human society.

342. Metalworking can be regarded as the most important technological process since metals are at present, and are likely to be during the coming decades, the main materials used for manufacturing a large variety of machines. For this reason, considerable attention is being paid to training engineering and technical specialists for the metalworking industry.

Managerial and technical allocation

343. Before technical and managerial manpower can be optimally organised and allocated, a roster of the country's available manpower resources must be available. Also, the requirements of specialised manpower for some future economic targets must be fairly accurately determined. A manpower census requires that the qualifications and availability of existing and potential managerial and technical personnel are identified and catalogued. A requirements index can be drawn up only through careful advance planning and organisation within the metalworking sector.

344. The steps to be taken in developing these inventories, if they are not available, are:

(a) To analyse the characteristics of positions at various levels in the sector and to prepare job-descriptions indicating the physical and educational qualifications and experience desired for each position presently being filled;

(b) To determine the expected number of individuals for each job to be filled at some target date;

(c) To make a catalogue of the available manpower, a central file in which, ideally, every person with existing or potential skills should be listed for assignment.

Manpower allocation in developed countries

345. Rosters of technical and managerial personnel are not easily developed in highly-industrialised countries where the allocation of skills is carried out voluntarily. The more usual practice in such countries is the maintaining of a manpower inventory by individual companies for their own employees. Gaps in the existing manpower pool in terms of future production programmes are then easily recognisable, and steps can be taken to remedy deficiencies by training or recruiting new personnel before needs become acute.

346. Experience in some metalworking plants has shown that competent operators using similar machines and working in close proximity to each other can be supervised in groups as large as thirty, and that the number of supervisors required per worker increases as the plant size decreases. Executives who are responsible for directing several dissimilar functions can generally control only between four and seven subordinate managers. The disadvantage of increasing the number of supervisory levels, while narrowing the span of control at each operating level, is that communications become more difficult and uncertain as messages must pass through more people.

347. Information from United States metalworking plants suggests that, as products become more complex, the ratio of indirect and specialized personnel to production workers increases. At the same time, the ratio of managerial and administrative workers compared to operatives decreases as the size of the plant increases, showing economies of scale as individuals become more specialized in their work.

Manpower allocations in countries with intermediate-term industrial traditions

348. The general industry profile of metalworking in countries with intermediate-term industrial traditions, such as Israel, Poland, Turkey and Yugoslavia, shows a preponderance of small- and medium-size firms. The present shortage of qualified personnel in these countries has typically necessitated an expansion of the span of control at the upper level beyond that found in the more industrially advanced nations. This has meant, as well, that men who fill other jobs, such as clerks, must perform a wider range of duties than would their counterparts, for example, in the United States of America. The manpower distributions shown in Table 6 point out the relative deficiency of technical talent - even if allowances are made for the fact that the engineering and design content may be less in the semi-industrialised countries than in the United States.

Table 6

Comparison of manpower distribution in a developed and a semi-developed country (United States of America and Turkey)

	USA (404 plants with more than 100 employees each)	Turkey (sample of plants with 50-750 employees)	Differences (Turkey - USA)
Executives, managers and department heads	3.0%	3.0%	0.0%
Foremen, other first-line supervisors	5.6%	5.1%	-0.5%
Engineers, staff specialists, technicians	6.2%	2.5%	-3.7%
Clerical workers	3.7%	6.5%	-2.6%
Manual workers (operators)	81.5%	83.1%	-1.6%
Total	100 %	100 %	0.0%

Manpower allocation in developing countries

349. The relative shortage of technical manpower in the developing countries, which have substantially no manufacturing tradition, is even more acute than in the semi-industrialized nations. In most of these countries, technical education and vocational training are organized by the government, and often persons who are educated at public expense, either abroad or locally, are obligated to perform public service in return for their training. In such cases, where the government can exert control over a developing manpower pool, the major problem is that of the allocation of particular individuals to those sectors in which they will be most effective. The metalworking industry is often very low on the priority list for trained manpower, and receives only a small part of its actual needs. There seems to be a tendency in the metalworking industries, also, to draw managerial personnel from indigenous persons who are oriented towards marketing. Such managers often face a difficult period of adjustment as they try to cope with many of the multiple responsibilities, technical authority included, which they must assume in addition to sales promotion.

Estimating manpower requirements in developing countries

350. Recent statistical studies in the metalworking industries showed that the ratio of the number of persons employed to the number of machine tools in service is about 2:1. For the following selected countries, this ratio was: United States of America - 2.1; Union of Soviet Socialist Republics - 1.9; United Kingdom - 2.8; Federal Republic of Germany - 1.9; France - 2.2; Italy - 1.6; Japan - 1.8; Brazil - 2.3, and Chile - 3.6.

351. Using such analyses and other methods, it has been estimated that, for each million of population, initial industrialisation will require about 10,000 to 12,000 persons for the metalworking industries. The typical manpower distribution will be managers, 5 per cent; first-line supervisors, 5 per cent; and workers, 90 per cent. Labour productivity in this phase, if the labour input per output is set at about one third, can be expected to be at least 2.5.

352. When the industry expands to the point where exports reach five per cent of all metal products manufactured, the work force should have increased to 25,000 to 30,000 per million of population. Within this number, the percentage of managers, engineers and technicians should have risen to eight to nine per cent. A small clerical staff of one to two per cent should now be available. The proportion of non-supervisory personnel possessing high skills will have increased sharply to more than half of the total work force. It should be noted in this connexion that utilization of automatic equipment, e.g. a modern nail-heading machine, does not increase skilled-labour requirements in proportion to the additional productive capacity which such adoption permits.

353. Organisational patterns in metal-product plants in Thailand bear out the pattern of development just described. However, the situation in Colombia is slightly different in that the greatest shortage has appeared in the ranks of technicians and foremen. Entrepreneurs, engineers and managers are drawn largely from the upper economic levels of the population and are capable of supporting their own educations.

Development of managerial and technical manpower

354. The main difficulty encountered in the training of managerial and technical personnel in the industrially advanced countries is that the skills and points of view acquired are often too sophisticated or too theoretical for application in a setting which includes obsolete machinery, short supplies of

material, non-discriminating customers, and unskilled labour. Such circumstances are often frustrating to the newly trained engineer or scientist and, along with the lure of higher salaries, account for the reluctance of some trained professionals to return to their developing countries when their studies are completed.

