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The Manufacture of Industrial Machinery and Equipment in Latin America

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The Manufacture of Industrial Machinery and Equipment in Latin America

I. BASIC EQUIPMENT IN BRAZIL

Study prepared by the ECLA secretariat in close collaboration with the Brazilian Association for the Development of Basic Industry (ABDIB) and the Executive Board of the Heavy Metal-Transforming Industry (GEIMAPE)

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I. INTRODUCTION, SUMMARY AND CONCLUSIONS

The present study was prepared with the aim of projecting the development of the Brazilian heavy metal-transforming industry during the next ten years, 1961-70, to meet the equipment requirements in five basic production sectors: petroleum and petroleum products, electric power, steel, cement, and pulp and paper. The paper constitutes the preliminary findings of a research project that is intended to include other Latin American countries, such as Argentina, Chile and Mexico, where there is already a heavy metal-transforming industry in its early stages and conditions favour its rapid expansion. It was prepared on the basis of direct surveys carried out in Brazil in co-operation with the Brazilian Association for the Development of Basic Industry (Associação Brasileira para o Desenvolvimento das Industrias de Base—ABDIB) and the Executive Board of the Heavy Metal-Transforming Industry) Grupo Executivo da Industria Mecánica Pesada—GEIMAPE), and the essential aim was to evaluate the capacity of industry in Brazil to meet the need for these types of equipment, as well as to determine what are the main factors likely to stand in the way of the effective use of this capacity through the optimum exploitation of the existing productive resources.

Since the present study represents the initial exploration of new territory, where the problems to be examined are numerous and complex, it should be regarded as provisional. At the second stage, which has already started, there will be a more detailed analysis of certain subjects that can only be discussed here in a very sketchy and tentative manner. These include the intriguing question of project engineering, that is, the technical capacity to draw up projects for complete industrial plants; this is a vast and complex question which warrants special study. Similarly it has not been possible to work out in detail what measures must be taken to ensure rapid expansion of domestic production of heavy equipment, and this too will be the subject of further study.

Both the information presented in this study and the comments deriving therefrom relate to conditions in Brazil at the end of 1960, when the corresponding field work was carried out. It is proposed to keep the information up to date by means of periodic reports showing the principal changes which occur in the different sectors of basic equipment manufacture. The first of these reports might possibly be issued with the end of 1962 as reference date, and would give an analysis of the chief developments which will have taken place in this sector during the two years which will have elapsed since the reference date of the present study.

1. Manufacture of basic industrial equipment: the nature of the problem

The Latin American countries at the most advanced stage of industrialization—Argentina, Brazil, Chile and Mexico—have now reached a point in their development where the needs for basic equipment are increasing rapidly, in both relative and absolute terms. This is due to a number of factors, one of them being a policy aimed at a more balanced industrial development, with special emphasis on the local production of raw materials, fuels and semi-finished goods, as opposed to the production of finished goods only.

However, the local production of basic industrial equipment such as that required for the steel and petrochemical industries, and the extraction and transport of minerals, is only in its infancy, and there are a number of obstacles to its expansion. The requirements for each type of equipment in the individual countries do not amount to a volume sufficient to justify, either at present or in the near future, the establishment of special plants for the production of such equipment, apart from a few exceptions which do not invalidate the general rule. Moreover, the manufacture of this equipment, by its very nature, involves a high level of technical complexity, and is frequently bound up with international design and process patents. Thus both the smallness of the domestic markets and the difficulty of transplanting the complex techniques involved are obstacles to any appreciable local production of basic industrial equipment by traditional methods. These obstacles hamper and delay the natural development of this type of production as a normal stage in the industrial evolution of countries that have already attained the intermediate stage of industrialization.

In these countries we observe at a given moment what amounts to a halt in industrialization resulting from the introduction of new methods and processes. Despite the appreciable growth of the various branches of the metal-transforming industry, and the considerable amount of technical experience accumulated in scattered form throughout the industry, there is a lag in the manufacture of basic industrial equipment, varying with the special situation of each country.

This time-lag in the transition from the light to the heavy metal-transforming industries cannot be explained by the higher level costs involved, since as the present study will show, the high proportion represented by labour in the inputs required for the production of heavy industrial equipment makes possible a final price that in some sectors compares favourably with that of the more advanced industrial countries.

The main limiting factor is probably the complexity of the techniques required at this more advanced stage of the metal-transforming industry. However, a more careful analysis shows that this technological difficulty is not necessarily insurmountable, since there are ways of greatly mitigating its unfavourable effect on the manufacture of basic industrial equipment. In other words, certain measures of economic policy, or of an institutional nature, can be adopted with a view to facilitating both the collation of the scattered technical

experience to be found in all the main firms in the metal-transforming industry of a country at the intermediate stage of industrialization, and also the introduction of technical know-how from abroad apart from any imports of equipment.

The manufacture of basic industrial equipment is concentrated in the heavy metal-transforming industry. There are many criteria for defining the basic industries, but in the present paper basic equipment is taken to mean that used in pulp and paper mills, in the cement, petrochemical and chemical plants, in oil drilling, extracting and refining, in steel mills and, in general, in all industrial plants which are manufactured or built to order, according to the individual requirements and on the basis of project engineering plans.

This equipment is of a kind that can be manufactured on the basis of large-scale sub-contracting, using the existing technical resources of the various branches of the metal-transforming industry, especially the heavy side of the industry. The items sub-contracted consist in part of all-purpose machinery and equipment regularly manufactured within the country and of standard design, such as electric motors, transformers, hydraulic pumps, control apparatus, valves, etc. However, a high proportion of the sub-contracted items consists of non-standard machinery or machine parts which have to be made specially according to individual specifications. The various branches of the country's existing metal-transforming industry, such as forging, boiler-making, foundry work, machine finishing, stamping etc., will have to produce spare parts and components, making maximum use of their installed capacity, and especially large-scale productive equipment, which represents that part of the investment of the sub-contracting firm with the lowest utilization coefficient.

In this way the Latin American countries should be able to undertake domestic production of a considerable range of equipment for the basic industries, and to by-pass the problem of the smallness of markets, which prevents the establishment of special production series for this equipment. The essential feature of this scheme —the know-how needed for drawing up the engineering project plans and breaking them down into a large number of designs for elementary parts, with their specifications, to be manufactured locally—can be achieved through the co-operation of the technical departments of each of the local manufacturing firms: a pool would be established in which accumulated experience would be centralized, and when necessary the essential know-how would be acquired from abroad, through the central project office (which is what the pool would actually amount to), against payment of royalties.

The proper application of this scheme for the manufacture of basic industrial equipment, which might be termed manufacture by the co-operative utilization of existing plant, the pooling of resources or large-scale sub-contracting, presupposes the prior solution of a number of problems. The present research project is designed, first to determine the possible field for the local manufacture of basic equipment, and secondly to ascertain what are the obstacles to such manufacture, and how to eliminate them or make their influence less felt.

Some of these obstacles cannot, of course, be eliminated, or can be eliminated only gradually, and as a result of the country's own development rather than of any special measures. This applies to the limited size of the domestic market for each specific type of equipment, in so far as it cannot be coped with by the sub-contracting procedure; it applies also to the high level of domestic costs for certain products and operations.

But, in other cases the difficulties attendant on the domestic manufacture of basic equipment can be disposed of in varying degrees. One step in this direction is the co-operative organization of the local metal-transforming and metallurgical plants; because of their technical experience, and the nature of their productive plant, they can act as subcontractors for parts and components that constitute a high proportion of the total output required.

Another obstacle is the lack of certain productive facilities (processes or machinery of special dimensions or type), resulting in bottlenecks; these can be dealt with by means of specially directed programmes of selective investments throughout the metal-transforming industries. Yet another is the system of comparing local and import prices with a view to awarding contracts open to public tender. This is an unsatisfactory system, since it regularly leads to the importing of equipment when local production would be relatively advantageous. This anomaly could be eliminated through the study and publication of properly adjusted standards governing such comparisons.

2. Aims of the study, and method used

The aims of this study on the manufacture of basic industrial equipment may be summarized as follows:

(*a*) To measure the amount of equipment that will be needed as a result of the execution of clearly-defined sectoral development programmes in the basic industries, particularly the petroleum, electric power, cement, pulp and paper, and steel industries.

Once this equipment has been estimated, it is classified according to type of manufacture.

(*b*) To compare these requirements with the existing production capacity of the metal-transforming industry already established, and to decide how far this capacity is adequate (with respect both to volume of production and to machinery of large dimensions or possessing special features).

(*c*) To look into the institutional solution of problems that limit the manufacture of heavy industrial equipment, e.g. the use of large production equipment on a co-operative basis, and the separation between project engineering and means of production.

(*d*) To estimate roughly both the additional investment required to eliminate bottlenecks in available productive capacity, mainly with respect to machinery of large dimensions or with other exceptional features, and the domestic financing requirements represented by the sectoral development programmes envisaged.

(*e*) To make tentative suggestions as to the areas where certain practical steps could be taken, e.g. steps towards the adoption of co-operative measures by the owners of the metal-transforming firms most closely related to the heavy metal-transforming industry, with

a view to building up know-how; the presentation of projects to international credit organizations with a view to obtaining loans for the domestic financing of the sale of the equipment produced or the purchase of very large machinery to be used on a co-operative basis by local industry in the execution of specific sectoral development programmes; or requests for aid from the Expanded Programme of Technical Assistance, the United Nations Special Fund, or other bodies that provide technical assistance, for programmes involving the acquisition of technological information needed for the progressive development of the heavy metal-transforming industry.

The above is a brief summary of the general aims of the study on the manufacture of basic industrial equipment. The extent to which these aims can be achieved will naturally depend not only on the prevailing situation in the countries considered as regards resources, experience already acquired in the metal-transforming industry and the line of the industrial development policy pursued, but also on the degree of co-operation received from the Governments and from industry. Consequently it may be expected that the reports on the various Latin American countries referred to will vary considerably, despite the fact that the criteria applied are the same in all cases.

The study comprises the following methodological stages:

(*a*) Estimating the requirements in the way of basic industrial equipment on the basis of projections (as a general rule covering a 10-year period) of demand for the final products to be produced by this equipment (cement, paper, steel products, etc.), and of present plans or targets for the production of the equipment.

This estimate should be based on maximum and minimum hypotheses as to both the growth of the gross product and the extent of import substitution made possible by existing circumstances (tariff and exchange policies etc., the evolution of domestic costs, and availability of means of internal financing). Nevertheless, there is every reason for using existing consumption projections, and this has been done in the present preliminary study on Brazil as regards most of the sectors examined, namely electric power, petrochemical production (petroleum refining and the production of certain petroleum derivatives), steel, cement, and pulp and paper. Other sectors using equipment which is similar in type to basic equipment and can be manufactured on the basis of large-scale sub-contracting are, for example, the non-ferrous metal trades, oil drilling and extraction, the mining, refining and transport of ores etc. If circumstances permit, this study will subsequently be extended to these other sectors.

In the planning of this study for each country, careful consideration must first be given to the question whether or not it should include only the basic industrial equipment that can be manufactured on the basis of large-scale sub-contracting, excluding such capital goods as machine tools etc., which are normally manufactured to standard designs. It is obvious that with respect to capital goods produced by the metal-transforming industry there are many features common to both these categories, and from this standpoint the study should be broad in scope. On the other hand, the inclusion of capital goods that are mass produced according to list specifications would extend the scope of the investigation considerably, and woud mean introducing a number of additional problems peculiar to that type of industry, apart from involving the consideration, in estimating market demand, of an enormous variety of finished products of the metal-transforming and metallurgical industries. Consequently it is preferable for the problems relating to these two categories of capital goods to be studied separately.

(*b*) Breaking down the estimated requirements under each type of equipment into basic parts that could be manufactured separately by such-contract (forgings, castings, boiler parts, structural parts, machine parts etc.). The degree of detail necessary for this breakdown will depend both on the nature of the equipment under consideration and on the degree of sub-contracting permitted by the specialized structure of existing metal-transforming plants.

This estimate of requirements should be both quantitative and qualitative; that is, it should show both the total volume of work required for each type (boiler-making, forging etc.) and the specifications for this work (maximum dimensions, special features etc.).

(*c*) Surveying the possibilities for the manufacture of parts by the local metal-transforming industry. The following points should be taken into consideration:

(i) The principal existing plants for boiler-making, forging, casting etc., a check being made of specifications at the upper and lower limits of the range and of special features that can be obtained by manufacturing to order;

(ii) The relationship between the equipment required and the facilities for manufacturing it, with special reference to specifications and other production features and also to the implied workload in the various branches and the existing capacity to cope with it;

(iii) Detection of bottlenecks in available capacity and determination of the need for partial increases in investment for plant in the existing metal-transforming industry to cope with programmes for the production of equipment in each of the basic sectors under consideration;

(iv) An analysis, for each of these basic sectors, of the requirements in the way of engineering for the manufacture of the equipment concerned by means of the co-operative use of existing plants through large-scale sub-contracting.

In this respect the situation may well vary considerably from country to country and from sector to sector. The plant for some sectors may include a higher proportion of standard equipment. There may also be a variation in the degree to which the manufacture of the equipment, being closely linked to processes covered by international patents or depending on complex and little known techniques, requires previous agreements for the acquisition of know-how, or special measures of technical assistance.

(*d*) Analysing the factors that hamper the expansion of the heavy metal-transforming industry to meet a higher proportion of the country's requirements in basic industrial equipment.

The following are the principal factors to be considered:

(i) The size of the market and the level of domestic costs, for the various types of equipment;

(ii) Tariffs, the exchange system and norms for comparing the prices of domestic products with those of imported goods in public bidding;

(iii) Domestic financing of sales of basic equipment and the different ways of encouraging it;

(iv) The insufficiency of the traditional methods of external financing, principally with respect to partial expansion of capacity in existing plants;

(v) The need for technological research on a pre-industrial scale, in relation to the particular nature of the country's natural resources (mainly the establishment of processes for the utilization of certain non-conventional raw materials);

(vi) Special requirements in the way of standardization of both products and raw materials;

(vii) Limitations on the use of the system of co-operative utilization of existing plants through sub-contracting, and methods of overcoming these limitations;

(viii) Ways of directing know-how from abroad into the proper channels.

Analysis of each of the above-mentioned factors or problems should lead to the consideration of certain alternative solutions, the basic features of which will be outlined below.

In some cases this may eventually serve as a starting point for some form of specific action, e.g. the establishment of the institutional structure necessary for a wholesale extension of the system of production by the pooling of resources, or the preparation, by the bodies concerned, of projects as a basis for requesting loans from the Inter-American Development Bank, or technical assistance under the Expanded Programme of Technical Assistance or from the United Nations Special Fund, in respect of detailed programmes for the manufacture of basic equipment.

Broadly speaking, this is the methodological approach used in the present study on Brazil, and the intention is to use the same approach for the other countries, subject to the limitations and modifications that are bound to be required by the particular circumstances of each country and of the basic industrial sectors selected for study.

3. Summary and conclusions

(a) *Equipment requirements and domestic production possibilities*

A study of the requirements for industrial equipment resulting from the programmes for the expansion of the sectors covering petroleum refining and the petrochemical industries, hydroelectric power, the steel industry, paper and pulp, and cement, gave the high estimated figure of 905.7 million dollars' worth of equipment for the 10-year period 1961-70 (1961-71 for the power sector and 1966-70 for steel-making). These equipment requirements represent known expansion programmes whose execution is highly probable.

The major part of this total (410 million dollars) represents equipment for the generation of electric power (hydraulic turbines, generators, transformers and auxiliary equipment). In the light of the technical experience and productive capacity of the Brazilian heavy metal-transforming industry to meet this demand, it is estimated that 351 million dollars' worth of equipment, or 86 per cent of the total requirements arising out of the 10-year programme, can be produced in the country. However, this very high proportion will involve substantial expansion in that section of the heavy metal-transforming industry that produces heavy electrical machinery. The shortage of existing capacity is particularly marked in the production of hydraulic turbines. The next major item is equipment for the production of pulp and paper, totalling 159.5 million dollars for the same period. It is estimated that the local industry can contribute production to the value of approximately 142.1 million dollars, that is, 90 per cent of the value of the machinery required for expansion and for the establishment of new pulp and paper mills.

The attainment of this level of domestic production of pulp and paper equipment presents no great problems with respect either to technical experience or to productive capacity. It may be that such problems would arise if this study included consideration of the domestic production of more complex machinery, such as that for the manufacture of newsprint; but this has not been the case.

In the sector covering oil-refining, pipelines, and the petrochemical industries, the demand for equipment to cope with the expansion envisaged in the next decade will amount to 138 million dollars. This estimate was based on the assumption that during the whole 10-year period the country would expand its refining capacity sufficiently to meet the whole of the requirements for the consumption envisaged for petroleum and petroleum products. With respect to the petrochemical industries, attention was concentrated mainly on those based on the processing of the anticipated stocks of natural gas. The activity of the Brazilian equipment industry in this field is already considerable, so that domestic production to the value of some 90 million dollars, or 64 per cent of the equipment requirements envisaged, largely corresponds to the projection for the period 1961-70 based on the contribution of domestic industry recorded recently. However, although this eliminates for the time being the need to consider possible obstacles of a technical nature, the survey made showed that the heavy metal-transforming industry would probably not be able to deal with the volume of work expected to result from the programme in question, particularly because of the placing of orders for equipment for other sectors with the firms concerned. Here the problem, unlike that in the electric power sector, is essentially to obtain advance information as to the total demand for equipment for the principal sectors, so as to enable the firms which make up the heavy metal-transforming industry to plan their expansion accordingly.

The expansion of productive capacity for steel envisaged in the study will require equipment amounting to 114 million dollars in the period 1966-70. This is a new activity in Brazil and the metal-transforming industry is embarking on it rather slowly, so that the estimated domestic contribution will amount only to about 77 per cent of total requirements, to the value

of 88 million dollars. The obstacle to domestic production is not of a technical nature, since most of the equipment and parts that make up a steel mill call for a technical level of production that does not exceed the experience already possessed by the Brazilian heavy metal-transforming industry. In this sector the problem is mainly that of the relation between external financing and the importing of the equipment, and also that of introducing the relevant engineering know-how into Brazil.

Lastly, for the production of cement during the period 1961-70 in accordance with the estimated increase in per capita consumption, investments in equipment amounting to 84.1 million dollars will be needed, of which 62 per cent (or 52 million dollars' worth) could be produced in the country. In this instance the contribution of Brazilian industry recorded in recent years has been very small, and consequently the hypothetical domestic manufacture of 62 per cent of the estimated requirements is conditional upon the prior removal of the main obstacle to production, which is the fact that thus far the main world producers of equipment for the manufacture of cement have not been prepared to cede the right to use their patents in Brazil under royalty agreements.

If the equipment for all five sectors is taken together, the Brazilian heavy metal-transforming industry can undertake to produce 80 per cent of the total, amounting to 721.9 million dollars. However, this is contingent on the prior solution of certain problems, some of which have already been briefly indicated above, while others will be referred to below.

(b) *Price levels for domestic production*

The level of prices indicated by the Brazilian heavy metal-transforming industry for the work considered under the heading of domestic production for all these categories of equipment should not constitute any obstacle to the execution of the programme outlined. If the whole petroleum equipment programme is considered together, we find that the prices for the domestic articles and the prices for the same equipment in the United States would be equivalent at an average exchange rate of 192 cruzeiros to the dollar. This comparison, like the others, is based on the situation with respect to domestic prices in October-November 1960, when the free exchange rate and the exchange rate for general category imports were 180 and 245 cruzeiros to the dollar, respectively.

However, the comparison gives results that vary considerably according to the type of equipment and the nature of its manufacture. Brazil's main comparative advantage in the field is in real labour costs (that is, the cost established on the basis of nominal wages and physical output). For equipment where the labour input per unit of production is very high (boiler making and heavy metal work, on the basis of short production series)—which applies to most of the equipment required for the petroleum refining and petrochemical industries programme—the Brazilian price level is actually highly favourable (from 160 to 183 cruzeiros to the dollar).[1] For the remaining equipment, manufactured in longer production series using more mechanized processes, the domestic price level is higher (220 cruzeiros to the dollar).

