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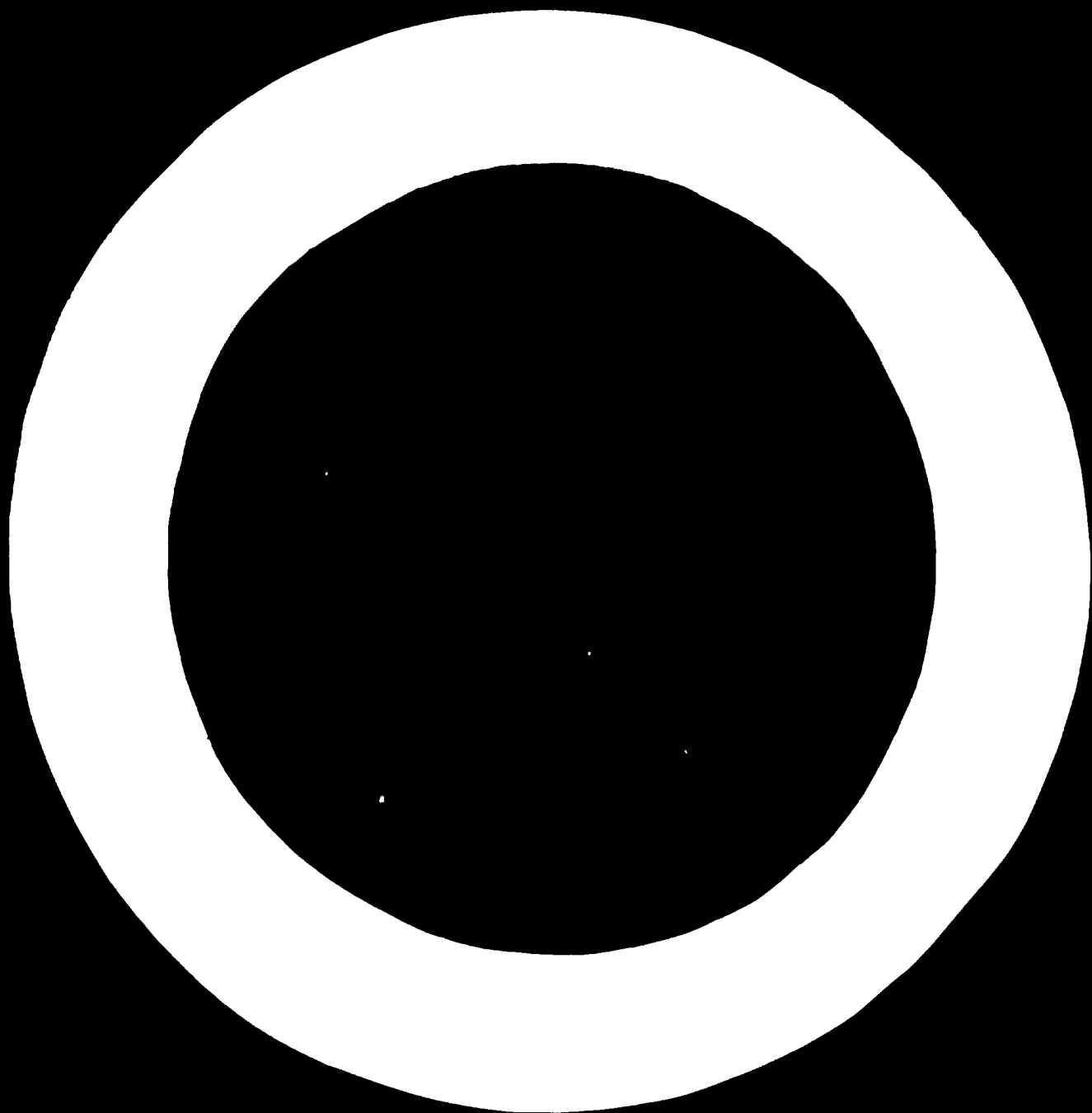
Development of Metalworking Industries in Developing Countries

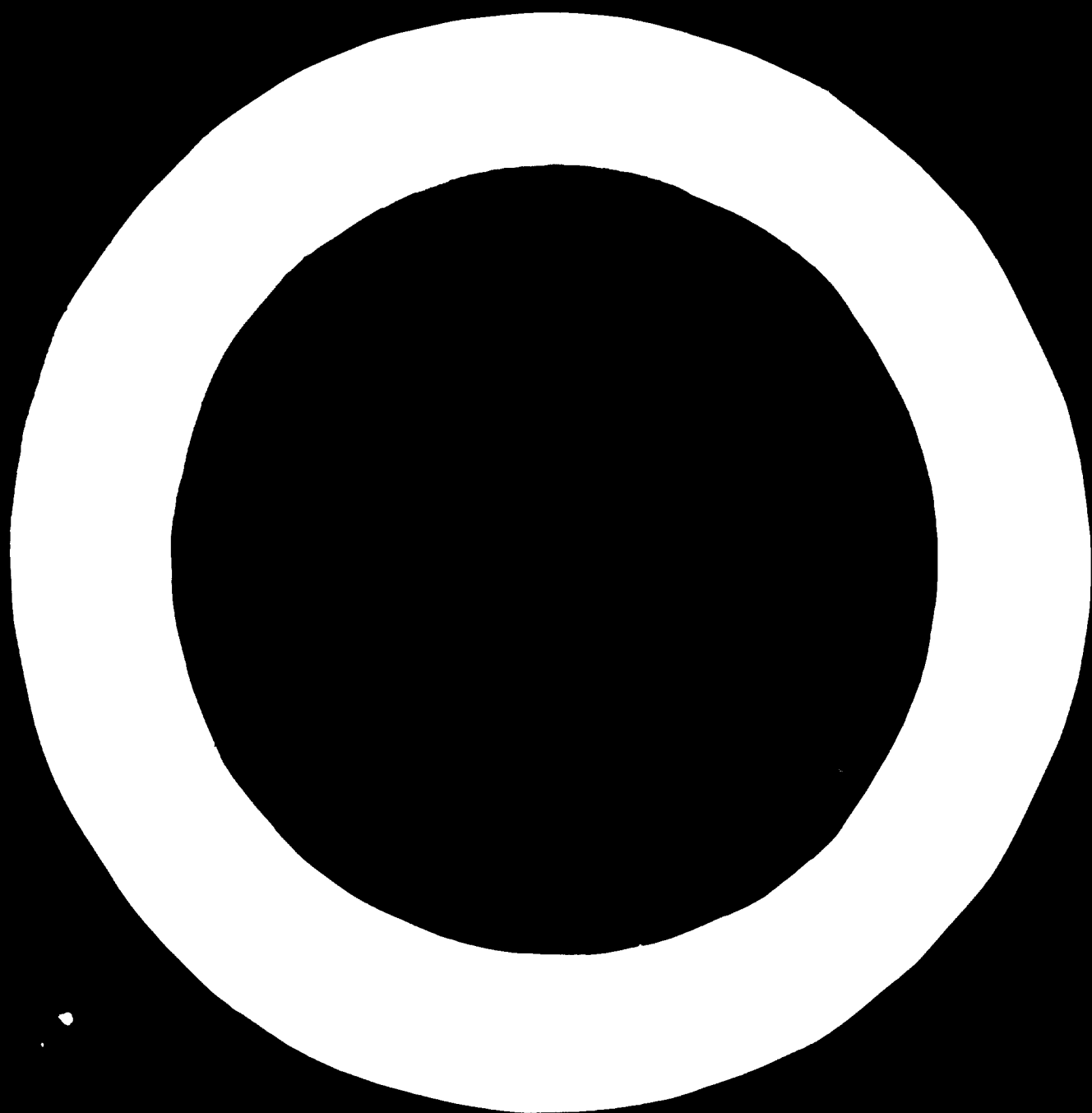
*Reports presented at the United Nations
Interregional Symposium, Moscow
7 September--6 October 1966*

Sale No.: E.66.II.B.2
ID/6



UNITED NATIONS
New York, 1969





THE MANUFACTURE OF MACHINE TOOLS IN BRAZIL

Secretariat of the United Nations Economic Commission for Latin America

INTRODUCTION

The importance of expanding production of capital goods at the present stage of Latin America's economic development, when the capacity to import is severely limited and a high rate of investment must be maintained, is generally recognized. The machine-tool industry has a key role to play in this expansion, since there is no branch of manufacture either of machinery and equipment or of durable consumer goods in which a high proportion of machines for metalworking is not used. Thus, the contribution to the economic development of Brazil made by the industry discussed in this report is of more vital significance than could be deduced from the number of enterprises or the labour employed in the sector.

There is a close connexion between a country's degree of industrial development and the technical and economic structure of the machine-tool industry. In this respect, Brazil is at a transitional stage.

The structure of the Brazilian machine-tool industry today is consonant with the country's requirements up to the present time, predominant among which have been machinery and equipment for maintenance and lines of manufacture which do not call for great precision or long production series. But as a result of Brazil's recent industrial development, there are signs of increasing demand for the more complex and heavier machinery used in more highly specialized branches of manufacture. To meet such requirements, the machine-tool industry will be obliged to supply the market with different products and in order to manufacture these it will have to introduce radical changes both in its technical and economic structure and in its methods of work. It would therefore seem that the industry has reached a decisive phase in its evolution, and needs overhauling and modernization so that it can continue to expand in the forthcoming decade.

However, in view of operating conditions in the industry, it is unlikely that these changes will come about of their own accord in response to the stimulus of market demand. The small- and medium-scale entrepreneurs of whom the industry is chiefly comprised have not sufficient knowledge of the market as a whole, or, more important still, can they foresee the direction in which this market will develop and the new types and models of machinery that will be required by the metal-transforming industry during the next few years. To present a qualitative and quantitative appraisal of the market up to 1971, that is, to define the framework into which the Brazilian machine-tool industry will have to fit during the next stage of its development, is the primary purpose of this report.