355. As an alternative to sending students abroad for study, countries often invite technically competent individuals to give courses or teach in local universities. Though drastically reducing expenses as well as the utilization of foreign exchange and the possible loss of students to other countries, this method contains the risk that instructors unfamiliar with local conditions may provide impractical solutions.

356. A third method for developing indigenous skills is to encourage foreign metal-product manufacturers to set up plants which are specially designed for local markets and fitted to the capabilities of the local labour force. Such plants can provide the required designs, techniques and supervisory manpower for production under licence. Foreign specialists and foreign designs can then gradually be replaced as indigenous technical and supervisory talent develops.

357. Correspondence schools for managerial training have been successful in several countries including Poland, and may be useful in developing additional know-how especially for workers who may not qualify for other types of training, but who have the desire and determination for advancement.

358. The training of indigenous research workers and designers and their instruction in increasingly specialised branches of machine-building is important for raising the competence of such personnel. This calls for close links between the research establishments and technical colleges of the country, especially at the initial stages of development of local industries. An analysis of the experience gained by various countries shows that the organisation of research and design establishments is practical at the following levels of industrial development: countries possessing less than 10,000 machine tools should have a training institute or college with laboratory facilities. If the machine tools are between 10,000 and 50,000 in number, a machine-building research centre should be established, while a metalworking research centre is desirable for 100,000 to 200,000 machine tools. Specialised metalworking centres are indicated if the machine tools in the country number more than 500,000. The lower figures apply to countries with state planning practices, while the higher figures are characteristic of countries with more highly developed private initiative: in the first case, all of the specialists of the country work at one centre where they service the enterprises of a given industry. In the second case, from 50 to 75 per cent of the specialists are scattered among individual enterprises. In the latter case, the research centre proves necessary only in a well-developed industry where it is used for handling difficult problems that are beyond the capacity of one company and call for concentration of efforts in several related sciences.

__Alternatives to ease the manpower shortage__

__(1) Manpower sharing in an industrial park__

359. It is especially important that developing countries make an effort to maximise the use of existing technical manpower. One way of accomplishing this is to develop a plan for sharing managers, engineers and other personnel in staff positions among non-competing industrial plants. Such an arrangement, which can be considered an industrial park for skilled manpower, constitutes the streamlining of all specialised activities so that jobs not requiring the attention of an experienced engineer or manager can be performed by a subordinate staff member. This practice would be most satisfactory if plants using the consulting service were located nearby- for example, arranged in an industrial estate; but this is not essential.

360. The industrial-park concept for technical services should be attractive to many nascent metalworking enterprises, especially those doing job-shop maintenance work or making relatively simple products where design activities are small, but require the attention of highly specialized personnel. Experience in the Union of Soviet Socialist Republics has indicated the efficiency of centralized repair shops not only in terms of monetary savings but also in serving as a training ground for accumulating essential experience and specialists' skills.

(2) Use of capital-intensive equipment

361. Contrary to popular belief, automated processes and equipment can bring a net gain to emerging nations in both their economic and social development. This gain occurs when the packaged intelligence of an automated device quickly and inexpensively supplements or provides production and control skills which would otherwise be scarce or unavailable.

362. if a special skill required for production of a given product is in short supply while "ordinary" labour is abundant, then this skill becomes the limiting factor in the total productive potential of the operation. Thus, the use of an automated device or process which can supply the needed skill in a package, by virtue of the intelligence designed into it, provides a very effective means of reducing the total cost per unit of the product, since less expensive labour can be assigned to the majority of job segments which require lesser skills.

363. The automated device can provide those skills which enable the machine-tool industry to initiate and continue its operation while the infrastructure of qualified manpower is being built up. The numerically-controlled machine tool is an example of such a device. This machine receives instructions on a step-by-step basis from a pre-recorded list; these may be stored in media such as punched cards, the holes of a paper tape, or the magentic spots of an oxide-coated film. The important feature is that the programme of instruction for the machine, once written, need never be written again. Since the control of the machine lies in the instruction list and the machine itself, it is possible to make identical products reliably and accurately, and to predict the time required to produce each. The file of procedures for which instructions are available can be augmented by the product designers as time goes on, so that a large library of possibilities is available to the operator. The instruction tapes that provide the intelligence for operating the machine can be prepared anywhere in the world and dispatched to the operator in compact form.

364. Usually, the majority of job skills is unaffected by the introduction of automated equipment; the operator of the specialized station must only be trained to use it. The operator training time required for automated equipment is measured in months, not years. One other advantage of modern techniques such as numerical control (N/C) and the use of electronic computers to prepare instruction tapes is that they give an incentive to the university-trained engineer to apply some of the more sophisticated skills that he has learned.

365. In the United States of America, for example, a skilled lathe operator (who can set speeds, grind tools, set up work, compensate for expansion when necessary etc.) requires at least four years of training. The training period for an N/C lathe operator is shorter by several months. The machine-servicing requirements, on the other hand, are considerably increased, and call for a service man who is a skilled specialist. However, comparatively few persons can service a large number of machines. N/C also requires additional supporting skills such as programming, and tape or card punching. These, however, are complex only in the case of contour machining, while being comparatively simple for N/C point-to-point machining.

366. Certain disadvantages may accompany the introduction of automated equipment in an emerging economy. Such equipment may aggravate for some time the structural weakness of an industry which lacks a large body of moderately skilled personnel ready to move up to more responsible positions as expansion occurs. The choice of the most modern equipment may be less advantageous than a decision in favour of slightly more dated machinery which may have skill and finance requirements better suited to the needs of a particular country.

367. In regard to the use of second-hand machinery in a developing country, the question of needed skills is not simple to answer. As has been pointed out, skills for the operation of an old machine are often different from those required for a machine of new design, and they are not necessarily simpler skills. The opposite is often true. On the other hand, the maintenance skills needed for modern machinery are usually greater than for older equipment. The statement that the use of second-hand equipment generates obsolete skills has no more validity than the statement that second-hand equipment should never be used in developing countries.

Experience of selected countries

368. The rapidity with which the expansion of metalworking industries has occurred in some Latin American countries has caused a lag in the adoption of institutional measures, among them technological research and the training of labour forces, which should accompany such an evolution. The training of personnel requires time, especially if export products, which must meet exacting specifications of quality, are to be manufactured. The existing training programmes in these countries have been deficient in not including an appraisal of quantities and specialities of the trainees who are required for the future.