With respect to prices estimated by the heavy metal-transforming industry in Brazil, electricity-generating equipment differs from other types both because of the smaller input of labour in the production process, and because of the effect of the high costs of the imported raw materials (in comparison with those produced in the country). As a result, domestic prices are appreciably higher (247 cruzeiros to the dollar for hydraulic turbines and 263-270 to the dollar for transformers and generators).

The situation with respect to the production of equipment for the remaining sectors (cement, paper and pulp, and steel) is somewhere between these two extremes.

(c) *Problems relating to engineering know-how and technical standards*

It is evident from the present survey that the expansion of the Brazilian basic equipment industry is hampered by the lack of technical standards of its own, in line with local conditions, and of domestic project engineering know-how capable of drawing up projects within the country for the installation of complete industrial plants.

The lack of any existing Brazilian technical standards for metal-transforming work makes it necessary to adopt a wide variety of foreign standards, as stipulated by the project engineers, that are difficult to adapt to local conditions, and highly prejudicial to domestic industry.

Attempts to overcome this difficulty are being made by the Brazilian Technical Standards Association (ABNT), with assistance from the Brazilian Petroleum Institute (IBP) and the Brazilian Association for the Development of Basic Industry (ABDIB). However, progress has been slow, since ABNT has neither the financial resources nor the team of technicians needed to carry out the work.

ABNT is a corporation which depends on the contributions of its small membership, although it is recognized and partly subsidized by the Government. Consequently it cannot maintain a team of engineers and assistants to work full time on the preparation of standards, for those at present engaged on the work are carrying on their normal activities elsewhere and devoting only a small part of their time to ABNT. This body would have to be reorganized, as could be done with international aid. A specific programme could be prepared to equip ABNT to study and publish the standards referred to. The aid needed could be provided through ABDIB, which could also collaborate.

The gradual building up of a national body of engineering know-how is a prerequisite for the sound development of the heavy metal-transforming industry. Once this know-how had been developed, at least with respect to mechanical engineering (since the acquisition of knowledge and experience in process engineering would take much longer) the placing of orders for equipment within the country would inevitably follow. To meet the present lack, ABDIB is carrying out ex-

[1] These values represent rates of equivalence obtained by comparing the ex-factory prices for each class of equipment in Brazil and in the United States.

tensive work in pooling the skills of its members in this field and promoting the exchange of information among the engineering departments of the various firms. Thus, it is clear that in this respect also, co-operation among the firms belonging to the heavy metal-transforming industry can help to solve the problem.

In conjunction with these activities there should also be negotiations for the establishment in Brazil, in close association with local bodies, of international engineering firms which could assist in establishing a national corpus of engineering know-how.

(d) *Problems of external competition*

The Brazilian heavy metal-transforming industry is in an unfavourable position as regards competition with its counterparts abroad; this is attributable to administrative practices and the lack of domestic financing for its sales. For example, the Brazilian customs legislation provides a system of registration for products similar to those made abroad, to prevent exemptions or reductions of customs duties on competitive imports and, when necessary, to enable higher duties to be imposed on such imports; but this procedure is not being properly applied, the reason being that the regulations are based on directives drawn up before the country's industrial development had begun, and stipulate the production of evidence of productive capacity that is difficult to obtain in the particular case of the heavy metal-transforming industry. Thus, for instance, they require an exact identification of the product to be registered, and proof of its permanent commercial availability, although it is recognized that the heavy metal-transforming industry works to order on specific projects and designs, producing whole plant units or parts of units, and consequently cannot meet such requirements. It is essential for this industry to find another, more flexible approach, based on the general capacity of the enterprise.

Closely related to his problem is that arising out of the application of Note 183 in Section XVI, chapter 84 of the Customs Tariff, concerning boilers, machinery, apparatus and motors. This Note empowers the Tariff Policy Council to grant, at the request of the importer, a reduction of 50 per cent of the duty on items included in the chapter when they are intended for domestic industrial or agricultural production and no similar domestic goods exist. The application of this Note without further safeguards may cause industry unnecescary difficulties, because of the problem of proving the similar nature of domestically-produced goods.

A change in the procedure might be made in this respect, first of all by making the right of registration for "similar" products more flexible, but more important still, by placing the onus of showing that no similar product is manufactured domestically on the person wishing to import the equipment.

In addition to these customs problems, the industry is faced in the exchange field with the problem of the release of foreign currency for the importation of equipment for activities regarded as important to economic development at a rate known as "cost exchange" which is much lower than that applied to normal imports; when the present study was being prepared, this special rate was 100 cruzeiros to the dollar. Moreover, domestic industry is at a disadvantage in public bidding sponsored by government bodies for the purchase of this type of equipment, because the price comparison is made not on the basis of the real exchange rate, but on the "cost exchange" rate. This procedure is the opposite of that followed in other countries, where similar public tenders ensure preference for the domestic product; in the United States, for example, the "Buy American" Act stipulates the preferential purchasing of domestic products even at prices slightly higher than those of foreign goods.

However, this situation has been improved by the recent exchange reform[2] which raised the "cost exchange" to 200 cruzeiros to the dollar. In addition, the Executive Board of the Heavy Metal-Transforming Industry (GEIMAPE), a Federal Government body responsible for encouraging the expansion and consolidation of that industry, is proposing the adoption of more appropriate standards in this respect.

Mention should also be made of the present policy of admitting foreign investments in the form of the importation of complete plants or equipment units without exchange cover, that is, without making foreign exchange available and taking an agio; not only does this involve the entry of equipment similar to that produced by domestic industry, and also used machinery, when domestic firms cannot operate on the same footing, but it may also lead to some imbalance in the distribution of investment. GEIMAPE is now working on this problem in co-operation with the authorities responsible for carrying out the policy.

(e) *Problems of domestic financing*

The principal factor limiting the expansion of this industry and placing it at a disadvantage as compared with foreign competitors is the lack of sufficient domestic medium and long-term financing to provide circulating capital for sales.

Because of the nature of the equipment, complexity of production and high unit costs, long-term financing is required, which cannot be provided by the industry itself; at the same time, the national banking machinery does not include any system of credit specializing in these operations, whereas foreign producers can have recourse to financing organizations, sometimes supported by the Government concerned, which can provide purchasers with credit on favourable terms.

An idea of the amount of funds required for this financing can be obtained from the figures representing the value of the equipment for the five sectors dealt with which can be supplied by domestic industry over the next decade. As stated previously, this amounts to 721.9 million dollars, or about 180.5 thousand million cruzeiros at a conversion rate of 250 cruzeiros to the dollar.[3]

Assuming regular demand, a credit period of five years, as required at present by the Brazilian authorities

[2] March 1961.

[3] This is approximately the free rate of exchange prevailing at the time when the preliminary version of this study was issued (April 1961).

for imports of equipment, and a down payment of 30 per cent, the total funds required for this financing over the decade will amount to about 63.2 thousand million cruzeiros, or an average of 6.3 thousand million cruzeiros a year.

The Brazilian banking system, which is subject to legal limitations with respect to interest rates, and exposed to inflationary pressures, is not in a position to supply these funds, since it normally operates on a short-term basis, with a maximum of 180 days; moreover, for the reasons stated, it cannot attract a larger volume of deposits in the form of private savings, which are invested in other ways less vulnerable to currency depreciation.

The establishment of credit or loan associations side by side with the banking system, able to circumvent the legal limitation on interest rates and operate on the basis of longer-term loans, mobilizing private savings and using them in acceptance and other transactions, is a step towards improving the conditions of internal credit. However, for the sector concerned, the assistance of such societies has not yet been effective, mainly because under the regulations in force their transactions may not cover a period exceeding twenty-four months, and because the interest charged is very high.

It may be necessary to solve the problem by organizing a special system of credit for the financing of sales in the heavy metal-transforming industry involving the use of the loan associations with support from a government finance organization, as is done in Mexico through the Nacional Financiera S.A.

In view of its nature the National Economic Development Bank, if it were suitably adapted, could perform this task, which would involve working with international financial agencies to mobilize the funds required for the purpose through the sale abroad of bonds issued by that Bank in foreign currency, with a guarantee of redemption and payment of interest. The resulting funds could be used to re-finance loan associations, by means of bonds representing sales in the heavy metal-transforming industry. This type of transaction would naturally have to conform to legal requirements, which would consequently have to be amended in order to permit transactions covering periods exceeding twenty-four months exclusively for basic industry.

In this connexion the co-operation of the Inter-American Development Bank would be most valuable, in the form of loans granted not for imports of equipment but for the domestic financing of the industry's sales, since broadly speaking, the metal-transforming industry, except in special cases, needs loans for the formation not of its fixed capital, but of its circulating capital, in the sales sector.

Furthermore, the government of the State of São Paulo could make a decisive contribution towards solving the problem through the "Fund for the Financing of Capital Goods" established by State Law No. 5,444 of 17 November 1959.

The foregoing observations on the problem of financing the domestic sale of basic industrial equipment are no more than suggestions that require more detailed study.

II. EQUIPMENT FOR PETROLEUM REFINING AND THE PETROCHEMICAL INDUSTRIES

In the present section an attempt has been made to evaluate the equipment likely to be required in order to meet internal demand for petroleum derivatives and petrochemical products in the ten-year period 1961-70, by the domestic refining and petrochemical industries, as well as to estimate the part played by Brazil's own heavy metal-transforming industry in satisfying these requirements.

The method of evaluation adopted was to project consumption of petroleum derivatives and petrochemical products for the period under consideration, in the light of Brazil's existing production capacity and the expansion programmes under way, and then to measure the need for further expansion plans or for the establishment of new factories. In this way, the amount of equipment required for execution of such expansion projects was arrived at.

The next step was to ascertain how far the domestic industry would be in a position to supply the requisite capital goods, and what measures should be adopted to ensure that it covered the highest possible proportion of the demand in question.

With respect to petroleum products the probable demand in 1970 was estimated as follows, in terms of number of barrels daily: crude petroleum, 390,000; petrol, 110,500; Diesel oil, 76,000; and fuel oil, 111,000. This projection was based on one formulated by the National Petroleum Council; more conservative estimates were adopted, however, in view of the likelihood of a decrease in the rate of growth of demand, partly as a result of the rise in selling prices due to adjustments of the exchange rates applicable to imports of crude, and partly, as from 1964, in consequence of the entry into operation of the big hydroelectric power plants, whereby the Diesel units and a few thermal plants installed as an emergency system would be released from service.

An annual growth rate of 7.3 per cent was adopted for consumption of crude oil up to 1964; thenceforward, the rate was established at an average figure of about 3.3 per cent.

Brazil currently aims at refining enough petroleum to cover total consumer demand for derivatives. On the assumption that this principle would continue in force, it was calculated that up to 1962 existing refining capacity (184,000 barrels per working day), augmented by the expansion programmes in process of execution at the Cubatão and Mataripe refineries and by the entry into operation of the Duque de Caxias refinery (90,000 barrels of petroleum per working day), would easily be able to meet consumer needs, estimated at 295,000 barrels per calendar day (BPCD) in the year mentioned. As from 1963, the construction of a new refinery with a capacity of 30,000-40,000 barrels per working day would become necessary. This additional plant, plus utilization of the natural petrol extracted from gases in the Recôncavo (Bahia) oilfields, would cater for the consumption projected for 1970.

It was ascertained that refining activities would have to be complemented by the construction (already programmed) of an oil pipeline-terminal for São Paulo (São Sebastião), a pipeline and terminal for Belo Horizonte and a terminal at Ilhéus (Bahia).

As regards the petrochemical industry, in view of market trends, consideration was given to the requirements of the synthetic rubber factories of PETROBRAS (at Duque de Caxias) and the State Government of Pernambuco; to the plant for utilization of the natural gases of the Recôncavo and the surpluses from the Mataripe refinery; and to the construction of various plastic raw materials factories.[4]

The survey carried out suggested that a figure of 138 million dollars might be taken as representative of aggregate equipment requirements for the programme outlined (1961-70), and that the domestic basic equipment industry could supply approximately 64 per cent of this amount, i.e. 88.8 million dollars, domestic production being computed on the basis of an average rate of 192 cruzeiros to the dollar, which is consistent with the level of internal sales prices.

This high proportion of domestic production in fact largely represents a mere projection of what Brazil's heavy metal-transforming industry has already achieved in recent years in the manufacture of petrochemical equipment. The extension of these achievements to other types of equipment was assumed to be feasible only on a very limited scale, since the manufacture of those capital goods to which the remaining 30 per cent of the programmed investment corresponds is affected by problems calling for long-term solution (the small size of the Brazilian market and the fact that technical improvements are perpetually being introduced into the equipment concerned).

With a view to establishing conditions designed to safeguard the domestic industry's share in the market under discussion, attention was devoted to the question of instituting satisfactory technical standards and of progressively transferring the engineering into Brazilian hands. In the final section, mention is made of the measures relating to tariffs, exchange rates and sales financing which would need to be adopted.

1. Projection of consumption of petroleum and derivatives

(a) *Petroleum consumption*

The first step towards determining probable requirements in respect of equipment for refineries, pipelines, crude petroleum terminals and petrochemical industries

[4] Equipment required in connexion with future private investment in other lines of petrochemical production was not taken into account, owing to the difficulty of obtaining sufficiently accurate data on such investment.

TABLE 1. BRAZIL: PROJECTION OF CONSUMPTION OF PETROLEUM AND DERIVATIVES, 1964 AND 1967
(*Barrels per calendar day, BPCD*)

Petroleum and derivatives[a]	*1959*	*1960*	*1961*	*1964*	*1967*
Crude	245,000	262,200	281,300	338,700	402,500
Petrol[b]	71,200	74,700	78,600	94,700	114,000
Diesel oil	45,200	49,200	53,400	65,600	78,100
Fuel oil[c]	74,400	79,200	84,500	99,400	114,900

Source: National Petroleum Council, *Consumption forecast 1959-67.*
[a] Including only the most important derivatives. Hence the discrepancy between totals for derivatives and for crude.
[b] A and B petrol.
[c] Excluding the consumption of the refineries themselves.

was to estimate consumption of petroleum and its derivatives in the period under consideration (1961-70). The estimate was based mainly on the forecast of consumption made by the National Petroleum Council, covering the period up to 1967. In extending it as far as 1970, the criterion applied was somewhat different from that adopted by the Council.

The Council's projection of demand, based on a hypothesis of linear growth, gives the results summarized in table 1. Comparison of the consumption actually registered in 1958, 1959 and 1960 with the National Petroleum Council's forecasts for the same years reveals no appreciable differences. The real consumption figures are to be found in table 2.

TABLE 2. BRAZIL: CONSUMPTION OF PETROLEUM AND DERIVATIVES, 1958-60
(*BPCD*)

Petroleum and derivatives	*1958*	*1959*	*1960*[a]
Crude	215,300	225,700	260,500
Petrol[b]	67,800	67,900	75,600
Diesel oil	40,900	46,900	52,600
Fuel oil[c]	69,300	72,600	82,100

[a] Based on average consumption figures for January-October.
[b] A and B petrol.
[c] Excluding the consumption of the refineries themselves.

If the two tables are compared it will be noted that, although consumption of crude petroleum fell slightly short of expectations, that of petrol, Diesel oil and fuel oil surpassed them.

The Council's projections show that by 1967 consumption of crude petroleum for refining purposes will probably reach about 445,000 barrels per working day, or approximately 402,500 barrels per calendar day. Given the same rate of growth as that adopted by the National Petroleum Council, Brazil's consumption of crude oil in 1970 should be in the neighbourhood of 460,000 barrels per calendar day.

So high a figure throws some doubt on whether it can reasonably be assumed that linear growth of crude oil consumption will continue throughout the next decade. The vigorous impetus acquired by Brazil's industrial development in recent years will necessarily play a decisive part in the maintenance of the rapid growth rate of consumption of petroleum and its derivatives. Special contributory factors will be such outstanding developments as the opening-up and paving of thousands of kilometres of highways linking up hitherto isolated parts of the country; the creation of a motor vehicle industry which will shortly be putting into circulation as many as 200,000 new vehicles yearly,[5] and the expansion of the chemical processing, cement and metallurgical (rolled and forged products) industries, which account for a substantial proportion of fuel oil consumption.

But on the other hand, given the purpose for which crude oil consumption estimates are to be used in the present study, it would seem advisable to adopt a slightly more conservative assumption, namely that the growth of consumption will slacken from 1964 onwards. Two factors might help to determine such a trend. In the first place, by about 1963-64 most of the large scale electric power projects will have entered operation, thus releasing from service the emergency Diesel and thermal plants, which are heavy consumers of Diesel and fuel oil. Secondly, there is a possibility that consumption of petroleum derivatives may contract in consequence of an appreciable rise in their prices brought about by the exchange adjustment put into effect recently.

Thus, as from 1964, the average rate of increase of crude oil consumption would be 3.3 per cent per annum, instead of the rate of 7.3 per cent adopted in the National Petroleum Council's forecast. According to this conservative estimate, consumption in 1967 would be about 10 per cent below the Council's projected figure. It should be noted that so moderate an estimate would probably not be tenable for a longer term, in view of the special circumstances obtaining during the period under consideration.

The forecast of demand for equipment, even on the assumption that Brazil continued its present policy of having its own refineries handle enough crude oil to satisfy total consumption, would still seem to be fairly realistic.

Table 3 gives the estimates of consumption up to 1970 obtained by using the projections of the National Petroleum Council and modifying them as from 1964.

TABLE 3. BRAZIL: PROJECTION OF CONSUMPTION OF PETROLEUM AND DERIVATIVES, 1964, 1967 AND 1970
(*BPCD*)

Petroleum and derivatives	*1961*	*1964*	*1967*	*1970*
Crude	280,000	325,000	360,000	390,000
Petrol[a]	78,000	90,500	102,000	110,500
Diesel oil	53,000	64,000	72,000	76,000
Fuel oil	84,000	95,200	104,000	111,000

[a] A and B petrol.

[5] Owing to the existence of carry-over requirements, almost the whole of Brazil's motor vehicle output at present represents a net increase in the vehicle park, with substitution on an extremely limited scale. This will probably continue to be the case for the next few years.

(b) *Refining capacity*

Brazil's refining capacity at 31 December 1960 amounted to 184,000 barrels per day (BPD).[6] The expansions under way and the entry into operation of a large new unit (Duque de Caxias refinery) should raise this capacity to 311,000 BPD by the end of 1962 (for further details, see table 4).

TABLE 4. BRAZIL: CRUDE OIL REFINING CAPACITY, 1960 AND 1962 (*BPD*)

PETROBRAS refineries	*1960*	*End of 1962*
Presidente Bernardes (Cubatão)	95,000	110,000[a]
Landulfo Alves (Mataripe)	30,000	52,000
Duque de Caxias (Rio de Janeiro)....	—	90,000
Refineries based on private capital:		
Petróleo da Amazonia (Manaus)..	6,000	6,000
Manguinhos (Guanabara)	10,000	10,000
União (Capuava)	32,000	32,000
Matarazzo (São Paulo)	1,000	1,000
Ipiranga (Rio Grande do Sul)	10,000	10,000
TOTAL	184,000	311,000

[a] Expansion already programmed and under way.

As regards the situation in 1962, a comparison of the capacity which will be available then with the estimated demand suggests that there will probably be surplus refining capacity amounting to some 16,000 BPD.[7] In all likelihood, however, this surplus will be quickly absorbed by the growth of consumption during 1963 and 1964; and thenceforward, available production capacity will not suffice to meet consumer requirements. It must therefore be ascertained what expansion or new construction projects would be justifiable, with a view to the placing of orders with the domestic petroleum equipment industry.