Detailed knowledge of the probable future market is an essential prerequisite, but not the only one for the introduction of structural changes in the industry. The latter's possibilities of spontaneous development are restricted by this small size and the difficulties which an incipient industry is likely to encounter in absorbing the know-how available in the more advanced countries.

Clearly, then, deliberate steps must be taken to create institutional conditions which will bring about the necessary transition towards a more balanced industrial structure and greater technical efficiency. These conditions should be conducive, in the first place, to the development of new industrial undertakings in the sector and the consolidation of those already in existence, through agreements on royalties in respect to technical assistance and the manufacture of new models. Secondly, they should be such as to encourage the creation, possibly through a specialized institution, of national technical assistance facilities chiefly designed to help small- and medium-scale establishments in their efforts to modernize, expand and improve technical plant and manufacturing activities.

Another purpose of this study is to indicate current conditions in the industry and the direction in which changes should take place, as well as to suggest basic lines of approach to the establishment of a national institution to provide technical assistance for the machine-tool industry.

Thus, the study covers two aspects of the background material on which development programming for the Brazilian machine-tool industry must be based: a quantitative and qualitative evaluation of the market in the next decade, and an analysis of operational conditions in the industry as it exists in Brazil, with an indication of the changes required.

METHODS OF RESEARCH AND SUMMARY OF MAIN CONCLUSIONS

The term machine tools, in its widest sense, is applied to a group of machines used for cutting, forming, grinding and polishing metals, wood and other materials, and usually classified in two major categories: chip producing (lathes, milling machines, drills, boring machines etc.) and non-chip producing (presses, forge hammers, bending, cutting and forming machines etc.). Those in the second category are also frequently referred to by the general name of forming machines. The definition of machine tools, however, varies from one country to another, so that in practice there is no standard interpretation of the term indicating which machines it should

be taken to cover.¹ For this study, machines used for metalworking, whether in cutting or forming operations, are regarded as machine tools.

Given the objectives and scope of the study, intensive field work was required in order to collect the basic data needed for knowledge and analysis of demand for machine tools and domestic production. The study was prepared in close co-operation with the executive board of the Heavy Metal Transforming Industry (GEMAPE), the Machine Industry Syndicate of the State of São Paulo (SIMESP) and the Brazilian Association for the Development of Basic Industries (ABDIB) which provided the facilities, and with two engineers from GEMAPE and SIMESP.

This study is the first of its kind in Brazil on machine tools, a sector in which there are many complex problems. It must therefore be regarded as provisional in some respects and subject to reservation. Certain situations, such as those relating to future demand for machine tools or to the average weight of the domestically produced or imported machines which will form the country's inventory in the future, can be evaluated only on the basis of assumptions which, while established on logical grounds and supported by the experience of other countries, are not guarantees. In this connexion, the field of machine tools is particularly complex, and does not seem to be governed by laws or criteria that can be universally applied or extended from one area to another.

A primary concern of this paper is the study of the machine-tool industry's actual construction of machines; complementary industries, such as accessories and spare parts, are not included. Similarly, owing to lack of time and resources for research, no attempt has been made to deal with production of the corresponding tools. These aspects are closely linked to the machine-tool sector and undoubtedly should be tackled in future studies.

Machine-tool requirements

In order to establish machine-tool requirements for the next ten years, consideration was given to the needs deriving from the country's industrial development and to machines for replacement purposes. The basis for estimating the former was Brazil's total stock of machine tools in 1960, which had to be determined by a survey. The inventory was taken in the metal-transforming industries,² the leading consumers of the machines, in the State of São Paulo, where almost 70 per cent of these industries' labour force is employed. By extrapolation, this result was extended to the rest of the country, and the machine tools used for maintenance work in other sectors (for example, the textile, food processing, chemicals and rubber industries) were added, for which an estimate was prepared on the basis of the experience recorded in other countries.

¹ In the United States, for example, the term relates only to metal-cutting machines, while in France both cutting and forming machines, for working both metal and wood, are comprised under the heading of *machine-outil*.

² Manufacture of metal products; machine industry, excluding the manufacture of electrical apparatus; manufacture of electrical and communications material; and transport material industry.

It was determined that the national inventory of machine tools in 1960 was 205,654 units. This inventory displays two interesting characteristics. In the first place, the high proportion of simple universal machines would seem to indicate a typical industrial structure in which activities with low volumes of output predominate; in the second place, it is a fairly new collection of machines in which those under ten years old represent 55 per cent of the total; only 24 per cent are over twenty years old.

From study of each of the various branches comprised by the metal-transforming industries, an estimate of individual machine-tool requirements up to 1971 was calculated on the basis both of growth trends in the past and of projects for developing new activities in the sector and demand prospects in respect to the final goods. Thus, with the inclusion of an estimate of machines for maintenance, it was computed that by 1971 the country's inventory of machine tools would total 369,146 units, i.e., it would exceed the 1960 figure by 80 per cent. This would imply an average annual growth rate of 5.5 per cent, which compares reasonably well with the growth prospects established for the gross domestic product (5.7 per cent a year) and for the metal-transforming industries (10.2 per cent).

In estimating the number of machines for replacement purposes,³ a conservative assumption was adopted, to the effect that a third of the machines which were over twenty years old in 1960, i.e. 8 per cent of the 1960 inventory, would be replaced in 1971.

By this method, demand for machine tools from 1961 onwards was established at 179,947 units, and after subtraction of the machines incorporated into the inventory in that year the conclusion was reached that requirements for 1962-71 would be 158,826 machine tools.

The existing machine-tool industry

Concurrently with the inventory of existing machines, a survey of the domestic machine-tool industry was carried out. This activity, which started in Brazil during the Second World War in response to the need to supply those internal requirements which were seriously affected by import difficulties, has made striking progress in the past twenty years and especially since 1956. At present, it constitutes an industrial complex of 114 establishments employing about 5,000 persons and producing an annual output of more than 13,000 tons.

Of those establishments, 88.8 per cent are in the State of São Paulo, which clearly indicates that this activity has been linked very closely to the expansion of the metal-transforming industries.

Not all the enterprises are engaged exclusively in manufacturing machine tools; it is common to find them undertaking other lines of metal-transforming production. According to the survey, the proportion of the establishments which manufacture items other than machine tools ranges from 46.5 to 100 per cent, according to the kind of machine. In terms of trade activity, the

³ The term replacement here relates to the final scrapping of a machine because it is no longer fit to perform any operation, so that the figures indicated represent net substitution requirements.

machine-tool industry's share in the annual invoicing of 62.5 per cent of the enterprises is not less than 75 per cent.

A point worth mentioning related to the breakdown of this group of establishments by size. Three fourths of the enterprises manufacturing machine tools employ fewer than 50 persons, only 7.8 per cent employ between 100 and 500, and only one employs more than 1,000. Such a structure is patently not the most appropriate for coping with larger manufacturing tonnages and with the demands in respect to quality and the range of types which the consumer industries will make the next few years. Consequently, the evolution of this structure towards a breakdown by size which is better adapted to future demand conditions will be one of the essential elements in the development of the industry if it is to secure a larger share in satisfying consumption in Brazil.

The manufacturing enterprises have an inventory of 2,527 machine tools at their disposal. In this connexion, it is of interest to point out that the eight establishments which employ more than 100 persons, 8.9 per cent of the total, own nearly 30 per cent of these machines. This group possesses complete, efficient and up-to-date production equipment, and at the same time the technical knowledge required for the proper use of the machines; and its projects and manufacturing lines keep pace with domestic market requirements and with the constant technological advances in the sector. In marked contrast with the situation of this group is that of the small enterprises whose manufacturing equipment is too light and too incomplete to be satisfactory, while at the same time indirect technical services are neglected.

Market requirements, however, differ sharply in relation to quality, types and prices according to whether the machines are for use in the technically more advanced industries or in the small- and medium-scale establishments whose level of technological development is lower and whose capital resources are very limited. As the national inventory of machine tools grows and with it the demand made in relation to quality, variety and low costs, production technology will be forced to develop, and some of the small- and medium-scale manufacturers will also have to take part in this process.

In relation to volumes of manufacturing output, the data and information afford clear evidence of the colossal effort made by the manufacturers of machine tools since 1956. In fact, in only six years the number of tons produced annually increased by 260 per cent, reaching in the course of that period cumulative figures exceeding 60,000 tons, the equivalent of more than 62,000 machines. In 1961 the industry managed to produce 15,517 units, with a weight of 13,250 tons. This substantial increase in domestic production finds justification in the powerful upswing of demand registered between 1956 and 1961 as a result of the establishment of the motor vehicle industry and the expansion of the various branches of the metal-transforming sector.

Today, the industry offers the market fifty-two types of machine tools in about 150 leading models, which represents a fairly satisfactory situation. Nevertheless, production is not altogether commensurate with the numerical size of the national inventory and its range of

types and models; and some machines are poor quality. This is another aspect of development to which the sector will have to devote attention: the task of improving machine quality and gradually increasing the number of models and types in order to maintain some degree of balance between evolution of the inventory and domestic supplies of basic types.

From 1955 onwards, a gradual decrease in the average weight of the machines manufactured (from 1,136 to 854 kg) is observable in this sector, chiefly owing to reductions in the metal-cutting machines which dropped from 960 to 650 kg. Forming machines stood at an average of 1,800 kg. It must be stressed, however, that this decline in unit weight does not mean that the weight of the traditionally heavier types of machines has been reduced, but is attributable to the fact that in the last few years new models have been put out in smaller sizes while at the same time construction of light machines has been intensified to meet the demand deriving from the manufacture of light articles, as well as from the emergence of small establishments. The perfecting of these machines and the incorporation of new types which are missing from the lines of manufacture will be bound to entail a rise in the average weight of domestic products. In this connexion, those machines which show development in respect to models and an increase in weight have secured a larger share percentage in the supply of the market, especially as to lathes, saws, milling machines and presses.

Price levels, broadly speaking, fluctuate around an average of \$2 per kilogramme, which may be considered satisfactory. Furthermore, since the export of certain types of lathes and presses has been taking place for several years and interest in purchasing Brazilian machine tools exists in some of the Latin American countries, it would seem that their prices are acceptable.