369. The first step in the development of the machine-tool industry in Brazil was an investigation of the manpower requirements for 1971 in each of the twenty groups into which the metalworking industry had been divided. As 70 per cent of the labour force employed in the industry is in the State of São Paulo, an estimate was formulated for this State and then extrapolated for the rest of the country. The projection of manpower requirements in there industries agrees with the growth trends determined from statistical data prepared by the State of São Paulo and the Brazilian Institute of Geography and Statistics. On the basis of these data, 600,000 persons will be employed in the Brazilian metalworking industries in 1971. The number of machine tools required was determined for the various types of machines by applying the ratio of the number of persons to the number of machine tools existing in 1960, i.e. 2.3 persons per machine.

370. A first evaluation of the import-substitution programme in Brazil suggests that its implementation would require, over a five-year period, the establishment of a labour force of 7,150 workers, some 3,600 of whom would be engineers, technicians, and skilled operatives. The feasibility of accomplishing such a great increase in skilled manpower (some 134 per cent) is unquestionably one of the most basic elements in the success of the plan.

371. In India, a survey of scientific and technological personnel has been undertaken by opening a Central Register. To assess the requirements in scientific and technical personnel, detailed studies are undertaken by the Directorate of Manpower and an institute established for this purpose.

CHAPTER XIX. PLANNING AND PRODUCTION MANAGEMENT

Long-term planning on a national scale

372. An analysis of the results of an import-substitution programme for a developing country can provide useful information that is relevant to the development of a metalworking industry. If grain is taken as an example, local installation of a fertilizer plant and of a machine-building industry capable of producing equipment for the fertilizer plant, resulting in a supply of grain equalling previous imports, yields very considerable savings in foreign exchange. Such an analysis, however, may not indicate that building the fertilizer plant implies that money must be invested four to five years in advance of the availability of the grain. The investment for the machine-building factory is required some eight to ten years in advance, as are the skills of the labour force needed to operate the plants and supply other services. Also, with a substantial investment of this kind, obviously a considerable sacrifice of domestic capital, and hence consumption, will have to be made until the investment pays off in increased production of grain. As seen from this example, all of these factors add up to a major planning problem for a developing economy in which the timing of investments in the metalworking industries plays a key role.

373. National planning for metalworking industries is desirable since the necessary industrial infra-structure for development will probably not come about simply in response to the stimulus of market demand. First, the small- and medium-scale entrepreneurs operating the main industries in developing countries have insufficient knowledge of the market as a whole. More important, they are unable to foresee the direction in which this market will develop during the next few years, and the new types and models of machinery that will be required by the metalworking industry. Secondly, the possibilities of spontaneous development of the industry are usually restricted by the limited size of the plants, the technical inadequacy of almost all of them, and the difficulties which an incipient industry is likely to encounter in absorbing the know-how of the corresponding industries in the more advanced countries.

374. The relationship of the industries of the metalworking complex to each other and to all other sectors of an industrialised economy must be understood before any national development plan reaches the stage of specific investment projects. Input-output analysis can make a substantial contribution to this end. For example, as an aid in analysing long-term planning activities, a dynamic input-output table can help to identify goods and services available in terms of the time during which a particular change took place. By working back from the required output in a given year (inversion of the input-output matrix), one can determine all the required capital and labour inputs for all industries necessary to produce the final output.

375. Input-output analysis is only one means by which long-term planning problems can be studied. Other mathematical programming and process-analysis models may also be useful in forecasting and co-ordinating the activities of metal-working industries within their own sector complex and in relation to the rest of the economy. Studies related to the consumption of various machine tools used in different manufacturing industries of both developed and developing countries are prerequisites for such sophisticated investigations. Some studies of this type have already been undertaken, notably in the Latin American countries, and are providing estimates of manpower and

machinery required in planning industrial development. A need still exists there, however, for developing specific models, on the basis of the data, for determining the optimal types and quantities of machine tools and personnel for the manufacture of specific items in countries of differing industrial structure and potential demand. Special attention may usefully be devoted to problems of the engineering industries in work projects that are already under way, such as the problems of repair shops, standardization, and second-hand machinery. There is also a fundamental need to reconsider the development of specialized technical and managerial manpower in terms of a long-term investment programme.

Programming the machine-tool industry

376. Certain questions usually arise in nations which are starting to expand their traditional industries, especially the mechanical industry, and also in countries which are already in a more advanced stage of industrial evolution. One of these questions concerns the need to establish, in terms of a general evaluation, the extent to which it is desirable that capital goods, among them machine tools, be manufactured within the country. This problem concerns not so much the attainment of total national self-sufficiency in the requirement of capital goods, but rather the determination, quantitatively and qualitatively, of the type of domestic effort needed in the face of world demand.

377. First, it is necessary to determine how many variables of types and models of machine tools should be manufactured in a country, knowing the inventory of machine tools already installed in its mechanical industries. To this end, criteria are needed for establishing what is meant by these variables. These criteria are than applied to arrive at the number of variables of machine tools which constitute world demand, also called the universe. Next, one must determine for some countries the number of variables of machines manufactured by each for its own consumtpion. In this way, it is possible to establish, in a tentative way, the relationship between domestic machine-tool manufacture measured in variables of types and models, and the inventory of machine tools utilised by the mechanical industries. If this relationship is proved by means of a more detailed study, concrete development plans could then be worked out for the manufacture of these machines in a given country.

378. Some macro-technological background may be useful for the planning stage prior to the installation or expansion of machine-tool industries. Some of this background is provided in the following paragraphs.

379. A great number of variables and their definitions, some of which it is difficult to express quantitatively, must be considered. Construction of the more popular types and models of machines is advisable, leaving aside the highly specialised machines which are not suitable for initial manufacturing processes in developing countries. An index representing the complexity of the machines is then adopted; the same complexity category will include machines differing widely from each other in regard to design and performance. The weight of the machines and their quality, the latter subdivided into separate categories, are also taken into account as some of the variables affecting production. Figures for the intended sise of the enterprises are selected in advance. For example, a plant may be designed to employ from twenty to 500 persons. Factory dimensions are planned to provide suitable space for the production equipment to be housed within their structure.