As the normal development of crude oil processing in the big PETROBRAS refineries, especially that of Duque de Caxias (whose projected nominal capacity is 90,000 BPD), warrants the supposition that output of refined products will exceed the rated capacity referred to above, it may be assumed that demand will perhaps be satisfied up to 1963 (when it will have reached 335,000 BPCD). After that date, a new refinery would have to be constructed with a rated capacity of 30,000-40,000 BPD. For this to enter production in 1969-70, the engineering would have to be begun in 1965, and the contracts for the purchase of equipment negotiated in 1965-66.

Even so, there would probably still be a deficit in 1970. The difference between a consumption figure of about 390,000 BPCD and a refining capacity of 341,000-351,000 BPD might, however, be covered by the output of the plant for extracting petrol from the natural gases of the Recôncavo (Bahia) oilfields (a project which is discussed later, together with those relating to the petrochemical industries), and perhaps in addition by such minor expansion programmes as might be authorized in private refineries. For the latter projects no very large orders for equipment would be needed, and they will therefore not be taken into account in the present study.

[6] Barrels per day—rated capacity.

[7] Capacity as of that date is estimated at 311,000 BPD, and consumption, in accordance with the projection adopted, at 295,000 BPCD.

Accordingly, as regards the refineries sector, for the purposes of the present paper only the equipment for the following projects will be computed:

(i) Expansion of the Presidente Bernardes refinery (Cubatão), where the engineering has been virtually completed, and a start is about to be made on the process of buying equipment;

(ii) Construction of a new refinery with a capacity of 30,000-40,000 BPD at a site to be decided upon in due course.

(c) *Oil pipelines and terminals*

For the transport of petroleum derivatives from the areas in which they are produced to the new consumer centres created by industrial development, the following three oil pipeline terminals will presumably have to be constructed, once the PETROBRAS Terminal da Guanabara (TEGUA), which will serve the Duque de Caxias refinery, has been completed:

(i) São Sebastião/São Paulo oil pipeline terminal;

(ii) Ilhéus terminal;

(iii) Rio/Belo Horizonte pipeline and terminal.

(d) *Petrochemical industries*

From the outset, PETROBRAS contemplated the installation of a synthetic rubber factory which would utilize the gas from the Duque de Caxias refinery. The construction of this plant was projected in three successive stages, for the production of copolymer, butadiene and styrene, respectively.

In the first stage, the plant for which is at present being assembled with a view to starting production in September 1961, the end product, copolymer—GRS—will be manufactured on the basis of imported constituents (butadiene and styrene).

The plant installed in the second and third stages will only be able to enter production when all the units of the Duque de Caxias refinery are in full operation. This will probably be in mid-1962, so that the construction of the butadiene and styrene units of the synthetic rubber factory must be regarded as falling within the investment programmes with which the present study is concerned.

As projected synthetic rubber consumption exceeds PETROBRAS' production possibilities, and as the other available source of ethylene[8] might be ethyl alcohol obtained from sugar cane, the Development Plan for the North-East contemplates the use of alcohol surpluses for conversion into rubber and certain plastic materials. The present study therefore includes two factories for which the blueprints have already been approved and will probably soon be in process of execution. These are the Pernambuco synthetic rubber factory (COPERBO) and PLASTIBRAS (a private capital group).

To improve the efficiency of operations in the Recôncavo (Bahia) oilfields—the only region of Brazil where petroleum is produced at present—plans are afoot to utilize the natural gases from the wells, extracting petrol and LPG, and then reinjecting them into the subsoil. Furthermore, the Landulfo Alves re-

[8] Ethylene is the basic raw material for synthetic rubber.

finery (Mataripe-Bahia) might be able to supply gases that could be turned to account in a petrochemical group in that part of the country. A preliminary survey to assess these production possibilities points to various industries whose equipment for the corresponding processes forms a single group related to the utilization of gases. Accordingly, the following industrial units will be comprised in the present study:

(i) Second and third stages (butadiene and styrene) of the PETROBRAS synthetic rubber factory (FABOR), which is already programmed and for which the preliminary projects have been prepared;

(ii) Utilization of the natural gases from the Recôncavo (Bahia) oilfields and of the gas surpluses from the Landulfo Alves refinery (Mataripe);

(iii) The Pernambuco synthetic rubber factory (COPERBO), for which the project has already been completed and the purchasing of equipment is due to begin shortly;

(iv) Construction of various factories based on private capital, in the areas indicated above and also in Recife (PLASTIBRAS), the initial stages of the work being already under way in some cases.

In this instance, the assessment of equipment requirements will be based not on a meticulous analysis of the characteristics of each undertaking but on a general estimate grounded mainly on the aggregate supplies of raw material (natural gas) available for transformation.

It is generally believed that the units discussed here in connexion with the refining and transport of petroleum and with the petrochemical industries would be justifiable and in all probability successful ventures. Should some projects be modified by force of circumstances, the change may not make any radical difference to the present study, since the values they represent must be considered only in terms of their approximate magnitude as an indication of the potential market for the equipment concerned.

2. Equipment for the petroleum and petrochemical industries programme

As was previously shown, a petroleum-refining programme based on the hypothesis of self-sufficiency as regards supplies of refined products implies the need to expand the capacity of the Presidente Bernardes refinery from 95,000 to 110,000 BPD—a measure which is in fact on the point of being carried out—and to construct a new refinery with a capacity of 30,000-40,000 BPD; while, in addition, transport by means of the oil pipelines mentioned, the construction of the second and third stages of the PETROBRAS synthetic rubber factory, the utilization of the natural gases of the Recôncavo (Bahia) oilfields, and the promotion of the use of ethyl alcohol surpluses under the Development Plan for the North-East, must determine the probable demand for equipment as broken down in table 5.

Table 5. Brazil: investment envisaged in equipment for petroleum refineries, oil pipelines and the petrochemical industries, 1961-70

(*Thousands of dollars*)

Type of equipment	*Refineries*	*Oil pipelines*	*Petrochemical industries*	*Total*
1. Storage tanks, including LPG[a] tanks and spheres	4,126	3,201	5,859	12,285
2. Pressure vessels: towers and pressure storage	3,774	—	5,546	9,320
3. Heat exchangers and surface condensers	3,208	944	5,443	9,595
4. Steam generators	842	490	2,082	3,414
5. Pumps and compressors	4,311	5,382	5,540	15,233
6. Turbo-generators	4,780	—	6,650	11,430
7. Direct furnaces (firing)	2,954	—	2,788	5,741
8. Electrical equipment—motors and transformers	1,394	3,542	10,250	15,186
Switches	446	1,135	631	2,212
Wires and cables	922	2,359	1,304	4,585
Electricity ducts	248	630	348	1,225
9. Steam turbines	510	—	900	1,410
10. Metal structures	984	425	1,089	2,498
11. Tubes and tubing (steel and cast iron)	2,123	21,287	2,522	25,931
Connexions	500	3,845	710	4,954
Valves	798	3,739	961	5,499
12. Welded tubes (large diameter)	108	—	169	276
13. Cyclones	83	—	124	207
14. Special instruments and valves	1,070	85	1,400	2,555
15. Special ejectors and filters	118	—	232	350
16. Travelling cranes, lifts and lifting tackle	74	156	254	485
17. Expansion joints	135	—	181	316
18. Mixers	98	—	541	639
19. Refractories and thermal insulation	427	663	604	1,693
Total	34,133	47,883	56,125	138,142

[a] Liquid petroleum gas.

TABLE 6. BRAZIL: DOMESTIC PRODUCTION (CRUZEIROS) AND IMPORTS (DOLLARS) MAKING UP THE INVESTMENT ENVISAGED IN EQUIPMENT FOR PETROLEUM REFINERIES, OIL PIPELINES AND THE PETROCHEMICAL INDUSTRIES, 1961-70

(Thousands of cruzeiros or thousands of dollars)

Type of equipment	Refineries			Oil pipelines				Petrochemical industries					
	Presidente Bernardes	Nova (30,000-40,000 BPD)	Total	São Sebastião-São Paulo terminal	Ilhéus terminal	Rio-Belo Horizonte terminal	Total	Fabor, second and third stages	Utilization of gases (Bahia)	Private industries	Pernambuco synthetic rubber plant	Total	Grand total for all equipment
1. Storage tanks, including LPG tanks and spheres													
Cruzeiros	470,000	320,000	790,000	260,000	16,300	326,000	602,300	354,000	118,000	175,000	450,000	1,097,000	2,489,300
Dollars	80	30	110	20	5	40	65	40	15	20	70	145	320
2. Pressure vessels: towers and pressure storage													
Cruzeiros	210,000	146,000	356,000	—	—	—	—	228,000	65,000	95,000	120,000	508,000	864,000
Dollars	1,100	820	1,920	—	—	—	—	1,400	300	400	800	2,900	4,820
3. Heat exchangers and surface condensers													
Cruzeiros	330,000	286,000	616,000	110,000	7,300	64,000	181,300	495,000	110,000	160,000	280,000	1,045,000	1,842,300
Dollars	—	—	—	—	—	—	—	—	—	—	—	—	—
4. Steam generators													
Cruzeiros	65,000	41,000	106,000	60,000	3,100	31,000	94,100	60,000	13,800	28,000	130,000	231,800	431,900
Dollars	170	120	290	—	—	—	—	250	55	70	500	875	1,165
5. Pumps and compressors													
Cruzeiros	187,000	132,000	319,000	260,000	22,000	110,000	392,000	110,000	55,000	83,000	185,000	433,000	1,144,000
Dollars	1,550	1,100	2,650	2,300	40	1,000	3,340	1,300	600	85	1,300	3,285	9,275
6. Turbo-generators													
Cruzeiros	—	—	—	—	—	—	—	—	—	—	—	—	—
Dollars	2,500	2,280	4,780	—	—	—	—	2,200	850	1,100	2,500	6,650	11,430
7. Direct furnaces (fired)													
Cruzeiros	152,000	106,000	258,000	—	—	—	—	48,000	32,000	48,000	100,000	228,000	486,000
Dollars	950	660	1,610	—	—	—	—	300	200	300	800	1,600	3,210
8. Electrical equipment—motors and transformers													
Cruzeiros	71,500	54,000	125,500	116,500	90,000	114,000	320,500	520,000	238,000	350,000	660,000	1,768,000	2,214,000
Dollars	420	320	740	686	532	655	1,873	307	140	205	390	1,042	3,655
Switches													
Cruzeiros	11,300	8,500	19,800	18,500	14,500	17,800	50,800	8,250	3,750	5,500	10,500	28,000	98,600
Dollars	195	148	343	318	246	306	870	145	65	95	180	485	1,698
Wires and cables													
Cruzeiros	100,000	77,000	177,000	165,000	129,000	159,000	453,000	74,000	33,800	48,750	93,750	250,300	880,300
Dollars	—	—	—	—	—	—	—	—	—	—	—	—	—
Electricity ducts													

Dollars	330	180	510	—	—	—	—	250	80	120	450	900	1,410
10. Metal structures													
Cruzeiros	112,000	77,000	189,000	48,000	1,600	32,000	81,600	48,000	25,000	36,000	100,000	209,000	479,600
Dollars	—	—	—	—	—	—	—	—	—	—	—	—	—
11. Tubes and tubing (steel and cast iron													
Cruzeiros	81,000	76,000	157,000	990,000	24,400	2,800,000	3,814,400	27,000	27,000	34,000	112,000	200,000	4,171,400
Dollars	650	655	1,305	500	20	900	1,420	200	200	280	800	1,480	4,205
Connexions													
Cruzeiros	24,000	24,000	48,000	60,000	5,000	150,000	215,000	10,000	12,000	18,000	30,000	70,000	333,000
Dollars	130	120	250	700	25	2,000	2,725	50	60	85	150	345	3,320
Valves													
Cruzeiros	44,000	29,000	73,000	176,000	13,200	450,000	639,200	15,400	13,200	20,000	40,000	88,600	800,800
Dollars	250	168	418	100	10	300	410	80	70	100	250	500	1,328
12. Welded tubes (large diameter)													
Cruzeiros	20,000	720	20,720	—	—	—	—	720	4,100	6,000	21,600	32,420	53,140
Dollars	—	—	—	—	—	—	—	—	—	—	—	—	—
13. Cyclones													
Cruzeiros	15,000	890	15,890	—	—	—	—	890	2,960	4,350	15,600	23,800	39,690
Dollars	—	—	—	—	—	—	—	—	—	—	—	—	—
14. Special instruments and valves													
Cruzeiros	—	—	—	—	—	—	—	—	—	—	—	—	—
Dollars	650	420	1,070	35	—	50	85	250	200	300	650	1,400	2,555
15. Special ejectors and filters													
Cruzeiros	—	—	—	—	—	—	—	—	—	—	—	—	—
Dollars	70	48	118	—	—	—	—	50	25	37	120	232	350
16. Travelling cranes, lifts and lifting tackle													
Cruzeiros	8,500	5,800	14,300	19,000	950	10,000	29,950	3,800	8,000	12,000	25,000	48,800	93,050
Dollars	—	—	—	—	—	—	—	—	—	—	—	—	—
17. Expansion joints													
Cruzeiros	20,000	6,000	26,000	—	—	—	—	2,000	1,500	3,000	10,000	16,500	42,500
Dollars	—	—	—	—	—	—	—	40	5	—	50	95	95
18. Mixers													
Cruzeiros	8,600	10,300	18,900	—	—	—	—	6,900	12,000	18,000	65,000	101,900	120,800
Dollars	—	—	—	—	—	—	—	10	—	—	—	10	10
19. Refractories and thermal insulation													
Cruzeiros	21,600	15,100	36,700	45,000	2,200	80,000	127,200	9,000	14,500	24,000	30,000	77,500	241,400
Dollars	140	96	236	—	—	—	—	100	20	—	80	200	436
TOTAL													
Cruzeiros	1,978,500	1,435,830	3,414,330	2,372,280	363,750	4,386,300	7,122,330	2,040,580	798,610	1,181,740	2,503,450	6,524,380	17,061,040
Dollars	9,185	7,165	16,350	4,659	878	5,251	10,788	6,972	2,885	3,197	9,090	22,144	49,282

In brief, this demand should work out as follows:

	Dollars
For refineries	34,133,000
For oil pipelines	47,883,000
For the petrochemical industries	56,125,000
TOTAL	138,141,000

The volume of each type of equipment in any given plant will be greater or smaller according to the project and the type of goods produced. However, as the present study is in the nature of a preliminary estimate, this percentage variation does not exceed reasonably narrow and acceptable limits. Furthermore, owing to the diversity of the units to be constructed, the margin of error deriving from the estimate will be in some measure compensated.

It is of interest to note that investment in refineries represents the smallest item, thanks to the installed capacity already in existence as a result of the sustained effort made by PETROBRAS during the last five years. The next task is to utilize the by-products of the refining operation and to promote the expansion of the plastics and synthetic rubber industry.

3. DOMESTIC PRODUCTION OF EQUIPMENT

(a) *Possibilities for domestic production*

In recent years a high proportion of total requirements of equipment for petroleum refineries and the petrochemical industries has been supplied by domestic production. This has been achieved by a combination of efforts on the part of the enterprises potentially capable of working in this sector, crystallized in the organization known as the Brazilian Association for the Development of Basic Industry (ABDIB).

A detailed analysis of the nature and working methods of this body is given elsewhere in the present study. The figures given below relate mainly to achievements to date. In the present state of Brazil's metal-transforming industry, the following average percentages of the required production are attainable by domestic industry for the principal types of equipment, grouped under nineteen headings, by type, an average standard specification being assumed:

	Percentage
1. Storage tanks (with conical or floating roofs, cylindrical or spherical, for gas)	98 to 100
2. Pressure vessels (towers and pressure storage)	60 to 70
3. Heat exchangers and surface condensers	100
4. Steam generators	60 to 70
5. Pumps and compressors	25 to 35
6. Turbo-generators	Nil
7. Furnaces (direct-firing)	45 to 55
8. Electrical equipment (all types)	65 to 75
9. Steam turbines	Nil
10. Metal structures	100
11. Tubes (all types)	70 to 80
12. Welded tubes (large diameter)	100
13. Cyclones	100
14. Special instruments and valves	Nil
15. Special ejectors and filters	Nil
16. Travelling cranes, lifts, and lifting tackle	100
17. Expansion joints	60 to 100
18. Mixers	100
19. Refractory materials and thermal insulation	75 to 80

It should be explained that the percentage of domestic production is taken as applied to the total amount of equipment of each type to be found in a traditional refinery or petrochemical industry. Refractory materials and thermal insulation are also included because they are clearly defined items, and the total investment they represent justifies listing them separately.

Taking these domestic production percentages as a basis, together with the equipment needs under each heading listed in the ten-year programme referred to in table 5, an estimate was made of the equipment in each category that can be produced in Brazil. The results of this estimate are shown in table 6. The values given there for domestic manufacture represent the current prices of such equipment, or similar heavy equipment, in Brazil in October-November 1960. The values in dollars represent the prices of the equipment f.o.b. United States. The situation indicated in table 6 for the 1961-70 programme of investment in petroleum refineries, terminals and pipelines, and the petrochemical industries, is summarized in table 7.

The dollar value of domestically-produced equipment is based on the conversion value of the dollar for each type of equipment, i.e. on the relation between the prices of Brazilian and United States goods for each type, as indicated by the most recent production of the Brazilian heavy metal-transforming industry. The results of this comparison are described and analysed elsewhere in this section. The average value, for all equipment taken together, is 192 cruzeiros to the dollar.

(b) *Evaluation of production capacity*

The comparison between the requirements in the way of equipment of various kinds and the possibilities for producing it in the country must be made from two standpoints, namely, the productive capacity of the

TABLE 7. BRAZIL: DOMESTIC AND IMPORTED EQUIPMENT FOR THE 1961-70 PROGRAMME

	Relative investment				
			Domestic equipment		
Equipment	*Total equipment (millions of dollars)*	*Imported equipment (millions of dollars)*	*Millions of cruzeiros*	*Dollar equivalent in millions*	*Percentage of total*
Refineries	34.13	16.35	3,415	17.78	52.1
Terminals and oil pipelines	47.89	10.79	7,120	37.10	77.5
Petrochemical industries	56.12	22.14	6,525	33.98	60.5
TOTAL	138.14	49.28	17,060	88.86	64.2

manufacturers of each type of equipment in present circumstances, and the prospects of a progressive expansion of the proportion of items produced domestically.

As previously stated, there are no manufacturers in Brazil who specialize exclusively in the manufacture of petroleum equipment. Such equipment is produced by metal-transforming and metallurgical firms whose production facilities and technical experience enable them, on the basis of engineering know-how from abroad, to devote a portion of their activity to the production of petroleum equipment, in so far as there is a demand for it. At the same time these firms produce equipment (either complete, or more commonly on a partial basis under sub-contract) for other industries. This practice of engaging in diverse activities makes it extremely difficult to assess the capacity to manufacture equipment of a single one of the various types produced. Existing capacity may be sufficient for some petroleum equipment, but prove insufficient to produce all the equipment required for that and the other sectors included in the present study, and for the varied market demand for boiler work, machinery in general, etc. Thus the comparison between requirements and capacity undertaken in this study can only be fully understood when the requirements of the various sectors are considered as a whole. A comparison of this nature, which is by no means easy, is undertaken tentatively in the last section.

In surveying capacity to manufacture equipment for petroleum refineries and the petrochemical industries, the main producers of equipment were considered, in the light of the special field of each firm and their technical qualifications in relation to the required construction standards. The information given below on these points is based on the experience gained by ABDIB since 1956, as the outcome of continuous activity in this field. The data relate to the situation in October-November 1960.

In arriving at an estimate of available capacity, a number of factors were taken into account which led to the introduction of substantial corrections in the rated productive capacity reported by the firms. This correction was usually downwards (that is, the corrected value of the rated capacity was lower), but in some cases there were good grounds for raising the capacity reported.

For the purposes of this study, equipment was grouped together according to the various mechanical construction characteristics, as follows:

Boiler making. Equipment using sheet steel, welded, which may also include structural shapes, tubes and castings. This group includes: storage tanks; pressure vessels (towers and pressure storage); heat exchangers and surface condensers; steam generators; furnaces (direct-firing, upright); large-diameter welded tubes; cyclones; expansion joints.