Prospects for the domestic industry, 1962-71

The interval between 1955 and 1961 was characterized by an exceptional increase in domestic consumption, attributable to the causes just indicated, which was reflected in the installation in Brazil of 158,719 tons of machine tools, equivalent to some 101,700 units, the Brazilian inventory being almost doubled during that period. The domestic industry was not dissociated from this trend, and developed during the years in question at a cumulative annual rate of about 14.7 per cent (in terms of weight), expanding from 5,085.6 tons in 1955 to 13,249.9 tons in 1961. This meant that on an average approximately 40 per cent of consumption in the period referred to was satisfied by means of domestically produced machines, the proportion varying between a maximum of 54 per cent and a minimum of 25 per cent in consequence of marked changes in imports.

However, as already pointed out, this industry's contribution to the inventory consisted of simple, light-weight machines, and both in its structure and in its technical potential it displayed certain deficiencies which assume decided importance in relation to the analysis of future possibilities. If no attention is paid to these

technical shortcomings, which must necessarily be remedied if the industry is to develop, a mere study of its evolution in the light of statistical data would be divorced from reality.

On the assumption that the machine-tool industry: (a) will develop structurally in such a way that by the end of the period under study from 15 to 20 per cent of its establishments will be employing between 100 and 500 persons; (b) will increase and supplement its existing stock of machines; (c) will improve upon some of the machines currently manufactured; (d) will start production of forty-one new models of machines for chip producing operations; and (e) will raise the unit weight by about 300 kg in relation to 1961, the conclusion may be reached that in 1966-71 it will be able to supply about 65 per cent of the domestic market, in terms of weight, and will be in a position to export a substantial proportion of its output. In such circumstances, a volume of production amounting to about 20,000 tons, i.e. 50 per cent more than in 1961, might be expected in 1971; this would cover approximately 70 per cent of consumption, leaving an exportable surplus of about 10 per cent.

To attain these goals, as regards the increase in the volume of production and improved quality and the incorporation of new machine types, machinery that can meet the technical demands involved will have to be available. Success will therefore also depend in part upon the incentives and facilities with which government agencies are able to provide this sector. A rough estimate of the investment which such a programme would entail, solely in relation to the machines that would have to be imported, gives a figure close to \$6 million which might be subject to modification according to the quality of the machine tools to be constructed.

To enable the industry to solve the financial problems which the foregoing programme implies, the following would have to be available:

- (a) Long-term financing for the purchase of heavy machines, all of which would be imported;
- (b) Medium- and short-term financing for the purchase of lighter machines, most of which would also be of foreign origin;
- (c) Financing for studies and construction of prototypes of new machine tools.

Given the many complex problems involved in the future development of this industry, structurally and technically, problems whose solution will have to be sought by programmed and co-ordinated effort, it is of fundamental importance that there should be an agency in Brazil which would guide and direct the development of the industry, at the same time rendering the necessary technical assistance, so as to channel it properly into suitable lines of manufacture and enable it to play its role in Brazil's industrialization process as efficiently as possible.

PRODUCTION OF MACHINE TOOLS

The manufacture of machine tools in general began in Brazil during the Second World War. At that time, the difficulties of importing constituted a powerful incentive

to the recrudescence of various undertakings in this sector and the emergence of new enterprises, whereby the most urgent requirements could be met, particularly in respect to machines for maintenance purposes.

The war once over, however, with the lifting of import restrictions, and in the face of certain instability of demand for domestically produced machine tools, some industries which a state of emergency and a series of noteworthy efforts had called into being no longer found sufficient inducement to continue in the same branch of manufacture, and changed over to other activities. On the other hand, the metal-transforming industries were progressively consolidated and strengthened until by 1950 an embryo market had been created which held out prospects of significant development. It was thus that machine tools, which until then had been associated mainly with maintenance operations, began to assume importance in the manufacturing process. Interest in local production of machine tools was thus reawakened, so that by 1955 domestic output had exceeded 5,000 tons.

The subsequent establishment of the Executive Group of the Motor Vehicle Industry (GEIA), with the ensuing application of its plans and its dynamic effects on other sectors, should be regarded as the true prelude to the consolidation of a large, up-to-date and diversified machine-tool market such as is in Brazil today: in the seven years preceding 1961, the domestic market absorbed from 90,000 to 100,000 machines.

This new incentive gave rise to new undertakings in addition to those which since the Second World War had successfully withstood critical periods and continued to supply the domestic market. At present, the machine-tool industry comprises about 114 establishments, employs nearly 5,000 persons and produces an annual output which has exceeded 13,000 tons, with an approximate value of \$26 million.

THE PRODUCTION SURVEY

Owing to the lack of adequate statistical data on the manufacture of machine tools, a survey had to be carried out among the manufacturers operating in Brazil, the number of enterprises totalling, as far as could be ascertained, 114 establishments. This survey was carried out by visits to the factories, and specially prepared questionnaires were used whereby general data could be obtained on the industrial establishments and on the machines in use, as well as on the quantities of each type manufactured since 1955 (in terms of units and of weight), the main characteristics of the machines manufactured, and the entrepreneurs' plans for the future.

Out of the 114 establishments, 104 were classified, including five which in 1961 were perfecting prototypes of machine tools to be put on the market in 1962. The establishments covered are those in which production of machine tools is either the sole activity or supplementary to other lines of manufacture; excluded are a few of an artisan nature which only occasionally produce a short series of machines, usually of a simple type, for consumers making no great demands for quality and precision. Among those covered by the survey are nine whose activity in this branch of industry represents less

than 5 per cent of the value of total sales, and which were excluded from some comparisons.

Thus, the considerations formulated below relate to ninety manufacturers, in regard to geographical distribution and number of machines in use; to ninety-nine where manufacturing data are concerned; and to 104 in respect to the types of machines currently produced.

The domestic machine-tool industry

General characteristics

Location. The data clearly show that the choice of sites for the industrial establishments manufacturing machine tools was closely associated with the expansion of the metal-transforming industries. The State of São Paulo is where 88.8 per cent of these establishments are situated, while the same state absorbs 72 per cent of the domestic labour force in the metal-transforming sectors (see table 1).

Table 1

GEOGRAPHICAL DISTRIBUTION OF ESTABLISHMENTS MANUFACTURING MACHINE TOOLS, 1961

State	Persons employed		Industrial establishments	
	Number	Percentage of total	Number	Percentage of total
São Paulo	4,527	94.7	80	88.8
Rio Grande do Sul	176	3.7	6	6.6
Santa Catarina	40	0.8	2	2.3
Guanabara	37	0.8	2	2.3
Total	4,780	100.0	90	100.0

Within the State of São Paulo, the greatest concentration of machine-tool manufacturers is observable in the state capital itself and in the municipalities of Santo André, São Bernardo do Campo and São Caetano do Sul (ABC), where the proportion is 83.7 per cent, with 67 establishments. In the interior of the state, the factories are mainly along the Jundiaí-São Carlos line, and it is in this area that the highest production capacity per establishment is registered. These enterprises number thirteen and employ 2,437 persons in all, i.e. 51 per cent of the total for the country. Communications between this area and the leading consumer centres are good, and transport of the heavy tonnages produced presents no difficulties.

The plants in the capital and in the ABC area employ 2,090 persons, 43.7 per cent of the total for Brazil, in sixty-seven establishments which are a good deal smaller than those in the interior. From the point of view of expansion, the location of some of these implies serious drawbacks in space both for increasing current production lines and for manufacturing heavier machinery, since adjacent lots are not available and, even if they were, anti-economic investment would be entailed. Decentralization of these establishments in the direction of the outskirts of Greater São Paulo should therefore be contemplated for more efficient organization and layout.

This does not apply to the firms in the interior of the state, which, from the point of view of the space for future expansion, are in a more privileged position.

In the south of Brazil, the manufacturers of machine tools in Rio Grande do Sul and Santa Catarina have so far supplied most of the requirements of the local market which, together with that of São Paulo, ranks as the oldest in the country.

The participation of the south of Brazil which at present is modest, since the area accounts for only 8.9 per cent of the total establishments and 4.5 per cent of the total personnel, will increase in the course of the next few years through the operation of various favourable factors which are beginning to make their influence felt. These include the quality of the labour, whose efficiency and low turnover play an important part; the development of local industries; the ease with which technical and commercial contacts with the State of São Paulo can be maintained; and the improvement of communications between the south and the other consumer centres. To judge from the new projects under way and the prototypes already tried out, a dynamic spirit prevails, especially in the Porto Alegre area. As in other countries that have had to tackle the same problems in the past, the decentralization of this branch of the metal-transforming industry is generally a factor making for progress and encouragement.

The factories in areas other than those mentioned concentrate on specialized lines of production or supply the local market.

To sum up, the principal areas in Brazil in which this sector is significant are three: the first is along the Jundiaí-São Carlos line in the State of São Paulo; the second is the state capital and the ABC area; and the third is that part of the Porto Alegre district which falls within a radius of 200 km from the capital.

Structure. Not all the establishments manufacturing machine tools devote their entire efforts to this activity, and other products of the metal-transforming industries appear in their manufacturing programmes in varying proportions. One reason for this is that most of the enterprises first became interested in the production of machine tools when they had already developed a certain tradition in other metal-transforming sectors which they did not wish to abandon; and another is that in some cases the consumers of these machines have themselves begun taking steps to produce them, as is not surprising in view of the rapidity with which the machine-tool sector has increased in recent years. This last category includes five enterprises covered by the survey which in 1961 were engaged in perfecting machine-tool prototypes to be put on the market in 1962.