380. On the basis of definitions and discussions of each variable, the most adequate technically productive field of action for each enterprise may be established; this field of action may be extended and complemented in passing from small to larger enterprises. It is also suggested that consideration be

given to productivity per person and per year, measured in tons, determining the annual production of each enterprise as well as the number of direct hours necessary to manufacture 100 kilograms of product. The latter quantity is regarded as the characteristic coefficient of production. All estimates are carried out by making abstractions for a given product; they show the great differences in quality and complexity of the products which may be manufactured in plants of different sizes.

381. If other coefficients of an economic type are added to the technical ones, such as the fixed expenditures of the enterprise for 100 kilograms of finished product, it is possible to establish a link between the technical and economic factors, thus complementing the field of action of each of the enterprises.

382. The analysis should also take into account the relationship which usually exists between the machine-tool manufacturing industry and the rest of the industry that supplies raw materials and parts. This dependence varies, of course, with the complexity of the products and the size of the enterprise.

Short-term planning at the plant level

383. In contrast to the planning of long-term goals, short-term planning, i.e. production management, relates in the main to the framework of resources which are already defined. The planning function is then confined to designing and evaluating alternative schemes for achieving production goals set by the top management of the plant.

384. The main activities of production management can be grouped under two categories, namely, production planning and control, and methods engineering. The production-consumption cycle starts with the customer and ends with him. The sales department studies consumer reactions and prepares a sales forecast which is submitted to the management. The finance department then prepares a production budget on this basis, and a decision is made regarding the quantities to be produced. The engineering department prepares drawings and specifications which, in turn, are used by the manufacturing departments to issue production and delivery orders. Passing through a series of further steps of production planning, the cycle is completed when the product is sold to the customer. During production, management receives interim and final reports on the technical and financial aspects of the manufacturing processes.

385. Methods engineering, the second category mentioned above, comprises work study, process evaluation, equipment policy, quality control, standardisation, safety, incentives, and plant layout. In some countries, it has come to include operational research, a new branch of engineering dealing with complex problems of the management of large systems of men, machines, materials, money etc.

386. The secret of use of both of these control techniques for developing countries is not to copy blindly particular practices from high industrialised countries, but to adapt selected techniques which seem particularly suited to their circumstances.

387. In the course of their industrial development, it is essential that countries occasionally take stock and examine not only the levels of performance in terms of quantitative targets, but also the structure and composition of their emerging industries. Plans for specific industries should be revised where necessary, so that a reasonable compromise between long- and short-range development goals is achieved. Otherwise a nation may achieve immediate economic goals without building up the industrial infrastructure, the cadres of skilled manpower and the quality of production capability required for sustaining future growth.

Experience of selected countries

388. Venezuela's national development plan for 1963-1966 establishes targets for the various economic activities, with a view to attaining an annual average growth rate of the gross national product of 7.9 per cent as against only 3.7 and 2.8 per cent registered in 1957-1960 and 1960-1962, respectively. In this programme, the metalworking industries play an outstanding role. Within the manufacturing sector, their projected rate of development - 25.6 per cent per annum in value of the gross product - is the highest.

389. The initial objective of an Economic Commission for Latin America study begun in 1963 was to consider the practical possibilities of meeting the targets established for the metalworking sector under the National Plan (Plan de la Nación), in the light of various earlier studies and of the characteristics of the existing industry. During the first phase of the study, serious deficiencies in the structure of the metalworking industry were noted as follows:

(a) General under-capitalisation of firms, with establishments contributing only 4.2 per cent of the fixed capital assets of the manufacturing industry while employing 14.2 per cent (22,215) of the personnel engaged in manufacturing. These statistics imply the presence of

(i) Very low capital density per employee and consequent low productivity - only 9.7 per cent of manufacturers' value added;

(ii) a predominance of servicing and maintenance enterprises over more strictly productive activities;

(b) A very high proportion (90 per cent) of medium- and small-scale establishments among the industry's 1,776 firms, with an industry average of 12.4 employees per establishment;

(c) A large proportion of production consisting of transport material - more than 55 per cent in terms of both gross value of production and value added. Composed chiefly of large-scale vehicle assembly plants and smaller-sized maintenance workshops, these establishments use only about 10 per cent of domestically manufactured goods and provide only a small addition to the value of the end products;

(d) A large group of plants manufacturing metal products, mostly metal structures, wire products and other construction goods, the installation of which was motivated by the fact that such lines of manufacture do not require very highly skilled labour;

(e) A machine-tool inventory consisting of a high proportion of metal-forming machines and a low proportion of cutting machine tools, the latter mainly of the simplest general-purpose type.

390. In addition to these structural defects, the lack of specific plans for metalworking activities was apparent. It was for these reasons that the sector had not fully responded to the promotional incentives provided by the Government, and that it was considered unlikely to succeed in reaching the targets set up under the 1963-1966 Plan.

391. In the revised programme, therefore, emphasis is placed on the correction of structural defects rather than on the actual fulfilment of the Plan's objectives. To this end, an import-substitution programme has been outlined for the metalworking sector, designed to fill the technological gaps in the

existing industry in terms of basic equipment, production techniques and skilled manpower. This should create the sectoral infrastructure which will enable the metalworking activities to improve their competitive position both on the domestic and on the world market, and also to undertake the manufacture of more complex products in the future. The effect of the programme on the country's balance of payments, and even considerations relating to internal manufacturing costs, are secondary criteria.

392. Businessmen in Venezuela will be given advisory assistance in the planning of establishments and of productivity. This applies particularly to the introduction of accounting methods that will keep them informed about their actual production costs. Thus the production process can be led through its various stages, and the management of existing and new plants facilitated to achieve fuller utilisation of the productive resources that are available.

CONCLUSIONS

393. From the 40 papers presented by the experts at the Symposium on Metalworking Industries in Developing Countries, most of which are technical and detailed and useful for future reference; from the general discussions held which were of great interest in regard to various issues; and from the preceding report, the following general conclusions can be drawn:

(1) In the survey of industries in general in both developed and developing countries, it is evident that the contributions of the metalworking industries to employment and value added to production, relative to other industries, are higher in developed countries (e.g. Britain, 40 per cent in 1958) than in developing countries (e.g. Pakistan, 3 per cent), and that the state of a country's metalworking industry is roughly indicative of the state of that country's industrial development.