Heavy metal work. Equipment using steel structural shapes, welded, riveted or screwed, which may also include sheet steel, tubes and casting. This group includes: metal structures; furnaces (direct-firing, horizontal box type).

Machinery. Equipment using any raw material where machine-finishing operations constitute a vital element in producing the equipment. As such equipment includes various special types, each of the types listed below was examined separately: pumps and compressors; steam turbines; tubing connexions; tubing valves; travelling cranes, lifts and lifting tackle; mixers.

Electrical equipment. Equipment using conducting materials involving large-scale machine-finishing and including electrical windings. This group includes: motors and transformers; switches; generators (coupled to turbines; turbo-generators).

Semi-manufactured equipment. Products which may constitute the raw materials for the manufacture of equipment, but which in the meantime are acquired and used as they stand for plant assembly (refineries, petrochemical plants or oil pipeline production plants): electric wires and cables; electricity ducts; steel and cast iron tubes; refractory materials and thermal insulation; castings and forgings.

Special materials. Products that by reason of their construction characteristics call for highly specialized work involving special design and production techniques: special instruments and valves; special ejectors and filters.

It should be stressed that the development of the production of raw materials and semi-manufactured materials is of paramount importance in ensuring the desired technical development, since this production constitutes the regular and essential source of supply of the equipment industries.

This subject will be dealt with again at the end of the present section and will be considered in greater detail in section VII, since it is possible for the same type of equipment to be used in several different industrial fields. Consumption must therefore be calculated in all fields, and it may thus be possible to establish the fact that there is a total market large enough to justify domestic production.

The normal tendency in the consumer market is to attempt to obtain equipment in the country, provided that it fully meets the necessary technical specifications. The reason is that the need for a chemical processing firm to operate continuously creates special conditions for the maintenance of the plant which are more easily dealt with if the equipment is supplied locally and the plant's own facilities can be called on. Moreover, because of the difficulties attendant on importing, equipment manufactured abroad takes longer to obtain, especially in the case of spare parts, and consequently the plant is obliged to keep a much larger stock of the main spare parts, which ties up its capital.

(c) *Limitations on domestic production*

When equipment requirements for refineries, oil pipelines and terminals, and the petrochemical industries, are compared with the possibilities of domestic manufacture of such equipment, two kinds of limiting factors are perceived, one quantitative, the other technical.

TABLE 8. BRAZIL: ESTIMATED QUANTUM OF EQUIPMENT IN RELATION TO INVESTMENT ENVISAGED IN REFINERIES, OIL PIPELINES AND THE PETROCHEMICAL INDUSTRIES, 1961-70

	Storage tanks	*Pressure vessels: towers and pressure storage*	*Heat exchangers and surface condensers*	*Cyclones, receiving tanks etc.*	*Large-diameter tubes*	*Steam generators and direct-fired furnaces (upright)*	*Metal structures and direct-fired furnaces (horizontal)*
Refineries:							
Presidente Bernardes							
Thousands of cruzeiros	470,000	210,000	330,000	15,000	20,000	65,000	264,000
Tons	18,800	1,500	860	130	280	295	3,100
Nova (30,000-40,000 BPD)							
Thousands of cruzeiros	320,000	146,000	286,000	890	720	41,000	183,000
Tons	7,100	1,000	740	7	10	186	2,160
TOTAL							
Thousands of cruzeiros	790,000	356,000	616,000	15,890	20,720	106,000	447,000
Tons	17,900	2,500	1,600	137	290	471	5,260
			32,200m²				
Oil pipelines:							
São Sebastião-São Paulo terminal							
Thousands of cruzeiros	260,000		110,000			60,000	48,000
Tons	5,800		285			275	600
Ilheus terminal							
Thousands of cruzeiros	16,300		7,300			3,100	1,600
Tons	360		19			14	20
Río-Belo Horizonte terminal							
Thousands of cruzeiros	326,000		64,000			31,000	32,000
Tons	7,200		166			140	400
TOTAL							
Thousands of cruzeiros	602,300	—	181,300	—	—	94,000	81,600
Tons	13,360		470			429	1,020
			13,000m²				
Petrochemical industries:							
FABOR, second and third stages							
Thousands of cruzeiros	354,000	228,000	495,000	890	720	60,000	96,000
Tons	7,900	1,600	900	7	10	275	1,130
Fertilizantes Bahía							
Thousands of cruzeiros	118,000	65,000	110,000	2,960	4,100	13,800	57,000
Tons	2,600	460	220	26	57	64	670
Private industries							
Thousands of cruzeiros	175,000	95,000	160,000	4,350	6,000	28,000	84,000
Tons	3,900	680	320	37	84	128	980
Pernambuco synthetic rubber plant							
Thousands of cruzeiros	450,000	120,000	280,000	15,600	21,600	130,000	200,000
Tons	10,000	850	560	138	302	590	2,350
TOTAL							
Thousands of cruzeiros	1,097,000	508,000	1,045,000	23,800	32,420	231,800	437,000
Tons	24,400	3,500	2,100	208	435	1,057	5,130
			52,500m²				
GRAND TOTAL							
Thousands of cruzeiros	2,489,300	864,000	1,842,300	39,690	53,140	431,900	965,600
Tons	55,660	6,090	4,170	345	743	1,957	11,410
			100,700m²				

As regards the first, the heavy metal-transforming industry, although adequately equipped technically, does not have at its disposal the total productive capacity needed to meet the large volume of orders resulting from the ten-year programme.

The technical limitations on the possibilities of domestic production are due to the need to employ processes or machinery not available to domestic industry, and beyond its technological capacity. This second limiting factor, however, is due in most cases almost entirely to the size of the market, and the situation is aggravated by the variety of specifications used by project engineers.

The size of the market is the principal limiting factor; current industrial development in Brazil has revealed a surprising ability to absorb technological improvements once the length of the production series justifies the effort of adaptation and the investment involved. In other words, the technological limitation is essentially a limitation caused by the size of the market.

The comparison between the petroleum refinery investment programme and the possibilities of Brazil's heavy metal-transforming industry was made for each of the six groups of equipment listed above (according to the nature of their production), and gave the results summarized below:

Group	*Limiting factors*
Boiler making	Certain technical features, and volume of production
Heavy metal work	Volume of production only
Machinery	Mainly technical production features
Electrical equipment	Technical production features, in particular for want of a market to support the necessary development
Semi-manufactured equipment ...	Volume of production only for some items and technical features only for others
Special equipment	Technical production features, exclusively.

Consequently the equipment in the first two groups, boiler making and heavy metal work, is a possible source of difficulty in executing the investment programme, because orders for these items will be very large compared with the existing capacity of the industry, and thus a more detailed study of the outlook in this field is required. On the other hand, the equipment in the last four groups, namely machinery, electrical equipment, semi-manufactured equipment and various special equipment, may be regarded as raising no vital problem, since each of them represents only a very small portion of the total value of the equipment in any given installation. In many cases the technical characteristics are too specialized to permit local manufacture, considering the size of the consumer market in the next ten years.

A particularly careful analysis was made of the situation of Brazil's heavy metal-transforming industry in relation to the boiler work and heavy metal work required by the ten-year programme for petroleum refining and the petrochemical industries. It seems possible that with respect to operations in these two categories there may prove to be some quantitative limitation on the productive capacity of domestic industry. A comparison between requirements and productive capacity for these two categories of equipment, which may be subdivided into eleven types, is given below. Equipment for refineries and the petrochemical industries produced by these two branches of the industry, in terms of the annual average requirements for 1961-70 for the specific projects planned, is expressed in tons and in square metres of area heated, as appropriate. The results of the calculation are given in table 8, and summarized in table 9.

TABLE 9. BRAZIL: ANNUAL REQUIREMENTS OF BOILER MAKING AND HEAVY METALWORK EQUIPMENT

Equipment	*Refineries*	*Pipelines and terminals*	*Petrochemical industries*	*Total*
Storage tanks (tons)	17,900	13,360	24,400	55,660
Pressure vessels; cyclones; large-diameter tubes; expansion joints (tons)	2,927	—	4,251	7,178
Heat exchangers; surface condensers (sq. m. of heating surface)	35,200	13,000	52,500	100,700
Steam generators; direct-fired furnaces (upright) (sq. m. of heating surface)	8,200	7,400	16,000	31,600
Metal structures: direct-fired furnaces (horizontal) (tons)	5,260	1,020	5,130	11,410

For purposes of comparison with the requirements indicated in table 9, use was made of the results of the survey of productive capacity for the same eleven types of equipment represented by the eighteen principal Brazilian producers of such equipment, who account for 60 to 70 per cent of the total productive capacity. The results of the survey are given in table 10, in terms of rated capacity on the basis of a single working shift (that is, a 48-hour week). The results are summarized in table 11 on page 19.

The comparison between requirements and productive capacity, with respect to equipment for refineries and the petrochemical industry under the ten-year programme, i.e. essentially boiler work and heavy metal work products, shows that there is only likely to be a considerable short-fall in a few types of equipment, such as storage tanks, heat exchangers and surface condensers. The discrepancy between requirements and productive capacity is not substantial enough to justify any hasty conclusion that a bottleneck is likely to form, since on the one hand the survey of productive capacity relates to the existing situation, and does not take account of future plant expansion in the heavy metal-transforming industry during the course of the decade in question, or of other possible developments which may substantially affect such a conclusion. These possible developments, which are bound up with the clear trend towards a more rational organization of operations in Brazil's heavy metal-transforming industry, are:

(i) The planning of production within work schedules that have been carefully prepared and staggered to prevent the unnecessary accumulation of orders during certain periods;

(ii) A planning study in which due account is taken of the time required to obtain domestic or imported raw materials (for further details in this respect see the final part of this section);

(iii) The rational use of machinery, available space and ancillary industrial plant by each manufacturer in order to prevent complementary orders from piling up (balanced programming);

(iv) A clear-cut scheme of guaranteed payments, drawn up in accordance with financing requirements for equipment production;

(v) Constant and strict inspection, which should

TABLE 10. BRAZIL: ESTIMATED ANNUAL PRODUCTION CAPACITY OF THE MAIN BRAZILIAN MANUFACTURERS OF EQUIPMENT FOR THE PETROLEUM AND PETROCHEMICAL INDUSTRIES, 1960

Manufacturer	Storage tanks (tons per year)	Pressure vessels, cyclones, large-diameter tubes, expansion joints[a] (tons per year)			Heat exchangers (heating surface per year)	Surface condensers (heating surface per year)	Steam generators and direct-fired furnaces[a] (upright) (heating surface per year)			Metal structures and direct-fired furnaces (horizontal) (tons per year)
		Up to 5 tons	5–25 tons	Over 25 tons			Up to 50 lb. psig[b]	Up to 200 lb. psig[b]	Over 200 lb. psig[b]	
Mec. Pesada		800	1,000	1,200	5,000m²	10,000m²				3,500
DEDINI		550	750	800			4,000m²	12,000m²	15,000m²	
IBESA	10,000	2,000	1,500	1,500						1,000
Fichet & Schwartz-Haumont	10,000									10,000
Cia. Bras. Construçoes		360	430	540	9,000m²	7,000m²	5,000m²	15,000m²	20,000m²	
Babcock & Wilcox		650	800	850			6,500m²	20,000m²	25,000m²	
ARMCO	10,000									
COBRASMA		250	250		20,000m²	10,000m²				
EBSE	4,500									
Fab. Nac. de Vagoes										5,000
Santa Matilde										5,000
Mecanica Jaragua		300	700	500	1,000m²					1,000
NORDON	500	200	200		500m²					1,000
Sanson Vasconcellos	10,000	400	500	700						1,500
Cia. Siderurgica Nacional										12,000
Edimetal										5,000
Uniao Const. Metalicos										5,000
Const. Metalica Nacional										3,500
TOTAL	45,000	5,510	5,930	5,090	35,500m²	27,000m²	15,500m²	47,000m²	60,000m²	53,500
Raw material	A7/A283		A283/ A285/ A201/ A212/A2		A285/A201/ A212/A214/ B111/B171	A285/A283/ A201/A214/ B111/B171	A201/A212/A83/A7			A7/A283

Estimated consumption of raw materials (tons per year)	
1. Storage tanks	45,000
Sheet steel	40,000
Structural steel shapes	5,000
2. Pressure vessels, cyclones, large-diameter tubes and expansion joints (average 5,500 tons per year):	
Sheet steel	6,000
Structural steel shapes	550
3. Heat exchangers and surface condensers (52,500 sq. m. of heating surface per year):	
Sheet steel	850
Steel tubes	600
Non-ferrous sheet	150
Non-ferrous tubes	300
Castings and forgings	300
4. Steam generators and direct-fired furnaces (upright) (average 41,000 sq. m. of heating surface per year):	
Sheet steel	1,200
Steel tubes	1,000
Structural steel shapes	500
5. Metal structures and direct-fired furnaces (horizontal) (53,500 tons per year):	
Structural steel shapes	52,000
Sheet steel	5,500
Steel tubes	1,500
TOTAL	
Sheet steel	53,550
Structural steel shapes	58,050
Steel tubes	3,100
Non-ferrous sheet	150
Non-ferrous tubes	300
Forgings and castings	300

NOTE: Principal raw material used and liable to become a suppiy problem (ASTM specification):

Carbon steel sheet ASTM A7, A201, A212, A283, A285.
Alloy steel sheet ASTM A203, A240, A263, A264, A300, A301, A353, A357.
Carbon steel tubes ASTM A83, A179, A192, A214, A226.
Alloy steel tubes ASTM A199, A200, A209, A213, A249.
Non-ferrous sheet ASTM B169, B171.
Non-ferrous tubes ASTM B111.
Structural steel shapes ASTM A7.
Carbon steel pipes ASTM A53, A106, A135, A211.
Steel forgings and castings ASTM A95, A216, A351, A105, A181, A182.
Non-ferrous castings and forgings ASTM B61, B124, B150.
Cast iron ASTM A126, A278, A339.

[a] The estimates of production of pressure vessels, cylcones, tubes and expansion joints, and of steam generators and direct-fired furnaces, are not cumulative.
[b] Per square inch gauge.

be carried out rapidly in order to prevent delivery delays causing congestion in the plants.

On the assumption that there is no possibility of or justification for implementing all the projects simultaneously, and that the heavy metal-transforming industry will undergo a normal and moderate expansion, it may be concluded, from a comparison of the figures, that there will probably be no particular difficulty in executing the programme so long as the above-mentioned factors are duly taken into consideration.

For the time being, this conclusion is applicable to refineries, oil pipelines and the petrochemical industries only. If, however, the problem is studied in relation to other industrial sectors as well (these being as a rule supplied with equipment by the same manufacturers), it will be possible to modify the existing situation.

TABLE 11. BRAZIL: ANNUAL PRODUCTION CAPACITY FOR BOILERMAKING AND HEAVY METAL WORK EQUIPMENT

Equipment	*Rated capacity*
Storage tanks (tons)	45,000
Pressure vessels; cyclones; large-diameter tubes; expansion joints (tons)	7,000[a]
Heat exchangers	35,000
Surface condensers (sq. m. of heating surface)	27,000
Steam generators; direct-fired furnaces (upright) (sq. m. of heating surface)	41,000[a]
Metal structures; direct-fired furnaces (horizontal box-type) (tons)	53,500

[a] Approximate average value.

With respect to the remaining groups—metal products, electrical equipment, semi-manufactured equipment and miscellaneous special items—the respective equipment was not considered to be a potential source of difficulty because the growth of the domestic consumer market, the normal unplanned expansion of plants and the development of engineering techniques as a result of industrial progress, will bring about gradual import substitution, especially if a successful attempt is made to arouse the interest of the project engineers, whose influence in this respect may be decisive.

Sooner or later the minimum levels that are necessary for the manufacture of such equipment in the country will be reached. Furthermore, if the demand for a specific type of equipment in various branches of industry can be increased, the basic conditions for production will be satisfied and resources will be available to establish the new industry in a shorter space of time.

To illustrate the influence of designing, mention may be made of equipment such as certain kinds of motors, transformers and electric switches, mixers and certain types of ejectors and filters. The construction standards and models adopted in Brazil are unknown to the project engineers; as a result, the lack of conformity between the original specifications and local standards rules out all possibility of utilizing such equipment from the outset.

Another typical example is that of the instruments forming part of main control panels. This item represents a relatively small volume of the investment required to build a refinery. Consequently, it is not always advisable for a panel to be dismantled so that some of the instruments may be acquired separately and subsequently incorporated. Moreover, if the demand for control panels in the iron and steel, electricity, pulp and paper, cement, general chemical and other industries is added up, there will be a large enough market to warrant the establishment of a new industry specializing in this type of equipment. The same may be said of certain types of pumps, compressors, small steam turbines and valves which have not yet found a propitious atmosphere in which to develop.

(d) *Raw materials problems*

The problem of obtaining the necessary raw materials for the implementation of a programme is one that calls for extensive study. Here again, it is necessary to make a detailed analysis of the problem as a whole in order to forecast the supplies required by the different branches of industry.

From an inquiry into the raw materials needed for manufacturing equipment the following may be regarded as the most important items:

	ASTM
Carbon steel sheet	A7 A201 A212 A283 A285
Alloy steel sheet	A203 A240 A263 A264 A300 A301 A353 A357
Carbon steel tubes	A83 A179 A192 A214 A226
Alloy steels tubes	A199 A200 A209 A213 A249
Non-ferrous sheet	B169 B171
Non-ferrous tubes	B111
Structural steel shapes.	A7
Carbon steel pipes	A53 A106 A135 A211 A181
Cast and forged steel	A95 A216 A351 A105
Non-ferrous cast and forged parts	B61 B124 B150
Cast iron	A126 A278 A339

These materials may become a critical problem owing to the difficulty of obtaining them in Brazil, this being due either to the quantities involved or to the fact that the specifications make it hard to produce them locally.

Carbon steel sheet. Although enough is produced in Brazil, demand is sometimes too small to justify a specific order. In such cases, the manufacturers resort to importing. This means a rise in costs, the increase varying with the incidence of the raw material on the final value of the equipment and the factor varying from 75 per cent (tanks) to 15 per cent (heat exchangers); the average for purposes of over-all discussion, may be taken as about 55 per cent. With the development of the iron and steel industry, the problem will be greatly simplified and dependence on imports will probably become negligible.

Alloy steel sheet. This is not produced in Brazil, and its manufacture is not contemplated in the expansion programme for the iron and steel industry during the next few years. Manufacturers will have to import on the basis of a carefully thought-out programme in order to ensure that equipment production will not be affected.

Carbon steel tubes. Welded tubes are manufactured in Brazil. The seamless type (not to be confused with the "pipes" mentioned below) will still have to be imported.

Alloy steel tubes. Similar conditions to those prevailing for alloy steel sheet.

Non-ferrous sheet. Produced in sufficient quantities under satisfactory technical conditions.

Non-ferrous tubes. Produced in sufficient quantities under satisfactory technical conditions.

Structural steel shapes. Produced in sufficient quantities under satisfactory technical conditions.

Carbon steel pipes. Produced in Brazil with a nominal width of 10 inches. Bigger sizes have to be imported for the time being. As this item is in great demand for oil pipelines, provision should be made in development programmes for the iron and steel industry to encourage its manufacture.

Cast and forged steel. Produced in sufficient quantities and under satisfactory technical conditions.

Non-ferrous cast and forged parts. Produced in sufficient quantities and under satisfactory technical conditions.

Imported raw materials are more expensive than the domestically-produced article, partly because of direct tariff protection and partly because of the difficulties of importing which include the process of purchasing foreign exchange, the advance payment of such currency and customs clearance problems.

Consequently, every time a manufacturer has to resort to importing, the cost of equipment rises in proportion to the share of the material in the total value.

(e) *Prices of domestically-produced equipment*

On the whole, the price of petrochemical equipment recently produced in Brazil compare favourably with those of similar equipment manufactured abroad, notably in the United States.