This situation is clearly reflected in table 2, which presents a breakdown of establishments by their extra- and intra-sectoral activities and by types of machines. It reveals how high a proportion of the establishments classified as manufacturing machine tools maintain other lines of production: from 46.5 to 100 per cent, according to the type of machine concerned. In the table, references to lines of manufacture within the sector relate to different categories of machines, not to the machine

Table 2

ORGANIZATION OF PRODUCTION OF MACHINE TOOLS, 1961

Type of machine	Number of establishments	Production		Breakdown of establishments by activity				Works include foundry
		Tons	Units	One line of manufacture within the sector	Two lines of manufacture within the sector	More than two lines of manufacture within the sector	One or more lines of manufacture outside the sector	
Lathes	24	5,265.0	4,638	16	4	4	16	4
Milling machines	14	289.8	278	7	3	4	9	4
Drilling machines	17	794.9	5,311	5	5	7	13	7
Shapers and planers	18	1,369.4	937	11	4	3	10	7
Threading machines	3	35.0	53	1	—	2	3	—
Cutting machines (saws)	12	342.4	1,296	7	3	2	8	4
Grinding machines	4	57.1	79	2	1	1	3	—
Tool-grinding machines	4	69.3	101	1	1	2	3	—
Presses	22	3,890.0	2,139	15	5	2	12	5
Pneumatic hammers	1	24.8	7	1	—	—	1	—
Machines for sheet	15	1,071.2	667	6	6	3	7	3

specified; in other words, if four of the establishments manufacturing shapers and planers are said to maintain two lines of production, this must be taken to mean that they produce another type of machine tool alongside shapers and planers, rather than that they make two models of the latter. It may also be seen from the table that seventy-two of the ninety-two firms manufacture a single type of machine tool, while the remaining twenty-seven maintain two or more lines of production within this sector.

Of the ninety-nine industrial establishments considered, 62.5 per cent accounted for no less than 75 per cent of this activity's trade transactions; the remaining 37.5 per cent contributed smaller proportions (see table 3).

Table 3

BREAKDOWN OF INDUSTRIAL ESTABLISHMENTS BY PERCENTAGE OF ACTIVITY DEVOTED TO MACHINE TOOLS, MEASURED IN TERMS OF ANNUAL SALES TURNOVER, 1961

Industrial establishments		Manufacture of machine tools (Percentages)
Number	Percentage	
62	62.5	75-100
14	14.2	50-74
8	8.1	25-49
6	6.1	5-24
9	9.1	under 5
99	100.0	

The distribution of these establishments by size constitutes another interesting feature of the activity under consideration. The figures given in table 4 relate to the number of persons employed in the manufacture of machine tools and therefore exclude personnel employed in the manufacture of other products within the same enterprise.

Table 4

BREAKDOWN OF ESTABLISHMENTS MANUFACTURING MACHINE TOOLS, BY SIZE,^a 1961

Size of establishments (Number of persons employed)	Number of establishments	Percentage	Number of persons employed	Percentage
More than 1,000	1	1.1	1,290	27.0
500-999	—	—	—	—
250-499	1	1.1	402	8.4
100-249	6	6.7	954	20.0
50-99	14	15.6	976	20.4
25-49	18	20.0	580	12.1
10-24	30	33.3	459	9.6
Fewer than 9	20	22.2	119	2.5
Total	90	100.0	4,780	100.0

^a Excluding nine enterprises whose production of machine tools represents less than 5 per cent of their annual sales turnover. Data as of 31 December 1961.

A comparison between Brazil and other countries in respect to the breakdown of establishments by size reveals the trend of this sector's evolution as a consequence of the increase in the tonnage produced, especially where the smaller establishments are concerned (figure 1, table 5).

Experience shows that a high level of productive efficiency in this sector is beginning to be obtained in factories employing 100 persons or more, where the products manufactured have a certain degree of complexity and a high standard of quality. This would seem to be the case in France, the United Kingdom and the United States, where between 20 and 30 per cent of the factories fall within the 100-500 size range. These percentages apparently remain stable, in association with outputs of about 40,000 to 50,000 tons and more.

The structure of the machine-tool industry in Brazil, where only 7.8 per cent of the establishments under consideration fall within the size range indicated, will have to develop along new lines if output tonnages are to be higher than at present and the demands of the consumer industries with respect to quality and diversity of types

Table 5

BRAZIL AND SELECTED COUNTRIES: PERCENTAGE DISTRIBUTION OF ESTABLISHMENTS MANUFACTURING MACHINE TOOLS

Size of establishments (number of persons employed)	Brazil		France		United States		United Kingdom		
	Number of establishments	Percentage	Number of establishments	Percentage	Number of establishments	Percentage	Size	Number of establishments	Percentage
0-49	68	75.5	60	50.0	431	57.9	0-49	104	46.4
50-99	14	15.6	30	25.0	95	12.8	50-99	38	17.0
100-249	6	6.7	16	13.4	106	14.2	100-299	55	24.6
250-499	1	1.1	8	6.6	53	7.1	300-499	13	5.8
500-999	—	—	6	5.0	34	4.6	500-749	3	1.3
1,000-2,499	1	1.1	—	—	20	2.7	750 or more	11	4.9
2,500 or more	—	—	—	—	5	0.7	—	—	—
Total	90	100.0	120	100.0	744	100.0	—	224	100.0

Sources: For Brazil: findings of the 1961 survey; for France, 1949: *Mission aux Etats-Unis de l'industrie de la machine-outil*, November 1949, January 1950; for the United States: *Census of Manufactures 1947*; for the United Kingdom, 1947: A. Garanger, *op. cit.*

are to be met. According to the projections formulated in the present study, Brazil should produce a yearly output of about 20,000 tons by 1970-71, and should therefore aim at remodelling the size structure of the industry so that it more closely approaches that found in the more highly industrialized countries. At this stage, it might be considered that satisfactory progress had been made if by the time the above-mentioned level of production had been reached, about 15 to 20 per cent of the establishments employed more than the minimum of 100 persons, with an average of 200 persons per establishment.

General data for the sector. To give an over-all idea of the sector's production potential, some of the most

characteristic data relating to the industrial establishments concerned are:

Number of persons employed [†]	4,780
Installed capacity	12,571 h.p.
Value of production, 1961	26.5 \$ million
Annual <i>per capita</i> production	5,544 dollars
<i>Per capita</i> capacity available	2.63 h.p.
Number of persons employed per establishment	53.1
Installed capacity per establishment	139.7 h.p.
Value of production per establishment	294,000 dollars

[†]Including operatives and technical and administrative personnel.

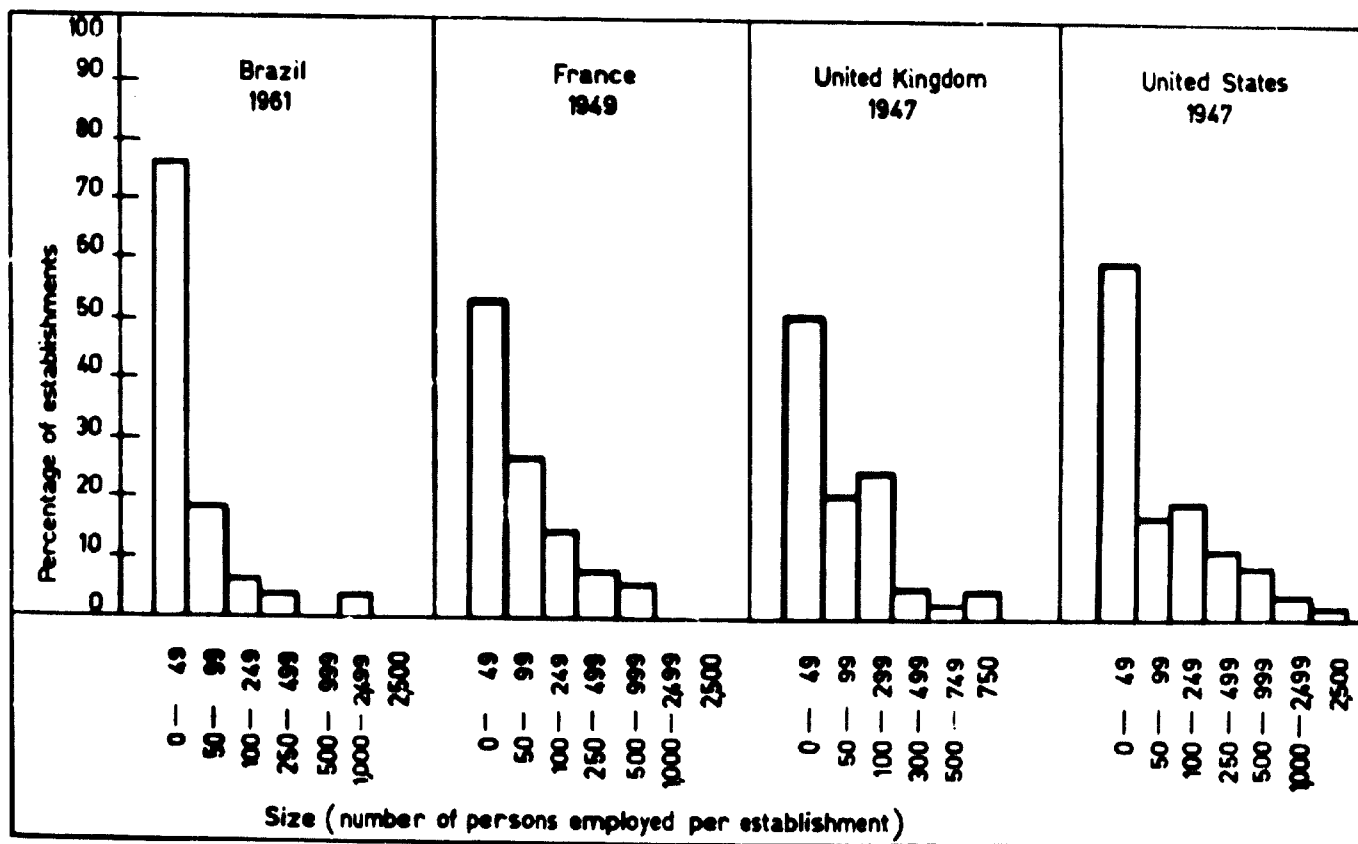


Figure 1

PERCENTAGE BREAKDOWN OF ESTABLISHMENTS MANUFACTURING MACHINE TOOLS IN BRAZIL AND SELECTED COUNTRIES AT A MORE ADVANCED STAGE OF INDUSTRIAL DEVELOPMENT

Prices per kilogramme vary a good deal in the case of domestically manufactured machines, partly because of the different types produced and partly because of the divergent sales methods adopted (through distributors, directly to the consumer, for cash down or on deferred payment terms). Moreover, the continual fluctuations in internal prices and the time lag before exchange rates are brought up to date cause sharp variations in the cruzeiro/dollar relationship. Thus, in order to estimate the value of domestic production, an average price of \$2 per kg was adopted.