(2) The growth of machine building is one of the most important factors in the development of industry, and in the increase of national income and employment in developing countries.

(3) From case studies of industries in the developing countries, it is found that a certain pattern of industrialisation prevails nowadays. A country developing its metalworking industry appears to go through three typical stages: a first stage during which installation, maintenance and repair of metalworking machines, and also of other types of machines in other industries, take place; a second stage in which some manufacturing of metal goods is carried out mainly for local consumption; and a third stage in which complicated machines are produced, not only for local use but also for export, and in which the development of basic industries like steel production takes place. Yugoslavia and India are examples of developing countries that have passed through the first two and are now in the third stage.

394. It is also found that the problems of developing countries vary at various stages of their metalworking development. It is therefore not possible to prescribe one formula for all developing countries. For instance, in those countries which are still in the first stage, the most pressing problems may be more organisational than technical.

395. Thus, when the conditions necessary for establishing and promoting metalworking industries are considered, the background of each country and the stage of its development have to be kept in mind. The experiences of developed countries are useful, but must be adapted to local conditions. Co-operation with developed countries enables developing countries to bypass many trial stages.

396. Machine-building projects cannot be considered separately, but must be viewed as part of a general plan for industrialisation. The government of the developing country can initiate plans for setting up such industries. It can encourage free enterprise or go into partnership with entrepreneurs,

and/or organise state-owned enterprises. Some means should be employed, however, to ensure that the industry is developing in the right direction.

397. The trade policies employed by governments of developing countries to protect newly developing industries can be useful. However, such policies should not lead to complacency and stagnation on the part of industry. Before protective tariffs are imposed, a detailed study of the existing situation is advisable.

398. As a result of the absence of universally accepted standard specifications, difficulties in the international trade of machine tools have arisen. The "Schlesinger Acceptance Tests" and other tests used during the early stages of industrialisation in some countries were designed to overcome such problems.

399. The metalworking industry is continuously developing as technological progress is made. This is evident in innovations applied to existing machines, and in numerical controls which reduce setting-up time and save the cost of jigs and fixtures, particularly for small-batch production. It is also evident in processes like the continuous-casting process. The use of electro-physical and electro-chemical procedures, while these may seem sophisticated and the necessary machinery expensive, may yet solve some particular production problems. Mass-production techniques may be applied to certain products to reduce costs.

400. It is generally supposed that automation will perhaps eventually make men superfluous. Also, it must be considered that, in the case of certain countries, labour shortages may arise in the future if automation is not applied. However, each case should be examined on its merits to determine whether mass-production techniques should be introduced. The knowledge of up-to-date methods, therefore, will enable the developing countries to select those that are best suited to their needs.

401. Since they are the basis of metalworking industries, machine tools were dealt with most extensively during this Symposium. To bring about improvements in machine tools, research should be carried out in the areas of rigidity, accuracy and durability, especially under conditions such as heat, large temperature variations, humidity and dust.

402. A developing country with scarce resources cannot easily undertake all research alone. The co-operation of developed countries and of international organisations, and also regional co-operation among developing countries, can help to solve this problem.

403. Centres whose function it is to collect data and give needed information will greatly help the development of the industries. These centres can also assist in the setting up of standards for industries for most of the common items. Standards used by developed countries can be adapted; help in this may be obtained from international bodies such as the United Nations, International Organisation for Standards (ISO) etc. However, a uniform world standard for items such as machine tools will facilitate their use, no matter in what part of the world they are manufactured, especially in developing countries.

404. Economic considerations in the setting up of metalworking industries are important. In addition to considerations of financing, there is a need to know to what extent the existence of such industries will affect a country's economy. Input-output analyses are useful means of working out a balance among interdependent industries, and are of help in reaching decisions about the types of industry to be set up. For this and for general planning, censuses of manufacturing plants and the preparation of machinery inventories are useful.

405. Several economic techniques are helpful during the planning stage of setting up a metalworking industry. The development of a statistical department equipped with computers makes statistical data readily available. Break-even analyses can be employed in selecting, among alternatives, the machines or methods best suited to a given task, and to the lot size to be manufactured. With these techniques, it can be determined whether a sophisticated machine su h as a numerically-controlled unit should be used, or whether mass-production methods are preferable. Economic considerations may favour the acquisition and use of second-hand machines in developing countries where shortage of capital is a problem, but technological and psychological considerations weigh heavily against this.

406. Local resources and services have to be taken into account during planning, and the availability of spare parts and cost of future maintenance considered. The possibility of setting up a centralised repair shop for machines, if transportation facilities are suitable, should be investigated.

407. Metalworking industries in developing countries require large investments. For countries too small to start and maintain such an essential industry, regional co-operation among several nations could solve this problem. Financial and technical assistance and other forms of aid from developed countries are another possibility.

408. The manpower required and available for the metalworking industries that are to be set up in a developing country should be considered during the planning stage, so that training can be begun where necessary. A pool of local managerial staff and experts can be formed; these could travel to areas where they are needed. Making optimum use of the few experts available in developing countries is of paramount importance. Developing countries also should provide sufficient incentive for their own experts so that the "brain drain" to developed countries can be prevented.

409. The training of skilled men is of the utmost importance in areas where the available manpower is insufficient for an industrial project. Training of personnel from the managerial level down to the skilled-worker level can be carried out with the assistance of developed countries. Already, there are some in-plant training schemes in operation for engineers, arranged by the United Nations with developed countries. Technical institutes in developed and developing countries, as well as apprentice training, can solve the problem of shortages of technicians and skilled workers. Training is another field where regional co-operation may be called into play.

410. If the developing countries are to contribute high-quality metalworking machines to the world market, modern and practical designs will have to be adopted by them. Designs from developed countries can be obtained at the initial stages of machine building through licence agreements, keeping in mind that changes in environment may necessitate modifications. Patent systems in developing countries will help induce and protect improvements or innovations resulting from local research and discoveries.

RECOMMENDATIONS

The United Nations Symposium on Metalworking Industries in Developing Countries calls the attention of the United Nations to the prime significance which the metalworking industry has for the welfare of the developing and developed countries.