TABLE 12. BRAZIL: PRICE COMPARISON OF DOMESTIC PRODUCTION WITH UNITED STATES PRODUCTION

(*Cruzeiros per dollar*)

Equipment	*Domestic manufactures dollar*
Metal structures; direct-fired furnaces	160.00
Pressure vessels (towers and pressure storage)	163.00
Large-diameter welded tubes	170.00
Storage tanks; steam generators—mixers	172.00
Electrical equipment—electricity ducts; tubing—steel and forged iron tubes; refractories and thermal insulation material	180.00
Heat exchangers and surface condensers	183.00
Cyclones	185.00
Travelling cranes, lifts and lifting tackle	190.00
Tubing—connexions; expansion joints	200.00
Pumps and compressors; tubing—valves	220.00
Electrical equipment—motors and transformers; switches, wires and cables	250.00
All types of equipment	192.00

Table 12 gives the results of a price comparison for the principal groups of equipment, on the basis of the experience acquired when PETROBRAS purchased equipment for the Duque de Caxias refinery, for the Guanabara terminal and for the synthetic rubber factory. The comparison was made by dividing the sales price (in cruzeiros) of the equipment manufactured in Brazil by the sales price (in dollars) of the same types of equipment with identical technical specifications manufactured in the United States. In both cases, the prices are ex-factory f.o.b.[9] The result obtained was called the "domestic manufactures dollar".

The wide price range represented by the "domestic manufactures dollar" in relation to the different types of equipment derives from various factors. In the first place, there is the use of imported raw materials. In the case of equipment for which possible requirements of imported raw materials are lower and the quantity of labour added to the product is greater, the value of the "nationalization dollar" is higher. This is true of equipment produced by the boiler-making and heavy metal-transforming industries, which chiefly use domestically-produced steel sheet and where the manufacturing processes have to be manual for the most part, with consequent high labour inputs. In extreme cases in which the imported raw materials, i.e., non-ferrous metals (copper, bronze and tin) and steel alloy (siliceous sheet), constitute a large proportion of the final product, the equivalence amounts to 250.00 cruzeiros per dollar.

Secondly, the length of the production series should be taken into account. When equipment can by its very nature be mass-produced, but the market is still limited and unstable, as, for instance, in the case of valves and connexions, domestic manufacturing prices are unfavourable. Moreover, as the equipment which forms the major part of investment compares fairly favourably in price, the weighted average for total equipment gives a conversion rate of not more than 192.00 cruzeiros to the dollar.

In the last section of this report, the problem of domestic and import prices will be analysed more closely, and for the basic equipment sectors as a whole.

It should be briefly mentioned here that during the period covered by the study—October-November 1960—the free market exchange rate was 180 cruzeiros to the dollar, whereas the rate prevailing under the exchange auction system for imports in the general category was 250 to the dollar.

4. PROBLEMS OF ENGINEERING AND TECHNICAL STANDARDS

By and large, it is true to say that up to mid-1960, all engineering work for the refineries, oil pipelines and petrochemical industries set up in Brazil was done outside the country.

The first refinery built in Brazil—a small plant—was established in Rio Grande do Sul by a private group (Ipiranga). It was followed by the Mataripe refinery, constructed in 1949-50 to plans made by the United States firm M. W. Kellog, and the refineries of Cubatão (PETROBRAS), União (Capuava), Manguinhos (Rio de Janeiro), Ipiranga (Rio Grande do

[9] If the equipment manufactured in the United States is priced at the c.i.f. value in a Brazilian port, the results of the comparison will be much more favourable for Brazilian prices than in the case of "nationalization dollars". This is because imports of this type of equipment are usually bulky and heavy and the freight charges have a heavy incidence on the import price.

Sul) and Amazonas (Manáus), the last four under private auspices.

All these refineries were designed by United States firms, which means that most of their equipment was planned in accordance with American building methods, specifications and raw materials. As a result of this, and also because Brazil's heavy metal-transforming industry was still insignificant, the equipment corresponding to those projects was practically all manufactured abroad.

The first important project carried out by Brazilian industry in relation to petroleum was the expansion of the Mataripe refinery. When the project was designed by the Kellog company of New York, no provision was initially made for the use of Brazilian equipment. But, in view both of the difficulty of obtaining even medium-term credit from United States equipment manufacturers for orders intended for a State enterprise, and of the fairly substantial supply of cruzeiros at the disposal of PETROBRAS, the general situation was favourable for the placing of a certain volume of orders for equipment in Brazil. This meant participation by Brazilian industry in the manufacture of equipment for the Mataripe refinery to the extent of about 20 per cent of the total value. In order to put this decision into effect in 1955, a group of Brazilian industrialists founded the Brazilian Association for the Development of Basic Industry. Its objectives were, first, to study the specifications stipulated by the Kellog company and to adapt them (in close collaboration with the company's engineers) to the possibilities of Brazilian metal-transforming, and secondly, to help domestic producers to comply with those specifications by means of technical advice.

Thus, for the first time, a group of foreign project engineers came into contact with numerous Brazilian manufacturers in the most varied branches of industry for the purpose of ordering equipment whose specifications, although easy to carry out abroad, were bound to be difficult to follow in Brazil where such production is still at the pioneering stage.

This field was largely unexplored for the Brazilians, whereas the United States engineers had acquired considerable experience after the Second World War when, to simplify the execution of projects or for economic and financial reasons, branches or subsidiaries of United States engineering firms were set up in Europe to make use of the basic industries in process of reconstruction, in collaboration with the local engineers, and thereby further the recovery and progress of the countries concerned. In 1953 the Fédération Européenne des Constructeurs d'Equipement Pétrolier (FECEP) was created to correlate United States and European building standards for petroleum production and refining equipment. According to information obtained, certain specifications for raw materials produced in the United States did not necessarily have to be applied in the case of European projects; these could be carried out on the basis of local materials that were sometimes more suitable in the particular circumstances.

However, the problem was infinitely more complex in Brazil, since those branches of the metal-transforming industry that were fitted to undertake large-scale work were still at a very early stage of development in comparison with the experienced and highly-advanced state of the industry in Europe. The bigger Brazilian enterprises producing heavy equipment had as yet barely started to expand their plant to meet new requirements and still lacked the necessary machinery for large-scale projects. The period from 1953 to mid-1957 was a critical one for Brazilian producers of petrochemical equipment; they were not yet fully acquainted with the difficulties of supplying material built to strict specifications, yet they submitted quotations for large-scale metal structures with special characteristics, pressure vessels, steam boilers, heat exchangers, storage tanks, electric motors, pumps and other items of equipment exceeding 5 million dollars in value.

From 1957-58 onwards, when all the necessary machinery had been delivered and the installation of plant in various industries had been completed, it became feasible to consolidate the activities of the petrochemical equipment industry through the production of other lines of equipment on a sounder and more realistic basis.

Even before the expansion of the Mataripe refinery had been concluded, the project for the Duque de Caxias refinery at Rio de Janeiro began to be prepared. This project, planned entirely in the United States by the Foster Wheeler Corporation was designed in such a way that part of the equipment could be manufactured in Brazil.

At this new stage, the Brazilian producers participated to the extent of 50 per cent (as against 20 per cent in the case of the Mataripe refinery) through the mutual adaptation of specifications by manufacturers and engineers. Their contribution rose to 70 per cent in 1959-60 in the synthetic rubber factory at Rio de Janeiro. This trend of developments bears eloquent witness to the importance of the part played by specifications in deciding where equipment is to be obtained. In planning petroleum refineries or petrochemical industries it is essential to be sure that the equipment will be manufactured in accordance with certain standards and specifications. If the same equipment is made on the basis of dual standards, there will be two technical designs, two sets of costs and possibly two different delivery dates.

In view of the embryonic state of Brazilian standards for the engineering industry, equipment manufacturers, under pressure from the project engineers, tend to adopt foreign standards and specifications, mainly of United States origin. But the industry is not always able to follow such standards exactly. Recourse has then to be had to what are known as deviations, which are permissible only after a searching analysis has been made of each code. The result is either fewer orders for Brazilian equipment or an unnecessary increase in costs.

In order to remedy this situation, ABDIB and the Brazilian Petroleum Institute (IBP) have been collaborating with the Brazilian Technical Standards Association (ABNT) in the establishment of standards for the engineering industry. But the results achieved through the collaboration of these three agencies in the work of formulating standards for Brazil do not hold out any hope that the impediment which the lack of a

complete set of such standards signifies for the expansion or development of the Brazilian equipment industry will shortly be eliminated.

The majority of the engineers who assist the standardization commissions of ABNT are unable to do so on a full-time basis because of their regular commitments with private firms. It may be necessary to provide ABNT with a permanent team of engineers who have specialized in the manufacture of equipment and could devote themselves to the preparation and drafting of standards, receiving comments from the commissions on the work being done and submitting texts duly documented for their approval.

It would probably be found, however, that ABNT could not be strengthened on the basis of domestic resources only, and foreign technical assistance would be needed as well. As the root of the problem is the assimilation of techniques (of design and construction) that have gradually developed and accumulated in the industrially more advanced countries, the time is ripe for the provision of some kind of international aid to facilitate the process of transfer. This assistance might eventually take the form of collaboration in a systematic programme for the preparation of engineering construction standards (not necessarily limited to the processing industries) to meet the present and foreseeable future requirements of Brazilian industry in its efforts to manufacture a rapidly increasing proportion of the basic industrial equipment that is essential for the development of the country.

As a counterpart to this international co-operation, ABNT would re-design its methods of work so as to make them more dynamic, and would broaden its financial base by seeking larger contributions from private industry.

III. ELECTRIC POWER GENERATING EQUIPMENT

In this chapter an attempt is made to estimate the probable demand for equipment needed to carry out the electric power output expansion programme during the next ten years (1961-70). For this purpose, the trend of power requirements is considered in the light of projects now under way or at the planning stage.

Requirements during the next decade are projected on the basis of the 10 per cent annual growth rate recorded in the studies of the Development Council for the period 1956-66.

A comparison of requirements with planned projects indicates that if the latter materialize, the electric power gap will be filled by 1970 when final installed capacity will amount to 14,078 MW as against an estimated demand of 13,148 MW, notwithstanding apparent shortages between 1961 and 1965 arising from the fact that the installations already purchased for production in that period have not been included in the estimates.

Considering the problem strictly from the standpoint of what is required in the way of generating equipment proper (i.e. essentially, hydraulic turbines, generators, step-up transformers and accessories), it would appear that some 410 million dollars will have to be spent on equipment in order to maintain a balance between power supply and demand during the ten-year period.

The domestic heavy machinery industry, represented mainly by four specialist manufacturers, will be in a position to meet most of the requirements for generators and step-up transformers, although some temporary difficulties may be experienced in 1964 when full-scale production of the General Electric plant and expansion of the Brown Boveri factory will have only just begun.

Production of turbines, which are manufactured locally by only two companies, is expected to fall far short of requirements. This is due, on the one hand, to the fact that most of the new plants to be built under the factory construction programme will only be ready at the end of the period and, on the other hand, to the inadequate production capacity of the manufacturers, viewed in terms of present output and estimated expansion. Meanwhile the problem may be solved, without recourse to imports, provided the factory construction programme is improved and the manufacturers make an additional effort by setting up two shifts and using sub-contractors.

Current production is also inadequate in respect of such accessories as circuit-breakers, lightning arresters, switches (over 220 kV), voltage transformers (over 220 kV) and current transformers (over 220 kV), although it is hoped that the difficulty may be overcome by expanding the facilities of three firms manufacturing these items. Other items (sluices, pressure ducts, valves, travelling cranes, etc.) do not present major problems.

Copper and silicon steel are two raw materials used in electrical equipment which may give rise to supply problems. A considerable amount of copper (some 25,000 tons) will be required during the proposed ten-year programme, and this may be a critical item since virtually no copper is produced in the country. Specific measures ought to be taken at once to ensure future supply. Silicon steel, particularly for transformers, might have to be imported, since the only local manufacturing firm is still in the process of consolidation and expansion.

Of major interest to local industry too is the question of financing, though this is needed much more for plant construction than for equipment, which represents a relatively small portion of the total investment in a hydro-electric plant. Financing is usually linked to engineering services, and as these are normally obtained from abroad, the tendency is for equipment to be ordered from foreign countries as well.

1. Electric power requirements

(a) *Trend of electric power requirements*

The projection of electric power demand prepared by the Development Council for the target programme is the one used in the present study. According to this estimate, covering the period 1956-66, the country's electric power requirements will increase at an annual

Table 13. Brazil: power requirements and programme of capacity to be installed, 1961-70
(*MW*)

	1961	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*
Installed capacity	5,069.5[a]	199.5	5,329.5	5,830	6,852	8,028.5	9,283.7	10,510.1	11,598.3	12.859.3
Annual increase	130.0	130.0	628.5	1,150	1,176.5	1,127.2	1,098.4	1,088.2	1,261.0	1,219.0
Capacity at end of year...	5,199.5	5,329.5	5,958.0	6,980	8,028.5	9,155.7	10,382.1	11,598.3	12,859.3	14,078.3
Requirements[b]	5,577.0	6,134.5	6,748.0	7,423	8,165.0	8,980.0	9,878.0	10,866.0	11,953.0	13,148.0
Surplus or deficit	—377.5	—805.0	—790.0	—443	—136.5	+175.7	+504.1	+732.3	+906.3	+930.3

[a] Development Council, Target Programme. As revised 31 December 1958.
[b] Up to 1966, data given by the Development Council as revised 31 December 1958. For 1967 to 1970, the estimates are based on those data.

rate of 10 per cent. This rate, while considerably higher than the average growth rate of the gross national product (6.7 per cent in 1956-59), is admissible in view of the country's present phase of economic development, which is based on accelerated industrialization. The same rate, applied to the period 1960-70, has been used in this report.

Hydro-electric improvements now under way or at the project stage are closely related to the estimated rate of increase of power requirements during the next ten years. The situation regarding requirements, installed capacity and its increase by means of new installations which will have to be provided is shown in table 13 on page 23.

TABLE 14. BRAZIL: TIME-TABLE OF ELECTRIC POWER WORKS, 1961-71

Agency responsible[a] and plant	*Capacity to be installed (MW)*	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*
CHESF:												
Paulo Afonso	1,100	130	130	105	210	105		105	105	105	105	
Goiás:												
Cachoeira Dourada	240			48	48		48	48	48			
Minas Gerais:												
Tres Marias	325			65	65	65	65	65				
Furnas	512			128	256	128						
Sobradinho	500					100	100	100		100	100	
Rio Grande do Sul:												
Antas	184				46		46		46		46	
Passo Fundo	220					55		55		55	55	
Tainhas	110						55		55			
Rio de Janeiro:												
Funil	210				70	140						
Gov. de São Paulo:												
Jupiá	1,260				200	200	200	200	200	260		
Ilha Solteira	1,630							200	200	200	230	800
Caraguatatuba	500					100	200	100	100			
CHERP:												
Carrapatos	31					31						
Vila Biela	5			5								
Promissão	234								58.5	58.5	117	
Ibitinga	124.8						31.2	62.4	31.2			
Avanhandava	180									90	90	
Rui Barbosa	100										50	50
Araçatuba	176											176
Andradina	250											250
USELPA:												
Xavantes	400			100	100	100	100					
Pirajú	100				50	50						
Ourinhos	37						37					
Cinzas I	63							63				
Cinzas II	72								72			
Capivara	240									120	120	
CPFL:												
Peixotos	285			47.5	47.5	95	95					
Estreito	500						100	100	100	100	100	
LIGHT:												
Ponte Coberta	90			90								
Santa Branca	40			40								
Registro	45								22.5	22.5		
Descalvado	180									90		90
Ribeira	96										96	
Eldorado	120									60	60	
Piauí:												
Boa Esperança	200				50		50		50		50	
Mato Grosso:												
Mimoso	15				7.5	7.5						
TOTAL	10,374.8	130	130	628.5	1,150	1,176.5	1,127.2	1,098.7	1,088.2	1,261	1,219	1,366

[a] The abbreviations relate to the bodies listed below:

CHESF —Companhia Hidroelétrica do São Francisco.
CHERP —Companhia Hidroelétrica do Rio Pardo.
USELPA—Usinas Elétricas do Paranapanema S.A.
CPFL —Companhia Paulista de Força e Luz.
LIGHT —São Paulo Light S.A.—Serviços de Electricidade.

Where states (Goias, Minas Gerais etc.) are referred to, the state governments concerned are responsible for the undertakings.

It should be pointed out that the deficits shown in the table for the years 1961 to 1965 are apparent rather than real, since the gap will be filled by equipment already purchased for the various projects but not included in the calculations.

(b) *Works programme for power generation*

Large-scale hydroelectric installations are now being built or planned in order to meet the estimated amount of power required by 1970.[10] A diagram of the installations planned for the ten-year period by the federal and state authorities, as well as by private enterprise, is given in table 14.

[10] The works programme covers the period up to 1971. However, equipment must be ordered and manufactured in the years immediately preceding 1971, so that the year 1971 must be included in this study.

TABLE 15. BRAZIL: GENERATING CAPACITY TO BE INSTALLED, 1961-71

Agency responsible[a] *and plant*	*Number of units (MW)*	*Head (M)*	*Classification of head*	*Capacity to be installed (MW)*
CHESF:				
Paulo Afonso	4 for 65	80	B	1,100
Paulo Afonso	8 for 105	80	B	
Goiás:				
Cachoeira Dourada	5 for 48	33	B	240
Minas Gerais:				
Tres Marias	5 for 65	55	B	325
Furnas	4 for 128	90	B	512
Sobradinho	5 for 100	35	B	500
Rio Grande do Sul:				
Antas	4 for 46	120	C	184
Passo Fundo	4 for 55	250	C	220
Tainhas	2 for 55	780	C	110
Rio de Janeiro:				
Funil	3 for 70	70	B	210
Gov. de São Paulo:				
Jupiá	12 for 100	28	B	1,260
Jupiá	2 for 30	28	B	
Ilha Solteira	16 for 100	35	B	1,630
Ilha Solteira	1 for 30	35	B	
Caraguatatuba	5 for 100	638	C	500
CHERP:				
Carrapatos	1 for 31	25	B	31
Vila Biela	1 for 5	15	A	5
Ibitinga	4 for 31.2	23	B	124.8
Promissão	4 for 58.5	26	B	234
Avanhandava	4 for 45	19	A	180
Rui Barbosa	4 for 25	15	A	100
Araçatuba	4 for 44	20	A	176
Andradina	4 for 62.5	28	B	250
USELPA:				
Xavantes	4 for 100	73	B	400
Piraju	2 for 50	58	B	100
Ourinhos	2 for 18.5	13	A	37
Cinzas I	2 for 31.5	18.5	A	63
Cinzas II	2 for 36	18.5	A	72
Capivara	4 for 60	38	B	240
CPFL:				
Peixotos	6 for 47.5	68	B	285
Estreito	5 for 100	150	C	500
LIGHT:				
Ponte Coberta	2 for 45	100	B	90
Santa Branca	1 for 40	47	B	40
Registro	2 for 22.5	12	A	45
Descalvado	2 for 90	93	B	180
Ribeira	1 for 96	93	B	96
Eldorado	2 for 60	47	B	120
Piauí:				
Boa Esperança	4 for 50	35	B	200
Mato Grosso:				
Mimoso	2 for 7.5	17	A	15
TOTAL				10,374.8

[a] See table 14, footnote [a].

[b] A. Kaplan turbine.
B. Frances turbine.
C. Pelton turbine.

All the equipment for the Ponte Coberta plant is reported to be ready abroad but has not yet arrived in the country because of administrative difficulties.

Table 15 describes the main features of each plant to be built during the ten-year period, including the capacity to be installed, the number of units, the height of head, and the organization responsible for construction.

In order to facilitate calculation of the weight of the equipment to be used in each plant, head has been classified into three groups: (1) up to 20 metres; (2) from 20 to 100 metres; (3) over 100 metres.