In view of the heterogeneous sizes of the industrial establishments in this sector, a few remarks must be made on the average values per establishment, since there is one group of enterprises whose size, organization, efficiency and technical level put a considerable distance between it and the over-all averages in question. The eight establishments which employ more than 100 persons together account for 55.4 per cent of total employment and 63.6 per cent of installed capacity, which means that the *per capita* capacity available is about 3 h.p., whereas in the other eighty-two establishments it is only 2.1 h.p. The capacity available per direct operative is even higher in the former group, because of the lower direct/indirect labour ratio. On the assumption that direct operatives constitute about 55 per cent of the personnel employed, available capacity amounts to about 5.5 h.p. per operative, almost twice as much as in the smaller establishments. This advantage is reflected, *inter alia*, in a satisfactory level of production capacity, in contrast with the situation in the other group.

Machine-tool manufacturers' inventories

Table 5 presents an inventory of the equipment used in domestic manufacture of machine tools by the ninety producers whose share in the sector's activity constitutes more than 5 per cent of their annual sales turnover.

In addition, there are sixty-one forming machines installed in these establishments in the aggregate, bringing the total up to 2,527. The firms employing more than 100 persons possess twenty-eight units of this type.

As the size distribution of the enterprises in question is so irregular and the proportion of firms employing fewer than fifty persons is high, it is difficult to make an over-all analysis of this inventory in such a way as to give a faithful interpretation of the machine-tool industry's real situation. The equipment to be found in about 9 per cent of the establishments, representing approximately 29 per cent of the total number of machines, is comparable to that of manufacturers in more highly industrialized countries; most of the remaining firms, in contrast, have only unsatisfactory and makeshift production facilities at their disposal. The eight establishments employing more than 100 persons belong to the first group.

In the case of this group, production equipment is complete, efficient and up-to-date, as can easily be seen from the high figures relating to the use of boring machines, milling machines of various types, threading machines, broaching machines, grinding machines, gear-cutting machines and special machine tools. There is no lack of technical knowledge of the kind required for

correct utilization of the machines, and it is thus possible to overcome those machining difficulties which characterize the manufacture of machine tools once the Schlesinger or Salmon standards are the goal.

In addition to the satisfactory equipment situation, jigs fixtures, special tools, and metrological and control instruments are used, both in the intermediate stages of machining and during the final process of assembly, in accordance with the standards referred to above. Consequently, the designs of the machines are more complex, and those manufactured by the group under discussion differ from the rest in that they are more complete, offer better working facilities, have higher power, bigger transmission fields and superior productivity in relation to others of the same type.

It may also be noted that in these enterprises which employ 2,646 persons in all, the proportion of indirect personnel ranges from 30 to 52 per cent, i.e., it is within the limits that should be considered essential for success in this difficult specialty. The manufacture of machine tools of more advanced and complex design calls for more project engineering and research and, consequently, for a greater number of indirect personnel working on the planning of production, quality controls and the making of tools and jigs (table 6).

Lastly, stress must be laid on the marked creative vitality displayed by this group of firms whose projects keep pace with the requirements of the domestic market and the constant technological advances in the sector. Studies aimed at perfecting machine parts, to which the patents registered and experiments with new models bear witness, are commonplace today, and have indeed been so since 1950.

In contrast, the position of the smaller enterprises leaves a good deal to be desired as regards their manufacturing equipment which is lightweight and incomplete, indirect technical services are neglected. This is sufficient indication of the category and quality of the machine tools manufactured.

Hitherto, however, market requirements in respect to quality, types and prices of machine tools have also assumed two very different forms, according to whether the prospective consumers are industries at a more advanced stage of technical development or establishments, usually on a small or medium scale, whose technological level is lower and whose supply of capital is limited.

To meet the needs of the former, the more advanced group of domestic manufacturers is in a position to deliver high-quality goods conforming to the specifications required, within their current lines of manufacture; the latter, on the other hand, preferring as they do machines of low cost (less than \$2 per kg as a rule) and hence also low in weight, power and precision are supplied, in the main, by the small manufacturers. Thus, some justification for such producers' limited manufacturing resources is to be found in the nature of market demand, at least to the present.

But as the Brazilian machine-tool inventory approaches 300,000 units, in order to attain low production costs together with an improvement in the quality of the final

product it will be essential for the technology of production to develop as well and, consequently, for most of the small establishments manufacturing machine tools to progress along the same lines.

The technical and manufacturing potential achieved by the leading group in this sector, and by the manufacturers of lathes and presses in particular, reaches international standards comparable with those registered in the more highly industrialized countries for manufacturers capable of supplying substantial machine-tool inventories.

The considerable size of the Brazilian inventory, together with its annual natural growth rate of about 5.5 per cent, suggests the need for at least some of the small-scale enterprises to increase their dimensions, with all the structural changes which this implies.

What has been said of the small enterprises and the equipment they use should be regarded rather as a warning for the near future than as criticism. The

design of the planer and the work bench. Significant deformation may thus take place in the course of machining.

Other machine tools and equipment which, to judge from the survey, are not usually found among the machining plant of the smaller establishments are: gear-cutting machines of the Fellows and Maag Types, and with gear generators; gear-grinding machines; milling machines for slot axles; grinding machines for grooved shapes; broaching machines for internal grooved shapes; special machines for long thread cutting; heavy drilling machines; grinding machines for long bed rails; dynamic balancers; group of units for tempering bed rails and benches; measuring instruments for testing Schlesinger and Salmon standards.

These machines and equipment usually are essential requisites for the production of good quality machine tools, especially those in the chip producing category. The latter, which also include finishing machines, offer

Table 6
INVENTORIES OF MACHINE-TOOL MANUFACTURERS, 1961

Type of machine	All establishments		Establishments employing more than 100 persons	
	Number	Percentage	Number	Percentage of total
Lathes.....	893	36.2	245	27.4
Milling machines.....	225	9.1	88	39.1
Drilling machines.....	459	18.6	88	19.2
Boring machines.....	63	2.6	33	52.4
Shapers and planers.....	377	15.3	86	22.8
Threading machines.....	18	0.8	8	44.4
Broaching machines.....	5	0.2	4	80.0
Gear-cutting machines.....	55	2.2	38	69.1
Cutting machines (saws).....	158	6.4	36	22.8
Grinding machines.....	136	5.5	64	47.1
Tool-grinding machines.....	77	3.1	32	41.6
Total	2,466	100.0	722	29.3

comments which follow are valid for most of the small establishments, and afford some justification for such an attitude.

Boring machines, for example, with which heavy asymmetrical parts can be machined at different levels, are replaced by devices which do not permit attainment of the close tolerances acceptable for internal diameters and distances between axles. Again, the very limited use of cylindrical grinding machines for internal and external diameters suggests that series couplings are unlikely to achieve ISO 6 and 7 quality, obviously to the detriment of both surface finish and the precision of the couplings themselves.

Similarly, the problem of machining small and large flats is generally tackled with unsuitable machine tools. Limited use is made of milling machines for which shapers are usually substituted with poor results in production time, precision and quality of surface finish. For machining larger parts, the table planers used, besides offering few facilities, are so light that the weight of the part being machined is disproportionate to the

a wider range of types and designs than forming machines; their manufacture calls for a more varied inventory of machine tools. Furthermore, the acceleration of cutting speeds of both rotary and alternating machine tools is compelling manufacturers to use increasingly difficult and complex manufacturing techniques applicable only if special and costly equipment is available.

In the manufacture of machine tools, more perhaps than in other sectors of the metal-transforming industry, the relationship between minimum size of establishment and quality and complexity of product takes precedence over the relationship between size of establishment and series produced.

This, taken in conjunction with the domestic manufacture projections in this study, makes it plain how necessary it is that by the end of the period under study the proportion of machine-tool enterprises employing, on an average, some 200 persons each should be about 15 to 20 per cent, either as a result of the expansion and modernization of the industries already established or by virtue of the installation of new enterprises.