After extended deliberations, the Plenum of the Symposium submits to the United Nations the following recommendations for promoting the progress of the metalworking industries in the developing countries:

1. Establishment of an Information Centre with the assignment of investigating and answering technological and economic questions related to the problems of metalworking, which are submitted by developing and developed countries.

2. The United Nations should extend its help to promote and organise Research and Development Institutes for the specific local needs of developing countries. These Institutes should begin as small pilot organisations and should gradually be expanded. The most effective locations of such Institutes should be investigated.

3. The United Nations should increase its help in advising the developing countries regarding planning and organisation of the development of metalworking industries, and in selecting the types of products to be manufactured.

4. An international multi-language classification system of all metalworking machines should be initiated under the auspices of the United Nations, in order to eliminate existing confusion in terminology and misunderstandings in various countries. Such a classification should be preceded by an international definition of a machine tool. A similar classification should be initiated for materials for metalworking industries.

5. The United Nations should assist in securing the capital required for the industrialisation of developing countries.

6. Assistance should be rendered by the United Nations in establishing patent systems and offices in developing countries.

7. The United Nations should investigate the feasibility of the creation of a world patent system for the international utilisation of patents.

8. Investigations by the United Nations of the possibilities of adapting acceptance tests for new machine tools to present requirements are recommended. These may include the up-dating of the Schlesinger and other accepted tests where required, taking into consideration developments in many countries. Type testing and grading of machine tools with United Nations assistance is likewise recommended for this investigation.

9. Steps should be taken by the United Nations to prepare technical textbooks in several languages, and other educational materials which can be used in the apprentice schools of developing countries. Preparation of similar books for training teachers is likewise recommended.

10. The United Nations should expand training courses and on-the-job training in both developing and developed countries for machine operators, technicians and engineers. Establishment of refresher courses for senior engineers is likewise recommended.

11. The investigation of the feasibility of setting up courts of arbitration for technical disputes between countries is recommended.

12. The assistance of the United Nations is recommended in securing low tariffs for the export of metalworking products from developing countries.

13. Investigations should be made by the United Nations on the establishing of standards for metal products manufactured in developing countries.

14. It is recommended to repeat symposia like the present one in different countries, since the exchange of views and information proved most useful.

The Plenum calls the attention of the developing countries to the following recommendations:

(a) To establish an agency for improving the collection of local statistical data. Such data will also be useful in supporting the aims of the United Nations;

(b) To carry out machinery censuses at intervals;

(c) To familiarise themselves with the latest technical developments, so that they can take optimum advantage of available resources; and

(d) To consider regional co-operation in setting up research centres, and in obtaining advantages from a common market, from common training and from the sharing of financing.

Annex I

LIST OF PARTICIPANTS AND OBSERVERS

Representatives of developing countries

Afghanistan:	AKEFIE, Ahmad Ali, General Director of Mines, Ministry of Mines and Industries, Kabul
	ALIEF, Mohammed Hassan, General Director of Minerals Survey, Ministry of Mines and Industries, Kabul
Algeria:	MERAD-BOUDIA, M., Deputy Director of Department, Ministry of Industries and Power
Bolivia:	MURGUIA-SANCHEZ, Guillermo, General Director of Mines, Ministry of Mines and Oil, La Paz
Brazil:	BELLO, Almeida, Consulting Engineer, Mechanical and Electrical Engineering Section, Ministry of Planning
	LEAL DE ABREU, J. G., Chief Engineer, Cia. Siderurgica Nacional, Volta Redonda
Ceylon:	JAYASIRI, N. W. N., Electrical Engineer, Ceylon Steel Corp., Athurugiriya
	MANIKAM, P. G., General Manager, Ceylon Steel Corp., Athurugiriya
Chile:	BUSTOS-SOFFIA, P. A., Chief of Metallurgical Planning, Department of Technical Assistance and Training
	HUTTNER SKALL, Felix, Department of Industries, Office of Production Development
Colombia:	BUENAHORA MUNOZ, Alvaro, Chief of Planning, Technological Research Institute
	OSPINA HERNANDEZ, Fernando, Adviser: FEDEMETAL, and Manager of Ferrotec, S. A.
	SANCHEZ VALENCIA, Daniel, Chief of Industries and Trade Section, Planning Administrative Department, Economic Institute for Industrial Development
Greece:	KATAFIGIOTIS, S., Technical Director, ATME Engineering and Mechanical Co. Ltd. (N. J.) Dritsas, S.A., Piraeus
Guinea:	BAH, Abdoulaye, Metallurgical Engineer, General Directorate of Industry, Mines and Geology, Conakry
	CONDE, Souareba B. B., Metallurgical Engineer, General Directorate of Industry, Mines and Geology, Conakry
Honduras:	MEMBRENO, Benjamin, Industrial Engineer, Department of Industrial Development, National Development Bank, Tegucigalpa

India: GEJJI, R. K., Industrial Adviser on Machine Tools to the Directorate General of Technical Development, Ministry of Supply, Technical Development and Materials Planning

GHOSH, Ajit Kumar, Chief Project Officer, Heavy Machine Tools Project, Heavy Engineering Corp. Ltd., Ranchi

Iran: OSTOVAR KERMANI, F., Technical Specialist, Ministry of Economy

Iraq: AL-ROBOEI, Y., Head of Industrial Planning Department, General Directorate of Planning

Israel: BARBASH, I., Director of Metallurgical Industries, Ministry of Commerce and Industry

LEEF-SHITZ, Y., Director of Import of Industrial Equipment, Ministry of Commerce and Industry

Japan: SHIMO, Kotaro, Technical Official, Ministry of International Trade and Industry, Tokyo

Madagascar: RAJAONIZELINA, Robert, Principal Engineer of Mines, Directorate of Mines and Power, Tananarive

Mali: SIDIBE, Sékou, A.C.M. - Société d'Etat, Bamako

Mexico: DE LEON FIGUEROA, Julio, Department of Special Studies, Ministry of Industry and Commerce

MORENO FRANCES, Vicente, Engineer, Maintenance, Social Security Institute

NORIEGA IMBERT, M. A., Technical Adviser, Department of Control of Industrial Enterprises and Relations, Nacional Financiera, S. A.