It will be seen from the diagram in table 14 that much of the construction programme is scheduled for 1970 and 1971. This will require building and equipment manufacturing on a scale difficult to carry out

TABLE 16. BRAZIL: HYDRAULIC TURBINE REQUIREMENTS, 1961-71

Agency responsible [a] *and plant*	*Number of units (MW)*	*Quantity*	*Turbines*		
			RPM	*Unit weight (tons)*	*Aggregate weight (tons)*
CHESF:					
Paulo Afonso	4 for 65	4	200	280	1,120
Paulo Afonso	8 for 105	8	163	400	3,200
Goiás:					
Cachoeira Dourada	5 for 48	5	120	800	4,000
Minas Gerais:					
Tres Marias	5 for 65	5	164	500	2,500
Furnas	4 for 128	4	128	500	2,000
Sobradinho	5 for 100	5	75	800	4,000
Rio Grande do Sul:					
Antas	4 for 46	4	220	200	800
Passo Fundo	4 for 55	4	200	300	1,200
Tainhas	2 for 55	2	450	200	400
Rio de Janeiro:					
Funil	3 for 70	3	150	650	1,950
Gov. de São Paulo:					
Jupía	12 for 100	12	75	800	9,600
Jupiá	2 for 30	2	250	200	400
Ilha Solteira	16 for 100	16	75	800	12,800
Ilha Solteira	1 for 30	1	250	200	200
Caraguatatuba	5 for 100	5	257	200	1,000
CHERP:					
Carrapatos	1 for 31	1	163	250	250
Vila Biela	1 for 5	1	250	100	100
Ibitinga	4 for 31.2	4	163	350	1,400
Promissão	4 for 58.5	4	106	500	2,000
Avanhandava	4 for 45	4	120	400	1,600
Rui Barbosa	4 for 25	4	120	400	1,600
Araçatuba	4 for 44	4	120	400	1,600
Andradina	4 for 62.5	4	150	350	1,400
USELPA:					
Xavantes	4 for 100	4	164	500	2,000
Piraju	2 for 50	2	225	200	400
Ourinhos	2 for 18.5	2	120	250	500
Cinzas I	2 for 31.5	2	72	300	600
Cinzas II	2 for 36	2	64	350	700
Capivara	4 for 60	4	120	800	3,200
CPFL:					
Peixotos	6 for 47.5	6	120	500	3,000
Estreito	5 for 100	5	200	600	3,000
LIGHT:					
Ponte Coberta	2 for 45	2	300	150	300
Santa Branca	1 for 40	1	250	200	200
Registro	2 for 22.5	2	75	200	400
Descalvado	2 for 90	2	120	400	800
Ribeira	1 for 96	1	120	400	400
Eldorado	2 for 60	2	120	500	1,000
Piauí:					
Boa Esperança	4 for 50	4	120	500	2,000
Mato Grosso:					
Mimoso	2 for 7.5	2	200	120	240
TOTAL		149			73,860

[a] See table 14, footnote [a].

in practice. However, as the programme develops it will be possible, if steps are taken two or three years in advance, to rearrange the investment programme for 1970 and 1971 by shifting part of it to earlier years and thus avoiding excessive demand for equipment and projects. The over-concentration of demand is shown in detail in tables 16 to 19 where the equipment required for the installations is listed.

2. Equipment for the power generation programme

The following are the major items of equipment used for producing electric power:

Generating equipment: hydraulic turbines; generators; step-up transformers; circuit-breakers and switches; operating, safety and measuring equipment;

Table 17. Brazil: generator requirements, 1961-71

Agency responsible [a] *and plant*	*Number of units (MW)*	*Quantity*	*Unit weight (tons)*	*Aggregate weight (tons)*
CHESF:				
Paulo Afonso	4 for 65	4	450	1,800
Paulo Afonso	8 for 105	8	470	3,760
Goiás:				
Cachoeira Dourada	5 for 48	5	250	1,250
Minas Gerais:				
Tres Marais	5 for 65	5	410	2,050
Furnas	4 for 128	4	800	3,200
Sobradinho	5 for 100	5	820	4,100
Rio Grande do Sul:				
Antas	4 for 46	4	200	800
Passo Fundo	4 for 55	4	230	920
Taínhas	2 for 55	2	180	360
Rio de Janeiro:				
Funil	3 for 70	3	360	1,080
Gov. de São Paulo:				
Jupiá	12 for 100	12	820	9,840
Jupiá	2 for 30	2	155	270
Ilha Solteira	16 for 100	16	820	13,120
Ilha Solteira	1 for 30	1	135	135
Caraguatatuba	5 for 100	5	320	1,600
CHERP:				
Carrapatos	1 for 31	1	170	170
Vila Biela	1 for 5	1	35	35
Promissão	4 for 58.5	4	400	1,600
Ibitinga	4 for 31.2	4	180	720
Avanhandava	4 for 45	4	300	1,200
Rui Barbosa	4 for 25	4	190	760
Araçatuba	4 for 44	4	300	1,200
Andradina	4 for 62.5	4	330	1,320
Bariri		1 [b]	360	360
USELPA:				
Xavartes	4 for 100	4	450	1,800
Piraju	2 for 50	2	220	440
Ourinhos	2 for 18.5	2	150	300
Cinzas I	2 for 31.5	2	300	600
Cinzas II	2 for 36	2	400	800
Capivara	4 for 60	4	380	1,520
CPFL:				
Peixotos	6 for 47.5	6	300	1,800
Estreito	5 for 100	5	400	2,000
LIGHT:				
Ponte Coberta	2 for 45	2	200	400
Santa Branca	1 for 40	1	170	170
Registro	2 for 22.5	2	250	500
Descalvado	2 for 90	2	500	1,000
Ribeira	1 for 96	1	540	540
Eldorado	2 for 60	2	380	760
Piauí:				
Boa Esperança	4 for 50	4	220	880
Mato Grosso:				
Mimoso	2 for 7.5	2	75	150
Total		150		65,310

[a] See table 14, footnote [a].
[b] Only generator still to be acquired.

TABLE 18. BRAZIL: STEP-UP TRANSFORMER REQUIREMENTS, 1961-71

Agency responsible[a]	Plant	Step-up transformers	Total (kVA)	Weight in tons[b]					
				Unit			Aggregate		
				Transformer	Oil	Total	Transformer	Oil	Total
CHESF	Paulo Afonso....	4 for 81,250 kVA 13 200/220 kV	325,000	135	70	205	540	280	820
	Paulo Afonso....	8 for 131,250 kVA 13 200/220 kV	1,050,000	185	100	285	1,480	800	2,280
Goiás	Cachoeira Dourada.....	5 for 60,000 kVA 13 200/132 kV	300,000	75	35	110	375	175	550
Minas Gerais	Tres Marias.....	5 for 81,250 kVA 13 200/289 kV	406,250	50.3	12.7	63.0	251.5	63.5	315
	Furnas.....	4 for 160,000 kVA 13 200/345 kV	640,000	180	60	240	720	240	960
	Sobradinho.....	5 for 125,000 kVA 13 200/132 kV	625,000	170	90	260	850	450	1,300
Rio Gr. Do Sul	Antas.....	4 for 57,500 kVA 13 200/132 kV	230,000	75	38	113	300	152	452
	Passo Fundo.....	4 for 68,750 kVA 13 200/132 kV	275,000	85	41	126	340	164	504
	Taínhas.....	2 for 68,750 kVA 13 200/132 kV	137,500	85	41	126	170	82	252
Rio de Janeiro	Funil.....	3 for 87,500 kVA 13 200/132 kV	262,500	113	65	178	339	195	534
Gov. de São Paulo	Jupiá.....	12 for 125,000 kVA 13 200/380 kV	1,500,000	140	48	188	1,680	576	2,256
	Jupiá.....	2 for 37,500 kVA 13 200/ 66 kV	75,000	55	30	85	110	60	170
	Ilha Solteira.....	16 for 125,000 kVA 13 200/380 kV	2,000,000	140	48	188	2,240	768	3,008
	Ilha Solteira.....	1 for 37,500 kVA 13 200/ 66 kV	37,500	55	30	85	55	30	85
	Caraguatatuba...	5 for 125,000 kVA 13 200/132 kV	625,000	170	90	260	850	450	1,300
CHERP	Carrapatos.....	1 for 38,750 kVA 13 200/132 kV	38,750	57	32	89	57	32	89
	Vila Biela.....	1 for 6,250 kVA 13 200/132 kV	6,250	20	15	35	20	15	35
	Promissão.....	4 for 73,125 kVA 13 200/132 kV	292,500	85	43	128	340	172	512
	Ibitinga.....	4 for 39,000 kVA 13 200/132 kV	156,000	56	32	88	224	128	352
	Avanhandava....	4 for 56,250 kVA 13 200/132 kV	225,000	73	37	110	292	148	440
	Rui Barbosa.....	4 for 31,250 kVA 13 200/132 kV	125,000	50	27	77	200	108	308
	Araçatuba.....	4 for 55,000 kVA 13 200/132 kV	220,000	71	35	106	284	140	424
	Andradina.....	4 for 78,125 kVA 13 200/132 kV	312,500	96	60	156	384	240	624
USELPA	Xavantes.....	4 for 125,000 kVA 13 200/220 kV	500,000	120	65	185	480	260	740
	Piraju.....	2 for 62,500 kVA 13 200/220 kV	125,000	78	38	116	156	76	232
	Ourinhos.....	2 for 23,125 kVA 13 200/220 kV	46,250	43	25	68	86	50	136
	Cinzas I.....	2 for 39,375 kVA 13 200/220 kV	78,750	57	30	87	114	60	174
	Cinzas II.....	2 for 45,000 kVA 13 200/220 kV	90,000	62	32	94	124	64	188
	Capivara.....	4 for 75,000 kVA 13 200/220 kV	300,000	96	60	156	384	240	624
CPFL	Peixotos.....	6 for 59,375 kVA 13 200/345 kV	356,250	70	35	105	420	210	630
	Estreito.....	5 for 125,000 kVA 13 200/345 kV	625,000	140	48	188	700	240	940
LIGHT	Ponte Coberta...	2 for 56,250 kVA 13 200/345 kV	112,500	72	36	108	144	72	216
	Santa Branca....	1 for 50,000 kVA 13 200/345 kV	50,000	67	35	102	67	35	102
	Registro.....	2 for 28,125 kVA 13 200/345 kV	56,250	45	25	70	90	50	140
	Descalvado.....	2 for 112,500 kVA 13 200/345 kV	225,000	126	65	191	252	130	382
	Ribeira.....	1 for 120,000 kVA 13 200/345 kV	120,000	126	65	191	126	65	191
	Eldorado.....	2 for 75,000 kVA 13 200/345 kV	150,000	96	60	156	192	120	312
Piauí	Boa Esperança...	4 for 62,500 kVA 13 200/132 kV	250,000	78	38	116	312	152	464
Mato-Grosso	Mimoso.....	2 for 9,375 kVA 13 200/ 88 kV	18,750	25	10.5	35.5	50	21	71
	TOTAL	149 for 12,968,500 kVA	12,968,500				15,798.5	7,313.5	23,112

[a] See table 14, footnote [a].

[b] The following criteria were used to determine weight:
1. European specifications.
2. Transformers up to 70 MW—three-phase.
   Transformers over 70 MW—three single-phase (in a bank).

lightning arresters; travelling cranes; sluice-gates; pressure ducts.

Transmission and distribution equipment: step-down transformers; circuit-breakers; operating, safety and measuring equipment; aluminium or copper cables, steel cables; switches; lightning arresters; insulators; transmission towers.

The last three items of generating equipment have not been included in the estimate of requirements because an accurate or even reasonable rough estimate of what will be needed in the way of travelling cranes, sluice-gates and pressure ducts for each project cannot be made until all the projects under the programme have been completed. The reason is that requirements for these items may vary substantially with the specifications of each project.

As regards transmission and distribution equipment, only that required for the actual production plant has been included in this study. An estimate by type of the

TABLE 19. BRAZIL: HIGH VOLTAGE EQUIPMENT REQUIREMENTS, 1961-71

Agency responsible [a] *and plant*	*Transformers*		*Circuit-breakers*	*Switches*	*Lightning arresters*	*Voltage trans-formers*	*Current trans-formers*
	Quantity	*Voltage (kV)*					
CHESF:							
Paulo Afonso	4	220	8	20	24	24	24
Paulo Afonso	8	220	16	40	48	48	48
Goiás:							
Cachoeira Dourada	5	132	10	25	30	30	30
Minas Gerais:							
Tres Marais	5	289	10	25	30	30	30
Furnas	4	345	8	20	24	24	24
Sobradinho	5	132	10	25	30	30	30
Rio Grande do Sul:							
Antas	4	132	8	20	24	24	24
Passo Fundo	4	132	8	20	24	24	24
Tainhas	2	132	4	10	12	12	12
Rio de Janeiro:							
Funil	3	132	6	15	18	18	18
Gov. de São Paulo:							
Jupiá	12	380	24	60	72	72	72
Jupiá	2	66	4	10	12	12	12
Ilha Solteira	16	380	32	80	96	96	96
Ilha Solteira	1	66	2	5	6	6	6
Caraguatatuba	5	132	10	25	30	30	30
CHERP:							
Carrapatos	1	132	2	5	6	6	6
Vila Biela	1	132	2	5	6	6	6
Promissão	4	132	8	20	24	24	24
Ibitinga	4	132	8	20	24	24	24
Avanhandava	4	132	8	20	24	24	24
Rui Barbosa	4	132	8	20	24	24	24
Araçatuba	4	132	8	20	24	24	24
Andradina	4	132	8	20	24	24	24
USELPA:							
Xavantes	4	220	8	20	24	24	24
Piraju	2	220	4	10	12	12	12
Ourinhos	2	220	4	10	12	12	12
Cinzas I	2	220	4	10	12	12	12
Cinzas II	2	220	4	10	12	12	12
Capivara	4	220	8	20	24	24	24
CPFL:							
Peixotos	6	345	12	30	36	36	36
Estreito	5	345	10	25	30	30	30
LIGHT:							
Ponte Coberta	2	345	4	10	12	12	12
Santa Branca	1	345	2	5	6	6	6
Registro	2	345	4	10	12	12	12
Descalvado	2	345	4	10	12	12	12
Ribeira	1	345	2	5	6	6	6
Eldorado	2	345	4	10	12	12	12
Piauí:							
Boa Esperança	4	132	8	20	24	24	24
Mato Grosso:							
Mimoso	2	88	4	10	12	12	12
TOTAL	149		298	745	894	894	894

[a] See table 14, footnote [a].

equipment required for the plant construction programme is given in tables 16 to 19. The data given in these tables for each major item of equipment are summarized below.

(a) *Hydraulic turbines*

An annual schedule of turbine requirements for the period 1961-70 has been prepared on the basis of the data contained in tables 14 to 16.

However, as explained in sub-section 4 of this section, because of the technical specifications laid down for the construction of the Furnas, Jupiá and Ilha Solteira plants and the inadequate capacity of Brazilian manufacturers, the turbines for these plants will probably have to be imported. If we subtract these turbines from the total demand we get the requirements which will have to be met by local manufacturers. Detailed figures will be found in table 20.

TABLE 20. BRAZIL: ESTIMATED DEMAND FOR TURBINES, 1961-71

Year	Total requirements		Furnas, Jupid and Ilha Solteira plants		Remainder	
	Turbines (number)	Weight (tons)	Turbines (number)	Weight (tons)	Turbines (number)	Weight (tons)
1961	2	560	—	—	2	560
1962	2	560	—	—	2	560
1963	10[a]	3,800	1	500	9	3,300
1964	15	7,370	4	2,600	11	4,770
1965	16	7,670	3	2,100	13	5,570
1966	17	7,950	2	1,600	15	6,350
1967	15	8,100	4	3,200	11	4,900
1968	16	7,850	4	3,200	12	4,650
1969	18	9,700	6	3,600	12	6,100
1970	19	9,700	3	1,800	16	7,900
1971	19	10,600	8	6,400	11	4,200
1961-71	149	73,860	35	25,000	114	48,860

[a] Eleven turbines needed, although the table shows ten only; one has already been ordered.

Looking at the probable demand for the period under review we see that from 1969 to 1971 it will be considerably above the annual average. The excess demand will have to be dealt with either by postponing the returns on the investment made or by importing some of the units required. The best course to follow will suggest itself as the programme develops. The expansion achieved by the heavy machinery industry will be fully known by 1967-68, and a more accurate estimate of the generating capacity of the equipment can then be made.

(b) *Generators*

The estimated demand for generators under the proposed investment programme corresponds more or less to the figures given in table 21.

The sharp rise in demand during 1969, 1970 and 1971 should be noted. A judicious rearrangement of the plant construction programme during the second half of the decade will make it possible to stagger orders more satisfactorily and thus avoid possible overloading of the manufacturing programmes.

TABLE 21. BRAZIL: ESTIMATED DEMAND FOR GENERATORS, 1961-71

Year	Number of generators	Total weight[a] (tons)
1961	2	900
1962	2	900
1963	11	3,645
1964	15	6,665
1965	16	6,925
1966	17	6,290
1967	15	7,140
1968	16	6,950
1969	18	8,360
1970	19	7,575
1971	19	9,960
1961-71	150	65,310

[a] Technical data provided by Brown Boveri S.A. were used to determine the average weight of the generators.

(c) *Step-up transformers*

In the light of the data provided in table 18, the summarized estimate of demand for step-up voltage transformers should correspond to that indicated in table 22.

TABLE 22. BRAZIL: ESTIMATED DEMAND FOR STEP-UP TRANSFORMERS, 1961-71

Year	Number of transformers	Total weight[a] (tons)
1961	2	270.0
1962	2	270.0
1963	10	911.3
1964	15	1,694.3
1965	16	1,766.3
1966	17	1,695.3
1967	15	1,661.3
1968	16	1,678.0
1969	18	1,940.0
1970	19	1,898.0
1971	19	2,014.0
1961-71	149	15,798.5

[a] Technical data provided by Brown Boveri S.A., based on the European type of construction, were used to determine the average weight of the transformers. The weight of transformers manufactured in the United States is about 30 to 40 per cent higher. It was considered that transformers up to 70 MW should be the three-phase type and those of a higher capacity the single-phase type, mounted in banks.

(d) *Accessories*

The present study is based on a survey which covers only electric power generating plants and does not include sub-stations and transmission lines. The high-voltage equipment required by these plants is shown in table 19. The following 66 kV to 380 kV high-voltage accessories considered necessary for the proposed investment programme:

	Units
Circuit-breakers	298
Switches	745
Lightning arresters	894
Voltage transformers	894
Current transformers	894

No reference is made to equipment for dams, sluices, stop-logs, pressure ducts, butterfly valves and travelling cranes because they come under the heading of machine-building proper (non-specialized manufacture) and were not considered vital or of major interest to this section. Moreover, as stated earlier, their inclusion would require data as yet unavailable.

In short, the total hydroelectric power generating equipment needed during the period under review is as follows:

	Tons	U.S. dollars (millions)
Turbines	73,860	70
Generators	65,300	260
Step-up transformers	15,800	30
Accessories	—	50
TOTAL		410

3. DOMESTIC MANUFACTURE OF EQUIPMENT

(a) *Estimated production capacity*

The following are the only Brazilian manufacturers of heavy electrical equipment:

1. Indústrias Elétricas Brown Boveri S.A.
2. Mecânica Pesada S.A.
3. Bardella S.A.—Industrias Mecânicas.
4. General Electric S.A.

The other manufacturers may be considered suppliers of accessory items which, as indicated earlier, are not regarded as vital. Hence, as demand cannot be quantified for lack of data, these items have not been included in the present report.

(i) *Hydraulic turbines*

Two limitations must be taken into consideration:

(*a*) The size of each unit;

(*b*) The volume of annual (or quarterly) production.