Types of machine tools manufactured in Brazil

In compiling the list of machine tools manufactured in Brazil, the output taken into account was that of 104 firms, i.e. including the five which in 1961 were engaged in perfecting prototypes of machines to be put on the market in 1962. The dimensions represent each machine's maximum working capacity:

Machines for chip producing

- (a) Bench lathes (diameter, up to 250 mm; distance between centres, 600 mm);
- (b) Single-pulley lathes (distance between centres, up to 4,000 mm);
- (c) Engine lathes (diameter, up to 600 mm; distance between centres, 2,000 mm);
- (d) Medium weight engine lathes (distance between centres, 2,000 to 4,000 mm);
- (e) Heavy engine lathes (up to 15 tons; distance between centres, 4,000 to 7,500 mm);
- (f) Extra heavy engine lathes (up to 61 tons; distance between centres, 10,000 mm. There are possibilities of manufacturing these lathes with higher tonnages and longer distances between centres);
- (g) Bench turret lathes;
- (h) Hand fed, single-pulley, hexagon turret lathes (spindle bore diameter, up to 2 in.; weight, 1 ton);
- (i) Hand fed, single-pulley, frontal turret lathes (spindle bore diameter, up to 2 in.);
- (j) Light hand fed hexagon turret lathes (up to 1.5 tons);
- (k) Medium weight hand fed hexagon turret lathes (up to 3.2 tons; lathe swing, 500 mm, and length 940 mm);
- (l) Heavy hand fed hexagon turret lathes (up to 11 tons; lathe swing, 800 mm, and length up to 1,780 mm);
- (m) Frontal or plateau lathes (lathe swing, 2,500 mm; 5 h.p., and weight up to 6 tons);
- (n) Special semi-automatic lathes for small parts (up to 2 in.);
- (o) Automatic lathes with radical slides (spindle bore diameter, up to 1 in.; weight up to 1 ton);
- (p) Semi-automatic lathes for second operations;
- (q) Universal bench drilling machines (up to 0.3 tons);
- (r) Light universal milling machines (up to 0.8 tons and 1.5 h.p.);
- (s) Universal milling machines with Morse cones No. 4 and 5 (up to 5 h.p., and weight between 1.5 and 3 tons);
- (t) Milling machines with automatic work cycle (table), simplex and duplex types (up to 3 h.p. and weight 1.5 tons);
- (u) Hand fed bench drilling machines;
- (v) Bench drilling machines with automatic feed;
- (w) Hand fed pedestal drilling machines (diameter capacity up to 1.5 in.);
- (x) Pedestal drilling machines with automatic feed (maximum diameter 1.5 in.);
- (y) Multispindle bench and pedestal drilling machines (up to 2 h.p.);

(z) Radical drilling machines with arm length up to 1,250 mm (maximum diameter, 25 mm for steel);

(aa) Shapers with stroke length from 300 to 1,200 mm, including a hydraulic model;

(bb) Table planers (up to 5 h.p.; table 1,000 - 3,400 mm, or over; weight 7.5 tons. Hydraulic models are also manufactured in a smaller size);

(cc) Semi-automatic and automatic threading machines for internal threads (diameter, up to 0.5 in.);

(dd) Threading machines with flat dies (up to 1.5 in.);

(ee) Threading machines with cylindrical die (working pressure up to 20 tons);

(ff) Hydraulic broaching machines, simple horizontal type (up to 20 tons);

(gg) Alternating saws for metal cutting;

(hh) Partially hydraulic alternating saws for metal cutting (up to 12 - 12 in.);

(ii) Completely hydraulic circular saws with automatic feed (diameter, up to 130 mm);

(jj) Band saws, horizontal and vertical types;

(kk) Hand and semi-automatic universal grinding machines, with mechanical and hydraulic controls (distance between centres, up to 1,500 mm);

(ll) Grinding machines for flats (table, 135 - 600 mm; up to 3.5 h.p., also with electromagnetic table);

(mm) Universal tool-grinding machines;

(nn) Special grinding machines for tungsten carbide tools;

(oo) Special machine tools for long series composed of machining units up to 5 h.p. One stage or revolving table type;

(pp) Axle centerers.

Machines for forming

(a) Hydraulic presses (up to 1,600 tons);

(b) Eccentric presses, inclinable (up to 100 tons);

(c) Eccentric presses, fixed, with intermediate gears (up to 160 tons);

(d) Friction presses (up to 400 tons);

(e) Pneumatic forging machines (up to 500 kg);

(f) Forging machines (up to 150 kg);

(g) Drop forging machines (up to 250 kg);

(h) Shears (length, up to 3,000 mm; thickness, 0.5 in.);

(i) Bending presses (length, up to 3,600 mm; thickness, 5 mm; pressure, up to 75 tons);

(j) Machines for cutting shapes, universal type.

The list of variants of the types of machine tools is particularly long in respect to lathes, drilling machines and saws and forming machines in general. It should be taken for granted, for example, that, as regards presses, a wide range of capacities is manufactured: from 2.5 tons to a maximum of 100 tons, and the same applies to the other machines. In the categories of chip producing and forming machines, respectively, lathes and presses are the most highly developed and the most advanced from the technical standpoint in respect to types, models, weight and power per unit, quality and productivity. The progress achieved in the manufacturing of these machines during the past decade was so remarkable that for several years exports have been registered; this

applies particularly to lathes, which have found a market not only in Latin America and the Middle East, but also in European countries with long-standing traditions in manufacturing machine tools.

Milling machines are important items whose share in the composition of machine-tool inventories is usually about 8 to 10 per cent. Although a great variety of types and models of machines of this kind exists, domestic manufacture is confined to six models. It should be stressed here not only that the manufacturers are lagging behind in this sector, but that the national inventory too is deficient, milling machines being little used in Brazil.

Next in importance to milling machines come grinding machines of which only a few models are manufactured, whereas a wide and varied range is available on the world market. A comparison between the Brazilian inventory and that of other countries reveals an anomalous situation which suggests the urgency of the need to embark upon local manufacture of several basic models. Boring machines and gear-cutting machines are not manufactured in Brazil, and have to be imported.

Generally speaking, the list of the types of machine tools currently manufactured in Brazil is somewhat incomplete in relation to the significance already attained by the national inventory in respect to numbers and variety of types. Nevertheless, considering that the sector is in some instances very young and inexperienced and that the annual volume of output is a little over 10,000 tons, the manufacture of fifty-two types of machine tools in about 150 leading models represents a fairly satisfactory situation.

Given the country's stage of development and the growth projections for the next few years formulated in relation to the various sectors of the metal-transforming industry, the Brazilian inventory will exceed 300,000 units in 1971. Clearly, then, the sector will need to increase the number of models progressively year by year so that some balance is maintained between the evolution of the inventory and the domestic supply of basic types. Otherwise, if Brazil's own technological resources would not suffice to feed the inventory of machine tools, a difficult situation might arise because of the amount of foreign exchange that would be needed to import the requisite machines and the expansion of the metal-transforming industries would be slowed up.

It must be borne in mind, however, that no country is completely independent as regards the manufacture of all types of machine tools, not even those with inventories of over two million machines, and that the necessity for international trade in this field is almost a basic principle. The items concerned, however, are as a rule specialized machine tools, domestic production of which has no attractions from the economic or technical standpoint, and are very seldom the simpler basic types manufactured in longer production series.

Volume of output

The survey of Brazilian production of machine tools presented here, and covering the period between 1955 and 1961, is the first in the country.

The figures for the years 1955, 1956 and 1957 must be regarded as approximate, since in some cases the answers to the questionnaire were incomplete and either the number or the weight of the machines had to be estimated. In any event these estimates do not greatly affect the conclusions.

The findings of the survey with regard to chip-producing machines, forming machines, and the total accumulated during the period 1955-61 are given in tables 7, 8 and 9, respectively.

The tables give a clear idea of the tremendous effort put forth by the manufacturers of machine tools, since in only six years the annual tonnage was increased by 260 per cent, reaching cumulative figures of more than 60,000 tons, and equivalent to more than 62,000 units. This volume of production undoubtedly did much to account for the fact that the Brazilian inventory almost doubled between 1955 and 1961.

The data on the percentage distribution of the machines used for chip producing and for forming operations are worth analysing. During the period 1955-61, the average figures were 79.7 and 20.3 per cent, respectively. In 1960, Brazil's total stock of machine tools, including those used for maintenance purposes but excluding those not inventoried showed a very similar distribution, 78.2 and 21.8 per cent, which suggests that domestic production kept closely parallel to the composition of the total stock as regards the two categories. It must be pointed out, however, that during the period under discussion the proportion of output represented by chip-producing machines showed a decided upward trend, rising from 77.3 per cent in 1955 to 81.9 per cent in 1961. If similar comparisons are made on the basis of the tonnages produced, the position is reversed, and the share of chip-producing machines falls from 65.7 in 1955 to 62.3 per cent in 1961. The explanation lies in the fact that during this period a beginning was made on manufacture of some new types of machine tools (such as grinding machines, tool-grinding machines etc.), in the smaller sizes, while at the same time the manufacture of light machine tools such as lathes and bench drills, shapers and alternating saws was intensified with the aim of meeting the demand deriving from the manufacture of a great many light articles as well as the requirements of small establishments which came into being at that time. Thus, the average unit weight of the machines manufactured dropped from 960 to 650 kg. The unit weight of forming machines was maintained at about 1,800 kg.

While the changes registered in relation to these two major groups of machine tools are broadly indicative of a gradual adjustment of domestic production to internal market requirements, it is interesting to note the much more striking modifications that have taken place within the groups themselves as this industrial activity has gradually developed.

For example, the proportion of output represented by the manufacture of lathes, which in 1955 was 54.6 per cent in terms of units, had fallen to about 30 per cent by 1961. The manufacture of drilling machines has increased to such an extent, more than eight times over in the

Table 7
PRODUCTION OF CUTTING MACHINES FOR CHIP-PRODUCING OPERATIONS
 (Weight in tons)