Nigeria: ADEGBOYE, A., Executive Engineer, Defence Industries Corp., Ministry of Defence, Lagos

Poland: OSTROWSKI, W., Chairman, Prosanet Bepes Main Technical Council

Romania: BUZESCU, Mircea, Chief Engineer, Metalworking Factory Institute, Bucharest

Spain: PRADES SANCHEZ, F., Mining Bureau, Ministry of Industry

RODRIGUEZ ESPINOSA, A., General Technical Bureau, Ministry of Industry

Sudan: EL HAKIM, Munir Y., Mechanical Engineer, Sudan Industrial Research Institute, Khartoum

Uruguay: MASSONNIER, José E. G., Planning and Co-ordination, Division of Industrial Development, Banco de la Republica Oriental del Uruguay

Yugoslavia:	TRIFUNOVIĆ, Miljko, Expert, Foreign Trade Research Institute, Belgrade
	VUJAČIĆ, Djura, Expert, Federal Chamber of Commerce, Belgrade

United Nations experts

Bulgaria:	SOKOLEV, P. P. Director, Scientific Research and Design Institute for Metalworking and Machine Tools, Sofia
France:	CHAMPETIER, L., Consultant Engineer, Machine Tool Research Institute (SCFMO)
India:	PATIL, S. M., Managing Director, Hindustan Machine Tools Ltd., Bangalore
Japan:	IMAI, Y., Managing Director, Japan Machine Tool Trade Association, Tokyo
Netherlands:	BOON, G. K., Economic Adviser under the United Nations Technical Assistance Programme, Banco de Mexico, S.A., Department of Economic Studies, Mexico
Poland:	KACZMAREK, J., Director of the Institute of Metal Cutting and Pro-rector of the Technical University, Cracow
United Kingdom:	SPARKES, C. A., Director of Design and Development, H. W. Kearns and Co. Ltd., Altrincham, Cheshire
United States of America:	ASHBURN, A., Editor, American Machinist, McGraw Hill Inc., New York
	CARTER, Anne P., Senior Research Associate, Harvard Economic Research Project, Harvard University
	KRONENBERG, M., Consulting Engineer, Professor Emeritus, Doctor of Engineering
	LEONTIEF, W., Professor of Economics, Harvard University, and Director, Harvard Economic Research Project
Union of Soviet Socialist Republics:	ARSHINOV, V. A., Rector, Moscow Machine Tool-Building Institute
	BELOV, V. S., Deputy Director, Experimental Scientific Research Institute for Machine Tools
	LIVSHITZ, A. L., Doctor of Science, Experimental Scientific Research, Institute for Machine Tools
	PAGODIN, A. A., Chief of Department, Experimental Scientific Research Institute for Machine Tools
	PRONIKOV, A. S., Rector of Moscow Technological Institute
	PUSH, B. E., Pro-rector, Moscow Machine Tool and Cutting Tool Design Institute

SAKHAROV, G. M., Chief Engineer, Institute "GIPROSTANOK"

SURGUCHEV, J. A., Director of the Machine Tool Works, "Krasniy Proletariy"

VASILIEV, V. S., Director of Research, Experimental Scientific Research Institute for Machine Tools

VLADZIYEVSKY, A. P., Director, Experimental Scientific Research Institute for Machine Tools

YAKOBSON, M. O., Professor, Experimental Scientific Research, Institute for Machine Tools

Economic Commission for Latin America:

MATTHEWS, R., Chief, Metal Transforming Industries

VIDOSSICH, F., Machine Tool Expert

Economic Commission for Asia and the Far East:

SUBRAMANIAN, V. M., Chief, Metal and Engineering Section

Observers

Belgium:

REMBERS, M. J., General Manager, Belgian Association of Machine Tool Builders, Brussels

Bulgaria:

BASSAROV, G., Engineer, Central Union for Machine Tool Plants, Sofia

POPOV, Dimiter, Machine Tool Research Institute, Sofia

RADEV, S., Central Union for Machine Tool Plants, Sofia

Federal Republic of Germany:

BAUMANN, E., Engineer, Verein Deutscher Werkzeugmaschinenfabriken e.V. (VDW), Frankfurt

MELCHER, H., General Manager, Verein Deutscher Werkzeugmaschinenfabriken e.V. (VDW), Frankfurt

France:

FOUQUET, S., European Committee for Cooperation of the Machine Tool Industries, Paris

Italy:

CAVALLI, C., Principal Manager, Fiat Automobile Co., Torino

GRAZIOSI, R., Vice General Manager, Stabilimenti di Sant' Eustacchio, Brescia

RAGAZZI, P., Director, Fiat Automobile Co., Torino

Japan:

OGAWA, H., Chief of Factory, Riken Steel Co., Nagooha City

TERADA, K., Deputy Director of Business Department, Toyoda Machine Works, Ltd., Toyoda City

Switzerland:

MOTTU, A., Technical Manager, Société Genevoise d'Instruments de Physique, and President of the Swiss Laboratory of Watchmakers, Geneva

United States of America:	BRADNER, G. T., Director of Finance, The Lees-Bradner Company, Cleveland, Ohio, and Chairman of the Sales and Services Committee of the National Machine Tool Builders Association
	KEASBEY, William C., Second Secretary, American Embassy, Moscow
Union of Soviet Socialist Republics:	ABANKIN, V. I., Director, Quality Inspection Department, Ministry of Machine Tool Industry
	GRANOVSKY, G. I., Professor, Moscow Bauman Higher Technical School
	GRIGORIEV, V. K., Director, State Committee on Standards
	KOMAROVA, C. A., Secretary of the Scientific Council, State Committee for Science and Technology
	MONAKHOV, A. G., Director of "Orgstankinprom"
	MURAVIN, E. N., Deputy Director, Technical Department, Ministry of Machine Tool Industry
	NAZAROV, N. A., Director, Machine Building Department, State Committee for Science and Technology
	ZOREV, N. N., Professor, Deputy Director of ZNITMASH

Specialized Agencies

International Labour Organisation:	MOORE, C., International Labour Organisation, Geneva, Switzerland

Symposium management

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Annex II

PAPERS PRESENTED TO THE SYMPOSIUM

Technical papers A: State of metalworking industries

A-1. "Current developments in metalworking", by P.A. SIDDERS, Director and Chief Associate Editor, *Machinery*, United Kingdom.

A-2. "Machine-building technology", by A.E. PROKOPOVITCH, Deputy Minister of Machine Tool Industry of the Union of Soviet Socialist Republics.