At present the only firms manufacturing turbines are Mecânica Pesada S.A. and Bardella S.A.—Industrias Mecânicas. The two manufacturers cannot machine-finish parts with a diameter of more than 4 metres and 2.5 metres respectively. Their anuual production may amount to 2,500 tons and 360 tons respectively. However, under an expansion plan now being studied by Bardella S.A., its machining capacity will increase to a diameter of 4 metres and its annual production of turbines to 2,000-2,500 tons by 1964-65. By using subcontractors, Brown Boveri could machine-finish parts with a diameter of up to 5.6 metres, which are already being used by local industry. The volume of production for both firms is based on a single work-shift, which is the system now in force.

From the middle of 1962 onwards General Electric S.A. will be equipped to machine-finish parts with a diameter of up to 15 metres. Its facilities will be made available to turbine manufacturers on a sub-contracting basis. This is not a particularly good system in view of the distance between the turbine manufacturers and the General Electric S.A. plant—the Bardella plant at São Paulo and the Mecânica Pesada plant at Taubaté are respectively 150 km and 350 km away from the General Electric plant at Campinas—hence some method of work must be devised which will ensure a reasonable return on the operation. If this is done, once the expansion of Bardella S.A.'s facilities is completed there will only be a limitation on the annual volume of production.

Bearing in mind the figures in table 20, the situation should be more or less as shown in table 23.

The ten-year programme is likely to fall short of requirements by a total of 6,160 tons. The estimated availabilities shown for 1961-62 must be disregarded; but better programming might help to achieve a more balanced distribution of the short-fall for the years 1964, 1966 and 1970.

Under these conditions, the help of General Electric S.A. with its new facilities and an increase in the work period (two shifts) for machining and assembly (welding) operations at Bardella S.A. and Mecânica Pesada S.A. might perhaps fill the apparent gap and thus obviate recourse to importing turbines.

The estimated peak demand in 1970 might be distributed over subsequent (1971-72) and previous (1968-69) years on the basis of actual power consumption in 1967-68, which would then warrant a reliable extrapolation for determining future power consumption.

(ii) *Generators*

At present only Brown Boveri S.A. and Mecânica Pesada S.A. manufacture generators for electric power plans.[11] By the middle of 1962 General Electric, with its new installations at Campinas, is also expected to enter the market as a producer. For the purposes of this study it will be considered a manufacturer as from 1963.

Existing limitations will apply only to volume of production once generators are manufactured domestically for the following turbines:

	kVa
Frances	Up to 160,000
Kaplan	Up to 85,000
Pelton	Up to 200,000

Examination of the technical specifications of the plants to be built shows that the power of the generators is not a factor limiting domestic production. Consideration should therefore be confined to volume of annual production.

TABLE 23. BRAZIL: DOMESTIC TURBINE MANUFACTURING POTENTIALITIES, 1961-71

Year	Estimated demand (tons)	Domestic production[a] (tons)	Difference
1961	560	2,800	+2,240
1962	560	2,800	+2,240
1963	3,300	2,800	—500
1964	4,770	2,800	—1,970
1965	5,570	4,500	—1,070
1966	6,350	4,500	—1,850
1967	4,900	4,500	—400
1968	4,650	4,500	—150
1969	6,100	4,500	—1,600
1970	7,900	4,500	—3,400
1971	4,200	4,500	+300
1961–71	48,860	42,700[b]	—6,160

[a] Based on an estimated joint total production by Bardella S.A. and Mecânica Pesada S.A. of 2,800 tons up to and including 1964, and 4,500 tons from 1965 to 1971.

[b] Estimated value 40.35 million dollars at the rate of 945 dollars per 1,000 kg (average value).

Brown Boveri S.A.'s present annual generator production capacity amounts to 300,000 kVa. Planned expansion will raise this figure to 1 million kVa by 1965. Mecânica Pesada S.A. estimates its current capacity at 75,000 kVa but expects to be able to produce 150,000 kVa in 1963, although it has no specific ex-

[11] Mecânica Pesada S.A. manufactures only the mechanical parts and imports electrical parts.

pansion plans. General Electric S.A., in its new plant now under construction, will reach an annual generator production figure of at least 500,000 kVa in successive stages. For the purposes of this study, its annual output will be considered as 250,000 kVa in 1963 and 500,000 kVa beginning in 1965.

The estimate volume of production is based on a mean value represented by a hypothetical generator. The total kVa of the generators to be installed, and their respective weight, are divided by the number of units involved. This gives as an ideal value a generator of 87,000 kVa weighing 435 tons. By applying these figures to the total annual production of the three manufacturers, the average figures shown in table 24 are obtained.

TABLE 24. BRAZIL: GENERATOR PRODUCTION CAPACITY, 1961-71

	1961-62	*1963-64*	*1965-71*
Brown Boveri S.A.	300,000 kVa 1,500 tons	300,000 kVa 1,500 tons	1,000,000 kVa 5,000 tons
Mecânica Pesada S.A.	75,000 kVa 375 tons	150,000 kVa 750 tons	150,000 kVa 750 tons
General Electric S.A.	——	250,000 kVa 1,250 tons	500,000 kVa 2,500 tons
TOTAL	375,000 kVa 1,875 tons	700,000 kVa 3,500 tons	1,650,000 kVa 8,250 tons

On the basis of table 21 (estimated demand for generators), the position will be more or less as shown in table 25.

TABLE 25. BRAZIL: POTENTIAL DOMESTIC GENERATOR PRODUCTION, 1961-71

(*Tons*)

Year	*Estimated demand*	*Domestic production*	*Difference*
1961.....	900	1,875	+975
1962.....	900	1,875	+975
1963.....	3,645	3,500	−145
1964.....	6,665	3,500	−3,165
1965.....	6,925	8,250	+1,325
1966.....	6,290	8,250	+1,960
1967.....	7,140	8,250	+1,110
1968.....	6,950	8,250	+1,300
1969.....	8,360	8,250	−110
1970.....	7,575	8,250	+675
1971.....	9,960	8,250	−1,710
1961–71.....	65,310[a]	68,500	+3,190

[a] Estimated at 260 million dollars at the rate of 3,990 dollars per 1,000 kg (average value).

A critical year for domestic production is likely to be 1964, since General Electric S.A. will only just be beginning production and Brown Boveri S.A. will be carrying out its expansion programme. Subsequently, however, domestic production will exceed annual requirements under the proposed programme, except for the years 1969 and 1971 because of the already mentioned heavy concentration of investments in those years.

There are two possible solutions to the problem created largely by the 1964 shortage: one is to speed up the expansion of Brown Boveri and the other is to bring General Electric into full-scale production earlier than scheduled. If by any chance neither course should be feasible some generators will have to be imported so as not to jeopardize the investment programme.

(iii) *Step-up transformers*

The manufacture of step-up voltage transformers is combined with that of other types of transformers in which a dozen or so technically and economically equipped establishments are engaged. However, in view of the technical nature of the equipment, only the two largest manufacturers have been included in the estimate of step-up transformer output capacity, it being assumed that 70 per cent of their capacity will be used to manufacture step-up transformers.

Future domestic production will be adequate to meet the technical specifications of the electric power plants to be constructed under the investment programme. Brown Boveri S.A. upon completion of its expansion programme, and General Electric S.A. with its new facilities at Campinas, will be in a position to manufacture transformers up to a voltage of 380 kV (the highest voltage transformers are those of the Jupiá and Ilha Solteira plants, which require 380 kV).

Domestic production should be able to meet the technical specifications required, since the first transformers will not have to be delivered to the Jupiá and Ilha Solteira plants until 1964 and 1967 respectively and the two manufacturers can now produce 380 kV transformers.

The estimated volume of production is based on an ideal transformer, whose output is equal to the total kVa to be installed divided by the respective number of units and whose weight is equal to the weight of each transformer (without oil) divided by the number of units. This gives as an average value a transformer of 87,000 kVa, weighing 106 tons.

If these figures are applied to the total annual production of the two manufacturers, the average figures given in table 26 are obtained.

TABLE 26. BRAZIL: STEP-UP TRANSFORMER PRODUCTION CAPACITY, 1961-71

	1961	*1962-64*	*1965-71*
Brown Boveri S.A.			
(kVa)	1,000,000	1,200,000	1,400,000
(tons)	1,200	1,460	1,710
General Electric S.A.			
(kVa)	500,000	1,000,000	1,400,000
(tons)	610	1,220	1,710
TOTAL			
(kVa)	1,500,000	2,200,000	2,800,000
(tons)	1,830	2,680	3,420
Reduced to the 70 per cent level for step-up transformers			
(kVa)	1,050,000	1,540,000	1,960,000
(tons)	1,280	1,880	2,400

On the basis of table 22 above (probable demand for transformers) the position will be more or less as shown in table 27.

TABLE 27. BRAZIL: POTENTIAL DOMESTIC PRODUCTION OF STEP-UP TRANSFORMERS, 1961-71

(*Tons*)

Year	*Estimated demand*	*Domestic production*	*Difference*
1961	270.0	1,280	+1,010.0
1962	270.0	1,880	+1,610.0
1963	911.3	1,880	+968.7
1964	1,694.3	1,880	+185.7
1965	1,766.3	2,400	+633.7
1966	1,695.3	2,400	+704.7
1967	1,661.3	2,400	+738.7
1968	1,678.0	2,400	+722.0
1969	1,940.0	2,400	+460.0
1970	1,898.0	2,400	+502.0
1971	2,014.0	2,400	+386.0
1961–71	15,798.5[a]	23,720	+7,921.5

[a] Estimated at 30 million dollars at the rate of 1,900 dollars per 1,000 kg (average value).

A glance at table 27 shows that there are ample facilities for meeting demand, subject always to two essential requirements being fulfilled:

(*a*) Clear-cut production programming in accordance with the proposed investment time-table;

(*b*) Engineering plans making proper allowance for the limitations relative to the maximum voltage patterns to be adopted.

(iv) *Accessories*

These include the following items of equipment: circuit-breakers; lightning arresters; switches; voltage transformers; current transformers; operating, safety and gauge panels; sluices; pressure ducts; stop-logs; butterfly valves; gantry and travelling cranes.

A brief study of the above list and of current Brazilian production shows that at the moment there is no domestic production of the following items: circuit-breakers and lightning arresters; switches (over 220 kV); voltage transformers (over 220 kV); current transformers (over 220 kV).

However, estimated demand is expected to be met in full as a result of the new General Electric S.A. plant and the expansion programme of Sprecher & Schuh do Brasil S.A. (now under way) and of Brown Boveri S.A.

From now on, voltage transformers, high tension cables and operating panels will not constitute a bottleneck for domestic production.

Demand during the period under review was expected to amount to some 50 million dollars;[12] of this figure only 3.3 million dollars (6.6 per cent) represents items manufactured in Brazil to-day. It is assumed, however, that as from 1964 the estimated demand will be fully met by the capacity of the new plants.

As for the remaining equipment (sluices, pressure ducts, etc.) the metal-transforming industry (chiefly the boiler-making and metal frame manufacturing branches) is fully capable of supplying the market. But consideration should be given to the over-all requirements of the petroleum, cement, pulp and paper, and steel industries, since the total demand in these sectors might ultimately constitute a problem for the proposed investment programme.

[12] Estimated by ABDIB in the light of data obtained from the projects studied.

(b) *Raw material requirements*

Two items must be mentioned particularly as critical elements in the electrical power plant investment programme.

The following raw materials will be needed for the production of generators and step-up voltage transformers during the ten-year period under review (see table 28):

TABLE 28. BRAZIL: RAW MATERIAL REQUIREMENTS FOR ELECTRIC POWER GENERATION

(*Tons*)

Raw materials	*Generators*	*Transformers*[a]	*Total*
Electrolytic copper	4,572	1,849	6,421
Insulators	358	10	368
Silicon steel plates	12,120	9,245	21,365
Carbon steel plates	45,174	5,316	50,490
Wrought and cast iron	3,085	50	3,135
Miscellaneous	1	171	172
TOTAL	65,310	16,641[b]	81,951

[a] Excluding oil—6,471 tons. Total raw material requirements for transformers thus amount to 16,641 tons + 6,471 tons = 23,112 tons.

[b] Total, including step-up voltage and current transformers (15,798.5 + 842.5) = 16,641 tons.

Electrolytic copper

Brazil has no copper-refining capacity to speak of and must therefore import copper. The proposed programme will require 6,500 tons of copper for electric power generating equipment alone. If sub-stations and transmission equipment are considered in addition, requirements will exceed 25,000 tons.

If consumption of copper (including its use as the chief component of bronze and tinplate) in other branches of industry, particularly petroleum refineries, steel plants, cement and pulp and paper plants, is likewise included in the estimates, the volume of requirements will be very high indeed and copper might thus become a vital item in the execution of the proposed programme.

The demand for copper should be the subject of a special study aimed at ensuring supplies to the domestic market within the framework of a Latin American regional market.

Silicon steel plates

Estimated consumption will only amount to some 21,500 tons and even if we add the demand in other branches of industry, the Brazilian producer of this raw material—Aços Especiais Itabira S.A. (ACESITA)—should be able to supply the market.

It should be pointed out, however, that present production is intended exclusively for the manufacture of motors and some types of transformers. To supply the remaining market the firm in question proposed to obtain a special rolling-mill which will enable it to meet the demand deriving from the manufacture of generators and, more particularly, transformers.

In the circumstances, substantial quantities of silicon steel plate may still have to be imported during the first few years of the proposed investment programme, until

full-scale domestic production of this material is feasible.

(c) *Price level of domestically-manufactured equipment*

When prices were last checked at São Paulo for the purpose of awarding contracts for the supply of equipment for electric power generation (October-November 1960), the following comparative rates for equipment manufactured locally and abroad were obtained:

	Cruzeiros per dollar
Hydraulic turbines	247
Generators	270
Transformers	263

The comparison was made with prices in North America and Europe and the rates are for medium-size equipment ex-factory (f.o.b.). Since the prices for imported equipment exclude loading costs, freight charges, insurance and customs duties (generally waived under special legislation), the above rates seem high, reflecting the fact that domestic production is, relatively speaking, in its initial stages. It is reasonable to assume that prices will fall once the production programme considered here has been under way for a few years. It should also be pointed out that the average rate of exchange at the time the comparison was made was 245 cruzeiros per dollar for imports of goods classified in the general category.

With respect to the question of foreign financing, which is generally contingent upon the purchase of the equipment in the countries where the funds are made available, it should be noted that in a hydro power plant equipment usually constitutes not more than 25 per cent of the total investment. Hence this is a relatively minor problem in so far as electric power generating equipment is concerned.

Apart from the portion relating to equipment, however, considerable importance is attached to financing, including funds from abroad, for plant construction work. This is a practice not yet accepted by the international credit agencies.

4. Problems of engineering and technical standards

(a) *Nature of the project*

From the outset two fundamentally different engineering operations must be considered:

(i) A civil engineering project, including a complete study of water power reserves, catchment systems, dams, spillways, run-offs and service roads. With respect to power transmission, a complete survey of the strip of land which the power lines will cross and the technical data needed to calculate the foundations of the transmission towers;

(ii) An electro-mechanical engineering project, the dimensions of all the equipment to be based on the data provided in the civil engineering project: turbines and corresponding power generators; step-up voltage transformers; sluices, pressure ducts, stop-logs, and valves; travelling and gantry cranes; circuit-breakers, switches, lightning arresters and instrument transformers; transmission towers and lines; step-down sub-stations and their equipment.

(b) *Influence of the project*

The basic conditions of an electric power plant are determined by the civil engineering project; in the case of the 1961-71 investment programme, this was drawn up by Brazilian engineers most of whom have no connexion whatsoever with foreign firms.

The method used for determining the dimensions of equipment, however, is usually quite different. Since foreign financing must be obtained, the data compiled by the civil engineers are sent to foreign groups which study them and work out the supply programme, frequently making the over-all financing contingent upon the purchase of equipment from the country providing the funds.

Since the Brazilian manufacturers of equipment are either subsidiaries of, or have close connexions with, reputable European or American manufacturers, proposals for supplying equipment usually include a few submitted for items to be manufactured in Brazil (wholly or partly, according to circumstances) but without the benefit of financing.

In some cases, where Brazilian firms are directly consulted by the purchaser—as has happened fairly often in the past two years—the dimensions of the equipment are worked out by the technical shops of the Brazilian equipment manufacturer, with or without direct assistance from the foreign firm concerned. Whatever the method, plans are drawn up for the equipment to be manufactured in Brazil and there is more and more a tendency to make use of all available local resources. This happens most of all in the case of public electric power production bodies, which by decision of the authorities, follow a policy of giving preference to Brazilian suppliers. This point will be dealt with again in the final section of the present study.

Hence, engineering is not necessarily a problem as far as the domestic share of investments is concerned, either in respect of its present high level or in the event of an increase in the domestic share.

(c) *Technical standards*

In Brazil the study and preparation of electro-mechanical construction standards has not kept pace with industrial development. Hence producers and buyers are compelled to adopt American or European standards. Because of the cost factor involved, the choice by the authors of projects of a particular standard to be used for production will largely determine the placing of the orders for equipment. American standards are the strictest, which means substantially higher costs. This sometimes places manufacturers in an unfavourable position with respect to comparison of prices and other supply conditions, since these standards are more difficult and costly to achieve under present labour and raw material supply conditions in Brazil. European manufacturers are more flexible in accepting American standards than their American counterparts in accepting others.

It is suggested that a set of standards, adapted to conditions in Brazil, should be drawn up for electrical

engineering construction and should constitute a basic pattern for future projects relating to hydro-electrical plants. In this connexion it may be added that the Brazilian Technical Standards Association (ABNT) already has a Brazilian standard for power (up to 345 kV) and distribution transformers, which closely follows the United States standard for similar equipment. Other standards are now being considered by study groups in the Association, e.g. for instrument transformers, lightning arresters for transmission and distribution systems, transformer bushings, shunt capacitators, low-voltage circuit-breakers, etc. Some manufacturers of generators and high-voltage circuit-breakers are about to request the Association to prepare standards for these items. In the same connexion, it is interesting to note that the Pan-American Standards Committee (PASC),[13] at its last meeting held at Montevideo in April 1961, decided to include standards for generators in its list of priorities. Other standards in the field of power generation and transmission to receive priority are those relating to electric power meters.

[13] PASC has its headquarters at Rio de Janeiro. Brazil is represented on it by the Brazilian Technical Standards Association.

IV. EQUIPMENT FOR IRON AND STEEL PRODUCTION

The present section deals with the probable expansion of Brazil's iron and steel production between 1965 and 1970 and the main equipment needs resulting therefrom. The period 1961-65 was not taken into account in calculating equipment requirements, because the work of expanding or constructing steel mills is prepared and carried out so far in advance of entry into production that orders for equipment relating to that period are already in hand at the time of writing or are linked to programmes currently under way.

Probable consumption of rolled steel products in 1970 had to be estimated, and this was done in relation to national per capita income. The approximate breakdown of this demand between flats and non-flats[14] also had to be calculated. The figures obtained were compared with the corresponding breakdown for other countries at the same or at a more advanced stage of development. The breakdown adopted was considered to be approximately consistent with conditions in Brazil.

The breakdown of demand by flats and non-flats is followed by suggestions for a programme to meet requirements in respect of the former, and by the adoption of a hypothesis to the effect that production of non-flats will be increased by means of new undertakings which will account for 60 per cent of requirements, leaving the other 40 per cent—about 400,000 tons—to be covered by the expansion of mills currently in production.

The proposed expansion of production of non-flats includes the sector manufacturing heavy, medium and light structural shapes, on the assumption that demand for such products is likely to be intensified in the near future. The main installations needed for this expansion are determined, and the value of the equipment is estimated at 60 million dollars.

It is calculated that an additional investment of 40 million dollars will be required in order to meet the balance of demand for non-flat products, and 14 million for flats, giving a total of 114 million dollars for investment in equipment.

It was recognized, on the strength of the knowledge available as to the plants at present capable of manufacturing equipment, that domestic manufacture was subject to certain limitations, the conclusion being that approximately 88 million dollars' worth of equipment can be manufactured in Brazil, and that imports to the value of 26 million dollars will be necessary.