Type of machine	1955		1956		1957		1958		1959		1960		1961	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
<i>Lathes</i>														
Bench lathes	2,443	2,681.9	3,072	3,305.3	2,583	2,814.9	3,149	3,673.9	3,053	3,902.6	3,766	4,295.2	4,638	5,265.0
Engine lathes	—	—	20	2.4	20	2.4	10	1.2	—	—	600	78.0	720	83.6
Frontal or plateau lathes	1,949	2,382.4	2,444	2,914.1	1,958	2,391.5	2,386	3,067.2	2,341	3,369.8	2,238	3,545.6	2,500	4,196.7
Turret and semi-automatic lathes	7	42.0	10	52.0	9	54.0	8	48.0	10	56.0	10	56.0	13	62.0
Automatic lathes	487	257.5	597	336.3	579	356.1	708	534.2	670	456.0	849	566.5	1,279	813.7
Others	—	—	1	0.5	11	5.4	12	10.8	12	10.8	24	21.6	76	73.0
<i>Milling machines</i>														
Universal	72	42.2	67	42.0	142	77.2	159	143.9	190	168.5	186	187.1	278	289.8
Vertical	40	18.0	40	18.0	80	32.0	111	103.0	145	126.6	126	129.8	191	215.3
Others	11	5.7	—	—	2	2.3	7	4.6	2	1.4	6	3.0	13	6.7
<i>Drilling machines</i>														
Bench drills	21	18.5	27	24.0	60	42.9	41	36.3	43	40.5	54	54.3	74	67.8
Pedestal drills	614	164.9	1,341	275.2	1,522	2,842.0	2,051	360.0	2,346	430.6	2,809	525.0	5,311	794.9
Radial	227	12.1	347	17.8	441	7.9	761	49.4	965	76.2	1,231	164.1	3,590	245.0
Multi-spindle	387	152.8	994	257.4	1,081	256.3	1,290	311.2	1,380	354.2	1,571	411.1	1,707	526.4
<i>Shapers and planers</i>														
Shapers	200	408.4	384	554.7	369	578.8	446	739.5	504	892.6	765	1,079.6	937	1,369.4
Table planers	168	236.1	346	335.7	337	389.8	413	554.5	458	616.6	715	788.1	878	1,027.4
Others	32	172.3	38	219.0	31	186.8	33	185.0	46	276.0	50	291.5	59	342.0
<i>Threading machines</i>														
Cutting machines (saws)	19	3.6	18	2.7	25	5.3	36	6.9	28	7.0	45	29.5	53	35.0
Reciprocating saws	113	19.5	676	203.1	588	210.1	862	273.9	873	308.6	1,210	387.4	1,296	342.4
Band saws	113	19.5	634	193.3	518	196.1	678	225.7	560	214.1	740	258.1	817	200.7
Circular saws	—	—	42	9.8	70	14.0	184	48.2	313	94.5	470	129.3	478	139.6
<i>Grinding machines</i>														
Plain	2	3.0	—	—	—	—	44	33.0	61	43.5	46	34.3	79	57.1
Universal cylindrical	—	—	—	—	—	—	42	30.0	60	42.0	44	31.3	76	53.1
Tool-grinding machines	2	3.0	—	—	—	—	2	3.0	1	1.5	2	3.0	3	4.0
Universal	—	—	—	—	—	—	22	22.0	38	38.0	69	50.7	101	69.3
Special	—	—	—	—	—	—	22	22.0	38	38.0	54	43.2	91	64.3
<i>Special machines and machine units for special machining operations</i>	—	—	—	—	—	—	—	—	—	—	15	7.5	10	5.0
Total	3,463	3,323.5	5,558	4,383.0	5,229	3,970.5	6,769	5,273.7	7,093	5,791.4	8,943	6,606.8	12,704	8,263.9

Table 8
MACHINES FOR FORMING OPERATIONS
(Weight in tons)

Type of machine	1955		1956		1957		1958		1959		1960		1961	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
Presses	818	1,390.4	1,349	2,336.9	1,146	2,157.6	1,475	2,558.8	1,360	2,465.7	1,820	3,326.3	2,139	3,890.0
Hydraulic.....	131	86.1	244	158.1	210	116.6	314	181.6	228	226.5	318	488.5	333	510.6
Eccentric.....	643	1,055.0	1,003	1,720.3	848	1,643.9	1,075	1,989.6	1,035	1,831.8	1,384	2,314.7	1,651	2,734.8
Friction.....	44	249.3	95	438.9	79	371.9	83	379.2	87	379.4	108	495.1	128	569.0
Upsitters.....	—	—	7	19.6	9	25.2	3	8.4	10	28.0	10	28.0	27	75.6
Forging machines	1	3.6	1	3.6	1	3.6	6	21.6	5	18.0	9	32.4	7	24.8
Pneumatic hammers.....	1	3.6	1	3.6	1	3.6	6	21.6	5	18.0	9	32.4	7	24.8
Machines for sheet	196	368.1	301	507.6	250	467.1	317	564.6	354	731.7	473	890.7	667	1,071.2
Shears.....	71	160.3	124	246.3	114	245.9	139	255.7	160	376.1	248	490.1	346	601.6
Bending machines.....	98	183.3	134	221.5	94	182.9	128	261.6	133	297.4	131	304.0	182	317.9
Bending rolls.....	12	12.2	16	17.6	14	15.4	26	27.6	31	33.6	63	71.2	108	126.3
Other machines for sheet.....	15	12.3	27	22.2	28	22.9	24	19.7	30	24.6	31	25.4	31	25.4
Total	1,015	1,762.1	1,651	2,848.1	1,397	2,628.3	1,798	3,145.0	1,719	3,215.4	2,302	4,249.4	2,813	4,986.0
Total for chip-producing machines.....	3,463	3,323.5	5,558	4,383.0	5,229	3,970.5	6,769	5,253.7	7,093	5,791.4	8,943	6,606.8	12,704	8,263.9
Total for forming machines.....	1,015	1,762.1	1,651	2,848.1	1,397	2,628.3	1,798	3,145.0	1,719	3,215.4	2,302	4,249.4	2,813	4,986.0
Total Brazilian production.....	4,478	5,085.6	7,209	7,231.1	6,626	6,598.8	8,567	8,398.7	8,812	9,006.8	11,245	10,856.2	15,517	13,249.9

Table 9
TOTAL OUTPUT OF MACHINE TOOLS, 1955-61
 (Weight in tons)

Type of machine	Number	Percentage	Weight	Percentage
Lathes	22,704	36.3	25,938.8	42.9
Milling machines	1,094	1.7	950.7	1.6
Drilling machines	15,994	25.6	2,835.4	4.7
Shapers and planers	3,605	5.8	5,623.0	9.3
Threading machines	224	0.4	90.0	0.1
Cutting machines (saws)	5,618	9.0	1,745.0	2.9
Grinding machines	232	0.4	179.0	0.3
Tool-grinding machines	230	0.4	180.0	0.3
Special machines	58	0.1	59.0	0.1
Total for chip-producing machines	49,759	79.7	37,592.8	62.2
Presses	10,107	16.2	18,125.7	30.0
Forging machines (pneumatic hammers)	30	-	107.6	0.2
Machines for sheet	2,558	4.1	4,601.0	7.6
Total for forming machines	12,695	20.3	22,834.3	37.8
Grand total	62,454	100.0	60,427.1	100.0

course of the period, that the share of this line of production has risen to 34 per cent as against 13.7 per cent in 1955. The reason lies in the heavy demand deriving from the production of light manufactured goods for which hand drills are generally used, and also in the fact that the use of high output drilling machines such as, for example, the multi-spindle type, is not very common in Brazil.

As may logically be inferred from the low percentage of milling machines both in the Brazilian inventory and in domestic production of machine tools, output of shapers and planers expanded considerably, attaining a figure that should be considered the maximum in percentage terms. As the manufacture of new types of milling machines is consolidated, these will come to predominate over shapers and planers, and the position will thus be reversed.

Outputs of saws increased more than tenfold between 1955 and 1961, which meant that their share in total production rose from 2.5 to 8.4 per cent in that period. This state of affairs is attributable to the widespread use of these machines in maintenance workshops and small establishments, and also, as would seem to be the case with circular saws, to the very limited use of higher yield machine tools.

Production of presses was approximately trebled, but their share too, like that of lathes, dropped from 18.3 to 13.8 per cent.

Despite the substantial increments registered, there is remarkably little manufacturing activity in the field of grinding machines, tool-grinding machines, threading machines and special machine tools, which already represent a considerable proportion of the domestic inventory, although the percentage is lower than in other countries.

The average weight of the machine tools has fluctuated

significantly in the course of the period. Worthy of special mention is the progress achieved in respect to lathes, the average weight of which has risen by about 300 kg in the past six years; this was one of the factors responsible for the acceptance of Brazilian lathes on external markets (tables 10, 11 and 12).

Noteworthy, too, is the increase of almost 900 kg in the unit weight of hydraulic presses, although this is not clearly reflected in the over-all average for presses, because the expansion of capacity to manufacture heavier machinery is offset by an increase in output of other types, chiefly eccentric presses, in respect of which domestic industry has for many years been supplying internal requirements of the models and sizes in most general use.

Since the milling machines manufactured in 1955 were simple models, their weight had almost doubled six years later. But this progress must not be regarded as sufficient, since the average weight of these machines recommendable at the country's present stage of industrialization should be in the neighbourhood of 1,500 to 1,700 kg. The introduction of new types will probably permit the attainment of this target in the next ten years.

The heavy consumption of bench drills accounts for a decrease in the average weight of the drilling machine group, which was 150 kg per machine in 1961. Here too the modest share of domestic production may be noted in relation to the heavier types, for example those with capacities of up to 2 in., the pedestal type, multi-spindle drills and radial drills.

The figures for shapers, planers and saws fluctuate mainly on account of the influence of production of the lighter types, demand for which varies greatly. Within these categories, machines of higher capacity and weight have been manufactured in Brazil.

Despite the progress achieved as regards volumes of manufacturing output and the fairly high level reached in 1961, the phase under review might be defined as the formative stage of Brazil's machine-tool sector, on the basis of an over-all evaluation, and in the sense that a considerable proportion of the establishments are equipped to cope with production in terms of quantity rather than of quality. What has been said of the manufacturers' own inventory of machine tools is fairly conclusive in this respect.

Thus, while certain types of machine tools, such as engine lathes, medium weight hexagonal turret lathes and presses have already reached a high level of quality and productivity, many of the other machines are deficient on the technical side. This is because most of the small manufacturers, owing to their limited production facilities, have to make the simplest models. The only advantage of such a situation is the low price of the machine tools which in the last analysis proves anti-economic in terms of productivity.