A-3. "Manufacture of industrial machinery and equipment in developing countries", by G. CUKOR, Technological Division, Centre for Industrial Development, United Nations Secretariat.

A-4. "The development and planning of metalworking industries in the ECAFE countries", by V.M. SUBRAMANIAN, Chief, Metal and Engineering Section, United Nations Economic Commission for Asia and the Far East.

A-5. "The metalworking industries in Latin America", by R. MATTHEWS, Chief, Metal Transforming Industries Section, United Nations Economic Commission for Latin America.

A-7. "World machine tool production with special reference to developing countries", by V.N. VASILIEV, Technological Division, Centre for Industrial Development, United Nations Secretariat.

A-8. "The metal-transforming industry in Venezuela: an import substitution development programme", presented by the United Nations Economic Commission for Latin America.

A-10. "The manufacture of machine tools in Argentina", presented by the United Nations Economic Commission for Latin America.

A-11. "The manufacture of machine tools in Brasil", presented by the United Nations Economic Commission for Latin America.

A-12. "A study of the Indian machine-tool industry", by S.M. PATIL, Managing Director, Hindustan Machine Tools Ltd., Bangalore, India.

A-13. "Metalworking industries in southern Italy", by V. VALLETTA, Honorary President, Fiat Motor Company, Torino, Italy.

Technical papers B: Production problems in the metalworking industries

B-1. "Trends in the design of metalworking machinery and in production methods", by M. KRONENBERG, Consultant, United States of America.

B-2. "Special considerations of machinery design for industrially developing countries", by H. OPITZ, Aachen Technological Institute, Federal Republic of Germany.

B-3. "Problems in the development of metal-cutting techniques", by J. KACZMAREK, Member, Academy of Science and Director, The Institute of Metal-Cutting, Cracow, Poland.

B-4. "New methods for non-mechanical machining of materials: electro-physical and electro-chemical methods", by A.L. LIVCHITS, Experimental Scientific Research Institute for Machine Tools, Union of Soviet Socialist Republics.

B-5. "Development of aggregation in the production of metal-cutting machines" by K. GLEZER, Director of Machine Tool Research Institute, Eastern Germany.

B-6. "Methods of process control in engineering industries", by A.P. VLADZIYEVSKY, Director, ENIMS, Union of Soviet Socialist Republics.

B-7. "Product automation in developing countries", by VAN COURT HARE, Jr., Columbia University, United States of America.

B-8. "Simplified systems of programme control for universal machine tools", by E. SADOR, Director, Development Institute for Machine Tool Industry, Budapest, Hungary.

B-9. "Production management for developing countries", by S. EILON, Imperial College, London, United Kingdom.

B-11. "Mass production methods in the machine-tool industry in the Union of Soviet Socialist Republics", by J.A. SURGUCHEV, Director of the Machine Tool Works, "Krasniy Proletariy", Union of Soviet Socialist Republics.

B-12. "An example of machine-tool production methods", by C.A. SPARKES, Kearns and Co., United Kingdom.

B-14. "Basic problems in the efficient selection of metalworking machines for developing countries", by V.S. BELOV, ENIMS, Union of Soviet Socialist Republics.

B-15. "Main trends in development and organisation of designing and research work in machine-building industries of developing countries", by V.S. VASILIEV, Director of Research, ENIMS, Union of Soviet Socialist Republics.

B-18. "Organisation of facilities for repair and maintenance of industrial machinery and equipment", by M.O. YAKOBSON, ENIMS, Union of Soviet Socialist Republics.

B-19. "Repair and maintenance of machine tools in developing countries", by A.S. PRONIKOV, Rector of Moscow Technological Institute, Union of Soviet Socialist Republics.

B-21. "Research for the machine-tool industry", by A.E. DE BARR, Machine Tool Industry Research Association, United Kingdom.

B-22. "Some problems in the application of research in the machine-tool industry", by A. MOTTU, Technical Director, Société Genevoise d'Instruments de Physique, Switzerland.

B-25. "Some major problems in the introduction and mastering of digital control at machine-building plants", by L. CHAMPETIER, Chief Engineer, Scientific Research Centre for Machine Tools (CERMO), France.

Technical papers C: Economic aspects of development of metalworking industries

C-1. "Decision rules for equipment investments in metal products industries with special reference to metal-chipping and metal-cutting machines", by G.K. BOON, Consultant, Netherlands.

C-2. "Organisation of a machinery census and use of census data with special reference to industrially developing countries", by A. ASHBURN, Editor, American Machinist, United States of America.

C-3. "The problems and significance of industrial standardisation in metalworking industries of developing countries", by J.E. WILSON, Vice President of Manufacturing, SCM Corporation, United States of America.

C-4. "Criteria and background information for programming the machine-tool industry", by F. VIDOSSICH, Machine Tool Expert, United Nations Economic Commission for Latin America.

C-5. "Minimum nomenclature of metal-cutting equipment recommended for production in developing countries", by P.P. SOMLEV, Director, Scientific Research and Design Institute for Metalworking Equipment and Machine Tools, Bulgaria.

C-6. "The position of metalworking industries in the structure of an industrialised economy", by W.W. LEONTIEF and A.P. CARTER, Harvard University, United States of America.

C-7. "Report of expert group on second-hand equipment for developing countries", Report by Experts Group, prepared for the Centre for Industrial Development, United Nations Secretariat.

C-10. "Design of machine-tool plants in developing countries", by G.M. SAMMAROV, Chief Engineer, State Institute for Design of Machine Tool Plants, Union of Soviet Socialist Republics.

C-11. "Methodological and operational aspects of machine-tool studies in developing countries", by R. MATTHEWS, Chief, Metal Transforming Industries Section, United Nations Economic Commission for Latin America.

C-12. "Estimation of managerial and technical personnel requirements in metal-processing industries", presented by Technological Division, Management and Training Section, United Nations Centre for Industrial Development and W.W. WAITE, Columbia University, United States of America.

C-13. "Basic principles of training engineering and technical specialists for the metalworking industry", by V.A. ARSHINOV, Rector of Moscow Machine-Tool Building Institute, Union of Soviet Socialist Republics.

C-14. "Problems in machine tool replacement", by N.D.G. MOUNTFORD, Rolls Royce, United Kingdom.

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