One obvious result of the production of a large number of simple machine tools is the lack of extrasectoral manufacturing enterprise in supplementary equipment and accessories which are important factors in the development of the machine-tool sector. It must be acknowledged, however, that interest in the manufacture

Table 10
TREND OF AVERAGE WEIGHT OF SELECTED CHIP-PRODUCING MACHINE TOOLS, 1955-61
(Kilogrammes)

Type of machines	1955	1956	1957	1958	1959	1960	1961
Lathes (excluding bench lathes)	1,098	1,082	1,093	1,170	1,278	1,332	1,322
Milling machines	586	627	544	905	887	1,006	1,042
Drilling machines	269	205	187	176	184	187	150
Shapers and planers	2,042	1,445	1,569	1,658	1,771	1,411	1,461
Cutting machines (saws)	173	300	357	318	353	320	264
Total for chip-producing machines	960	789	759	776	816	740	650

Table 11
EVOLUTION OF AVERAGE WEIGHT OF SELECTED MACHINE TOOLS FOR FORMING OPERATIONS, 1955-61
(Kilogrammes)

Machines	1955	1956	1957	1958	1959	1960	1961
Total for presses	1,700	1,732	1,883	1,735	1,813	1,828	1,819
Hydraulic presses	657	648	555	578	993	1,536	1,533
Eccentric presses	1,641	1,715	1,938	1,851	1,770	1,672	1,656
Shears	2,258	1,986	2,157	1,840	2,351	1,976	1,739
Total for forming machines	1,736	1,725	1,881	1,749	1,870	1,846	1,772
Average weight of total machine-tool output	1,136	1,003	996	980	1,022	965	854

Table 12
COMPOSITION OF PRODUCTION OF MACHINE TOOLS IN 1955 AND 1961
(Percentages)

Type of machine	In terms of units		In terms of weight	
	1955	1961	1955	1961
Lathes	54.6	29.9	52.7	39.7
Milling machines	1.6	1.8	0.8	2.2
Drilling machines	13.7	34.2	3.2	6.0
Shapers and planers	4.5	6.0	8.1	10.3
Threading machines	0.4	0.3	0.1	0.3
Cutting machines (saws)	2.5	8.4	0.4	2.6
Grinding machines	—	0.5	0.1	0.4
Tool-grinding machines	—	0.7	—	0.5
Special machine tools	—	0.1	—	0.3
Total for chip-producing machines	77.3	81.9	65.4	62.3
Presses	18.3	13.8	27.3	29.4
Forging machines	—	—	0.1	0.2
Machines for sheet	4.4	4.3	7.2	8.1
Total for forming machines	22.7	18.1	34.6	37.7
Grand total	100.0	100.0	100.0	100.0

of highly specialized items is warranted only when the consumer market reaches a certain minimum level. By way of illustration, a list follows of some of the accessories which may be regarded as basic for the manufacture of good quality machine tools with a high productivity, which at present are difficult to find on the market:

- Component parts for low-, medium- and high-pressure hydraulic circuits;
- Electrohydraulic, pneumohydraulic and electropneumo-hydraulic equipment;
- Component parts for pneumatic circuits;
- Electric motors with brakes;
- Continuous speed variators, mechanical, electric and hydraulic;
- Electromagnetic, pneumatic, hydraulic and mechanical clutches, simple and compound, dry or oil bath types;
- Revolving tables with hand dividers;
- Hand and automatic high precision dividers for milling machines;
- Electromagnetic tables, higher powered than those currently manufactured;
- Hydraulic plates for lathes.

manufactured. This is one of the most important targets to be attained by domestic industry. In addition, as has already been pointed out, the nature of the problems connected with the technological evolution of machine tools is such that, generally speaking, they could not be tackled competently enough by the smaller firms unless they undertake the task of carrying out more advanced projects studied by third parties, or by an agency with the necessary technical qualifications, such as the Brazilian machine-tools institute.

In conclusion, the quality and types of the machine tools manufactured must in future keep up more closely with the increasing needs of the Brazilian machine-tool inventory (table 13), as the more advanced manufacturers have done hitherto, so that definitive consolidation of the sector may be achieved.

As regards price levels in the domestic machine-tools industry and its competitive positions vis-à-vis foreign machine tools, it is difficult at present to put forward conclusive data reflecting the real situation for each machine. In this type of industry, such factors as quality, complexity, and manufacturing characteristics and techniques exert a powerful influence on manufacturing costs

Table 13
TOTAL INVENTORY OF MACHINE TOOLS, 1960

Type of machine	Major groups				Total	
	I	II	III	IV	Number	Percentage
	Manufacture of metal products	Manufacture of machinery excluding electrical machinery	Manufacture of electrical and communications material	Manufacture of transport material		
Lathes	11,298	9,860	4,263	15,104	40,525	29.5
Milling machines	884	2,155	572	2,937	6,548	4.8
Drilling machines	7,834	6,067	3,459	9,401	26,761	19.5
Boring machines	83	218	59	597	957	0.7
Shapers and planers	2,653	2,112	724	2,139	7,620	5.6
Threading machines	557	359	332	1,077	2,325	1.7
Broaching machines	38	50	33	510	691	0.4
Gear-cutting machines	^a	270	36	718	1,033	0.8
Metal-cutting machines (saws)	2,631	1,842	909	3,046	8,428	6.1
Grinding machines	453	1,079	470	2,970	4,072	3.6
Tool-grinding machines	276	542	225	1,183	2,226	1.6
Total for chip-producing machines	26,707	24,563	11,082	39,682	102,034	74.3
Presses	14,140	2,240	4,242	8,191	28,813	20.9
Forging machines	81	54	^a	382	517	0.4
Machines for forming, bending and cutting sheet	2,348	1,455	1,062	1,135	6,000	4.4
Total for forming machines	16,569	3,749	5,304	9,708	35,330	25.7
Grand total	43,276	28,312	16,386	49,390	137,364	100.0

^a Lower than 10 units.

If suitable undertakings are to be set up to supplement and support the manufacture of machine tools, the prime requisite is that domestic manufacturers should interest themselves in producing more fully equipped machine tools and duly exploiting the resources offered by semi-automation to improve the productivity of the machines

and cannot be ignored in such comparisons which as a result become immensely difficult and in some cases even impossible or, if a strictly comparable counterpart cannot be found, virtually devoid of significance. Locally manufactured machine tools show a wide range of prices according to the greater or lesser incidence of these on

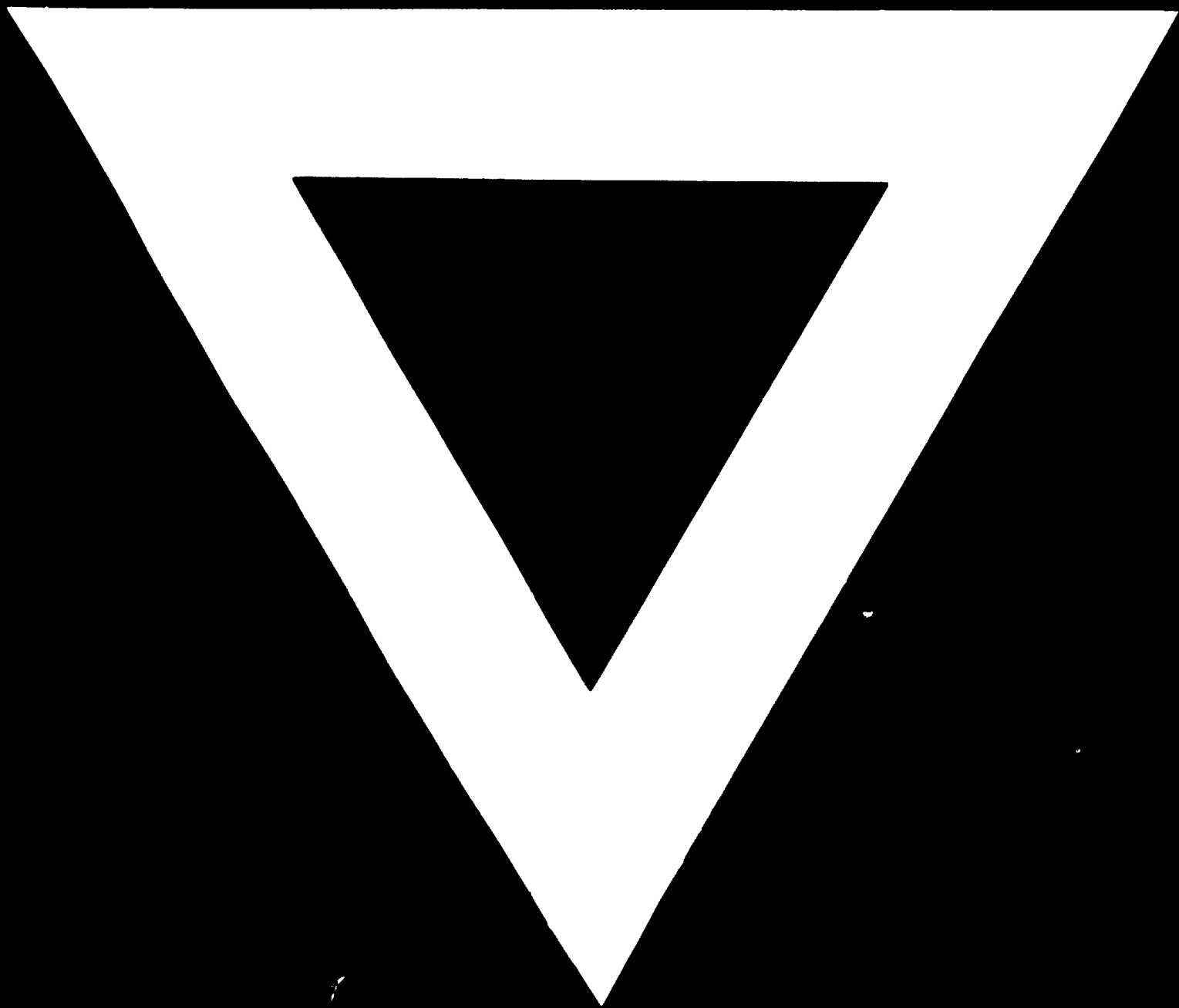
their manufacture, and this would make for unrealistic or meaningless results if a comparison at the level of the broad classification of machine tools were attempted; such an undertaking would have to be carried out in relation to each individual type of machine and for this insufficient data are available, besides which, it would be outside the scope of the present study.

Despite the price differences observable in domestic

machine tools, quotations fluctuate, broadly speaking, around an average of \$2 per kg, which may be considered satisfactory.

Again, since exports of particular machines, such as certain types of lathes and presses, have been achieved and some Latin American countries are displaying interest in purchasing Brazilian machine tools, it may be deduced that their price levels fall within an acceptable range.





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