Lastly, it was established that no very serious engineering difficulties are likely to arise, since Brazil already possesses the necessary resources for dealing with such problems, but that a study would have to be made of technical standards, geared to local conditions, for the domestic manufacture of iron and steel equipment.

[14] Flats comprise plate, sheet of all types (tin-plate, galvanized sheet, etc.) and strip. Non-flats are the other types of rolled steel products, such as bars, shapes, wire, rails, etc.

1. Projection of consumption of rolled steel products

It is of interest to note that when per capita income in Argentina and Chile is compared with the corresponding figure for Brazil in the period 1955-57, the results obtained are not unlike those emerging from a comparison of the same countries' average per capita consumption of steel in the same years. Average per capita income, expressed in terms of dollars at 1950 prices, was 569 and 321 dollars respectively, in Argentina and Chile, and 234 in Brazil; the corresponding coefficients are 2.43 and 1.37. Consumption of rolled steel products amounted to 70 and 36 kilogrammes per capita in Argentina and Chile and 28 kilogrammes in Brazil, the coefficients being 2.41 and 1.28. This indicates that the growth of per capita income runs approximately parallel with that of per capita consumption of steel. Again, it must be borne in mind that the limitations of the capacity to import account for the time-lag in the expansion of steel consumption in relation to the development of the factors determining demand. In these circumstances, any increase in the supplies available from domestic sources becomes very important, since it guarantees readier access to a supply that is unaffected by the problems of foreign exchange shortages and export market restrictions and thus can promote a more rapid rise in per capita consumption.

The foregoing considerations suggest the use of the increments in Brazil's per capita income in determining the possible demand for rolled steel products in 1970, due allowance being made for the steadily increasing share of domestic production in apparent consumption. In 1959 this share was 75 per cent—a proportion calculated to eliminate factors militating against the expansion of demand, such as foreign exchange shortages.

A projection of per capita income trends suggests that by 1970 the relevant figure would be the equivalent of 418 dollars; and the ratio established between demand for steel and per capita income would give an estimated per capita consumption of 72 kilogrammes by that date. Since the population is estimated at 84,442,000 inhabitants, this would imply an annual consumption of steel ingots[15] totalling 6.1 million tons.

It is particularly difficult to estimate the breakdown of total consumption of rolled steel products, as projected for 1970, by flats and non-flats. To judge from projection of the trends registered for the ratio of consumption of flats to total steel consumption in 1948-59, the figure for 1970 would be 49 per cent, although this proportion is considered very high. Nevertheless,

[15] In conformity with a trend that has recently become widespread, consumption of steel is given in terms of ingots rather than of finished products. In practice, a larger volume of non-flats than of flats is obtained from the same weight of ingots. However, this difference has not been taken into account in the present study.

it may also be noted that in Italy—with a per capita income level approximately the same as Brazil's is likely to be in 1970—the proportion in question is 39 per cent, which is less than that currently registered in Brazil. The explanation of the difference seems to lie largely in the present low consumption of structural shapes in Brazil, and hence, logically, it seems likely that this will increase considerably during the next ten years. To sum up, for calculation purposes it is postulated that the proportion of flats will rise from its present level of about 40 per cent to approximately 44 per cent by 1970.

2. Equipment required for the expansion programme in 1965-70

The steel industries in operation are currently engaged in active efforts to increase their production by 1.5 million tons in relation to the 1959 figure, which was about 1.9 million tons of steel ingots. Some plants will probably complete their expansion programme this year, but most of the projects concerned are likely to be carried out in 1962, while a small balance will remain to be completed in the first half of 1963.

At the same time, progress is being made with the construction of two big integrated mills—COSIPA and USIMINAS—programmed to be in operation in 1962 and 1963 respectively. This may raise the level of production in 1965 to 4.6 million tons of steel ingots (for a breakdown, see table 29).

Table 29. Brazil: estimated breakdown of steel production, 1965

(*Thousands of tons*)

Plant	*Steel ingots*	*Intended use*	
		Flat products	*Non-flat products*
Siderúrgica Nacional	1,300	975	325
Siderúrgica Belgo-Mineira ..	550	150	400
Grupo JAFET	400		400
Siderúrgica Mannesmann ...	320		320
ACESITA	240	40	200
Siderúrgica Barra Mansa ...	165		165
Siderúrgica Aliperti	140		140
Aços Villares	120		120
Siderúrgica Rio Grandense ..	75		75
LANARI	50		50
Cia. Brasileira de Usinas Metalúrgicas	45		45
Others[a]	200		200
TOTAL	3,605		
COSIPA	500	500	
USIMINAS	500	500	
GRAND TOTAL	4,605	2,165	2,440

N.B.—Some of the figures given in this table differ from those appearing in the corresponding table in the BNDE study entitled *Indústria Siderúrgica: Tendências da oferta e procura globais,* since this study used information furnished directly by manufacturers on their current plans.

[a] Laminação Pains, Ferro e Aço de Victoria, COSINOR etc.

(a) *Flat products*

What needs to be done is to determine how large a production increment will have to be achieved after 1965 in order to satisfy demand in 1970 (6.1 million tons), which broken down in the proportions established will probably amount to 2.7 million tons of flats and 3.4 million tons of non-flats.

According to table 29, 2,165,000 tons of ingots will be used for flats in 1965, so that by 1970 output of these products should increase by 535,000. The use of an estimated 2,440,000 tons for non-flats in the same year will entail an expansion of 960,000 tons.

In round figures, if demand is to be satisfied with domestic production, the latter will have to be increased by 500,000 tons of flats and 1 million tons of non-flats. But, as will be seen later while certain existing conditions are favourable for the expansion of the production of flats, they are not relevant in the case of non-flat products, and this raises some complications as far as the present study is concerned.

The forthcoming entry into production of the new COSIPA and USIMINAS mills, designed for rapid expansion, will simplify the problem of covering demand. These plants, which will ultimately have a capacity of 2.5 and 2 million tons respectively, will operate at the rate of only 500,000 tons in their initial stage; however, as will be shown below, a small investment will enable them to expand their production to such an extent that by 1970 they will be in a position to satisfy a high percentage of demand.

The first expansion projected by COSIPA should raise its production by 250,000 tons yearly; that is, its output will increase from 500,000 to 750,000 tons with the help of more intensive plan utilization and the addition of certain auxiliary equipment.

In order to produce 500,000 tons, the COSIPA blast furnace would have to operate on the basis of 1,238 tons daily; but it was projected for a nominal capacity of 1,650 tons per day and a maximum of 2,000 tons. If it were fed with 1,800 tons daily, enough pig iron would be produced for an annual output of 750,000 tons of steel ingots.

To enable the blast furnace to be operated at this capacity, more coke would have to be produced; this could be done by installing additional coking ovens. The increased output of pig iron would mean adding a new oxygen-producing unit; a few adjustments in the rolling-mill would also be required, as well as the expansion of certain auxiliary services, such as steam generation.

The picture is much the same in the case of USIMINAS, if this firm is to achieve an annual production increment of 250,000 tons. Its two blast furnaces, each working to begin with at a capacity of 700 tons daily, could reach 1,000 tons if a little expansion calling for a relatively small amount of investment were carried out; it would mean increasing the production of coke and oxygen and installing a new converter in the steel works, while at the same time a few changes would be introduced in the rolling-mills.

As can be seen, these expansion projects would merely involve enlargements of existing plant, and the investment in equipment they would entail is therefore low—it is estimated at the modest figure of 14 million dollars for both mills. The reasonable requirements in respect of time and capital suggest that this expansion might represent the best solution to the problem of satisfying Brazilian demand for flat products up to 1970.

(b) *Non-flat products*

Non-flats show an increment of 1 million tons in relation to 1965; that is, circumstances are favourable for the execution of USIMINAS' expansion programme for the manufacture of heavy, medium and light structural shapes.

Consumption of shapes at present stands at a relatively low level in Brazil, but this situation is likely to undergo a rapid change with the intensified use of metal structures in the building trade and the development of the shipbuilding and railway material and equipment industries, which are heavy consumers of the products in question.

TABLE 30. BRAZIL: ESTIMATED COST OF MAIN EQUIPMENT REQUIREMENTS FOR PRODUCTION OF 480,000 TONS OF HEAVY, MEDIUM AND LIGHT STRUCTURAL SHAPES BY USIMINAS

Equipment	*Cost (millions of dollars)*	*Volume (tons)*
1 battery of coking ovens with their auxiliary installations and plant for by-products	6.0	15,000
1 complete blast furnace installation, excluding ventilators	6.2	16,500
2 blast furnace ventilators	1.2	600
Expansion of steelworks to include two converters plus an additional mixer	1.8	1,300
1 battery of pit furnaces	2.5	2,700
1 blooming-mill and an auxiliary mill for billets	7.5	6,200
Annealing furnaces	2.0	1,500
1 rolling-mill for heavy and medium shapes	15.0	11,000
1 rolling-mill for light sections	2.0	1,500
Auxiliary rolling equipment, travelling cranes and buildings	9.0	
Sintering equipment	3.8	3,000
Equipment for production of oxygen	1.3	500
Auxiliary equipment in the plant	1.7	—

The expansion of USIMINAS would raise its output to 480,000 tons of shapes, for which about 600,000 tons of ingots would be required. Table 30 presents a breakdown of the main requirements of the plant for increasing production of structural shapes, together with estimates of the cost of the equipment (in dollars) and its weight (in tons). If the 250,000-tons expansion in respect of flat products and the construction of the new plant for shapes were to materialize, USIMINAS would become the steel mill with the highest capacity in Brazil, producing an annual output of 1,350,000 tons of ingots, of which 750,000 would be used for flats and 600,000 for non-flats. A balance of 400,000 tons of steel ingots for the manufacture of non-flat products would remain to be met, and of this considerable proportion would be covered by the expansion of other plants, particularly those producing special steels and tubes.

Furthermore, since it is not known how far it will be desirable to expand the steel industry on the basis of firing with charcoal, it is tentatively suggested that two small plants, each with an annual production capacity of about 100,000 tons, and designed to apply modern processes both in reduction of ore and in steel rolling, might be installed on carefully chosen sites. Perhaps the Krupp-Renn, RN or other reduction processes, together with electric furnaces and the continuous steel rolling operation, might form a combination which, from the standpoint of low investment and maximum utilization of domestic resources, would be a suitable alternative to future expansion projects based on charcoal.

Detailed study should also be given to the possibility of ultimately introducing the most up-to-date pre-reduction methods, linked to the use of electric reduction furnaces. Some of these have already been tried out on a semi-industrial scale.

In order to form a general idea of how much investment in equipment would be entailed if demand for rolled steel products were to be covered entirely by domestic production, an estimate was made of the investment requirements for the manufacture of the remaining 400,000 tons of non-flats. Since the projects concerned would consist in the expansion of existing mills or the installation of new plants using modern processes for which the investment needed is modest, the average annual figure for equipment was taken to be 100 dollars per ton, i.e. 40 million dollars in the aggregate. This figure of 100 dollars is an average obtained from estimates prepared for the expansion of selected mills in Latin America.

The over-all total for investment in equipment thus comprises the folowing items: expansion of plant for flat products in the COSIPA and USIMINAS mills, 14 million dollars; expansion of the USIMINAS plant for structural shapes, 60 million dollars; and expansion in several enterprises with a view to the manufacture of 400,000 tons of non-flats, 40 million dollars, giving a total of 114 million dollars.

3. DOMESTIC MANUFACTURE OF EQUIPMENT

(a) *Possibilities for domestic manufacture*

Except in special cases, most of the equipment needed for the expansion of the steel industry can be manufactured in Brazil. Any limitations on domestic manufacture of such equipment derive from the following factors:

(i) Specialization. This applies in the case of those highly specialized types of equipment which are undergoing a continuous process of evolution, examples being control and regulation instruments;

(ii) Demand. This is low in relation to the high investment in tools required for the manufacture of the equipment in question;

(iii) Weight factor. The heaviest parts for casting and machining are the trains for rolling-mills (blooming-mills and those producing heavy shapes), their weight being about 100 tons.

It should be pointed out that the first group does not include such control instruments as manometers, thermometers etc., which are already manufactured quite satisfactorily in Brazil.

The index of participation of domestic equipment in a steel production programme calculated to satisfy demand completely would differ as between flats and non-flats. The COSIPA and USIMINAS projects for the manufacture of flat products would carry decisive

weight in determining the purchase of a high percentage of the necessary equipment from the same source as the items originally imported, since the projects concerned imply expansions of the installations proper, such as additional coking furnaces, another oxygen-producing unit, and so forth.

The position is different in the case of the USIMINAS expansion programme for the manufacture of structural shapes, since most of the equipment items are independent and only the limitations described above would exert any influence. On the basis of the current capacity of the various plants which might manufacture such equipment, it is estimated that imports would represent under 20 per cent of the total value, i.e. about 12 million dollars.

The use of domestic equipment in expanding existing steel mills with a view to the production of 400,000 tons of non-flats might be almost 100 per cent. In other words, with the exception of control and regulation instruments, which account for a very low percentage of the total, the rest of the equipment could be manufactured in Brazil.

To sum up, investment requirements would work out at 88 million dollars for domestically-manufactured equipment and 26 million dollars for imported equipment.

(b) *Domestic equipment price levels*

Certain kinds of equipment for the steel industry have occasionally been manufactured in Brazil, but not enough data are available to permit comparison between locally-manufactured and imported items. Consequently, since the basic equipment for the iron and steel industry is similar, as regards manufacturing technique, to that used in the cement, pulp and paper and other industries, and its component parts are produced by means of the various metal transforming processes, a few figures have been prepared for purposes of reference (see table 31).

TABLE 31. BRAZIL: SOME PRICES IN THE DOMESTIC METAL TRANSFORMING INDUSTRY

Item	*Price in Brazil (cruzeiros per kilogramme)*	*"Nationalization dollar" (number of cruzeiros to the dollar)*[a]
Soldered tank in 1¼" sheet, capacity 250,000 barrels (before assembly)	45.00 to 50.00	170/175
Welded tubes, 12" in diameter and ½" thick	60.00 to 70.00	160/170
Heavy structural steel	70.00 to 75.00	160/165
Light structural steel	85.00 to 95.00	160/165
Carbon steel for welding		
Castings based on 300 kg steel ingots	70.00 to 90.00	—
Castings based on 50 kg steel ingots	80.00 to 95.00	—
Castings based on 5 kg steel ingots	90.00 to 115.00	—
Nodular cast iron		
Castings based on 300 kg ingots of pig iron	60.00 to 80.00	—
Castings based on 50 kg ingots of pig iron	70.00 to 90.00	—
Castings based on 5 kg ingots of pig iron	80.00 to 100.00	—
Forged steel parts weighing 100 kg	120.00 to 160.00	200/220
Travelling cranes, weight up to 50 tons, span 15 to 25 metres	140.00 to 160.00	180
Conveyor belts	150.00 to 170.00	185
Motors, transformers		200/250
Refractories		170/190

[a] These figures represent rates of equivalence obtained by comparing the f.o.b. factory prices for each kind of equipment in Brazil and the United States respectively.

4. PROBLEMS RELATING TO ENGINEERING AND TECHNICAL STANDARDS

The attractive prospects afforded by Brazil's increasing industrial development have induced United States and European project engineering firms of world repute, operating in the iron and steel sector, to establish branches in the country. Furthermore, in the course of the successive expansions of its Volta Redonda plant, the Companhia Siderúrgica Nacional has trained a group of project engineers who are collaborating actively on the designs submitted to them in connexion with the construction of the COSIPA works.

It may thus be assumed that future steel mill expansion projects will not give rise to any major engineering problems, since there will be enough qualified personnel in Brazil to deal with such matters. Nevertheless, the manufacture of steel-making equipment calls for a series of technical standards which do not exist in Brazil. They will have to be worked out with the help of the experience and advice of the foreign project-engineering firms. Considerable progress in this field will be an essential pre-requisite for any large-scale programme in respect of the manufacture of steel-making equipment in Brazil.

V. EQUIPMENT FOR CEMENT PRODUCTION

The same method as was used in earlier sections has again been adopted here in an attempt to determine the equipment required for the expansion of the cement industry in view of the probable growth of demand during the period 1961 to 1970.

Taking 1941 as the base year for the rate of expansion of the cement industry, and making due allowance for the growth rate of the population and average per capita consumption, a forecast was made which indicates that cement demand in 1970 will probably be 10.85 million tons as against a consumption of about 5 million tons in 1960. It was concluded that existing production capacity, enlarged by the additions already under way, would suffice to cover estimated consumption in 1962, when output and consumption will virtually balance one another at about 5.35 million tons, thereby maintaining the self-sufficiency recorded from 1956 onwards. After 1962 the cement industry is likely to need more plant to supply demand. The increase in productive capacity can be obtained either by expanding existing plants or by setting up new ones—it has been observed that demand has been covered in the past by both methods to an approximately equal extent.

It is estimated that 88,990 tons of equipment, worth 84.10 million dollars, will be needed to expand capacity. The first investments should be made in 1962-63 if production is to begin in 1964. From a technical point of view, Brazil's heavy metal-transforming industry should be quite capable of supplying a high proportion of the requirements, since except for air compressors and rotary kilns, where production presents some technical problems, the other items comprising a cement plant are not particularly difficult to manufacture. But as the industry's present production capacity is only 5,700 tons a year, it would be unable with its existing plant to supply more than 39,900 tons at the very most, out of the total required. It would also be faced with the problem of obtaining engineering services as well as with the problems of financing production and marketing the equipment.

Thus the sector manufacturing machinery for the cement industry definitely needs to be expanded if the capacity of the existing plants is to be enlarged.

1. Projection of cement consumption

Brazil's cement industry, which may be regarded as one of the pioneer basic industries, came into being in 1926 with the establishment of the Companhia Brasileira de Cimento Portland Perús. By 1956 it had achieved self-sufficiency with a production equal to 99 per cent of domestic consumption.[16] During the first six months of 1960, average daily output rose to 1,343 tons,[17] and it is believed that the proposed target of 5 million tons for the whole year was attained.[18] Average per capita consumption rose appreciably, and showed a tendency to rise at an ever-increasing pace on the basis of the highest figures for the national

[16] *Sindicato Nacional da Industria de Cimento.*
[17] P. M. Freire, *Industria de Cimento do Brasil.*
[18] Development Council, Target 22.

Table 32. Brazil: annual per capita cement consumption, 1941-59
(*Kilogrammes*)

Year	Region					Total
	North	North-east	East	South	Central-west	
1941	5.6	5.9	22.5	24.4	7.6	18.4
1942	10.0	4.4	24.9	23.4	5.8	18.7
1943	5.9	6.0	22.2	20.6	4.4	17.0
1944	7.8	5.7	27.0	24.6	7.2	20.0
1945	10.5	7.4	29.2	27.2	5.1	22.1
1946	6.8	8.2	30.6	32.8	5.0	24.2
1947	10.0	6.3	32.5	34.8	3.7	25.2
1948	10.4	8.5	33.6	42.1	5.6	26.5
1949	15.3	12.0	40.5	44.9	6.7	33.1
1950	16.7	13.1	42.6	44.2	5.8	33.9
1951	14.9	14.8	49.5	50.5	6.4	38.8
1952	13.3	13.7	52.4	63.4	6.2	43.8
1953	21.8	17.0	60.1	79.0	6.7	152.8
1954	17.3	16.0	57.9	67.4	8.0	47.8
1955	27.4	18.1	59.2	68.1	10.3	49.5
1956	23.2	18.0	64.9	72.3	18.1	53.0
1957[a]	—	—	—	—	—	54.7
1958[a]	—	—	—	—	—	60.0
1959[a]	—	—	—	—	—	60.0

Source: Associação Brasileira de Cimento Portland.
[a] *Sindicato Nacional da Industria do Cimento* (bulletin 9/60).

Figure 1

Brazil. Total and per capita cement consumption and projection to 1970

Semi-logarithmic scale

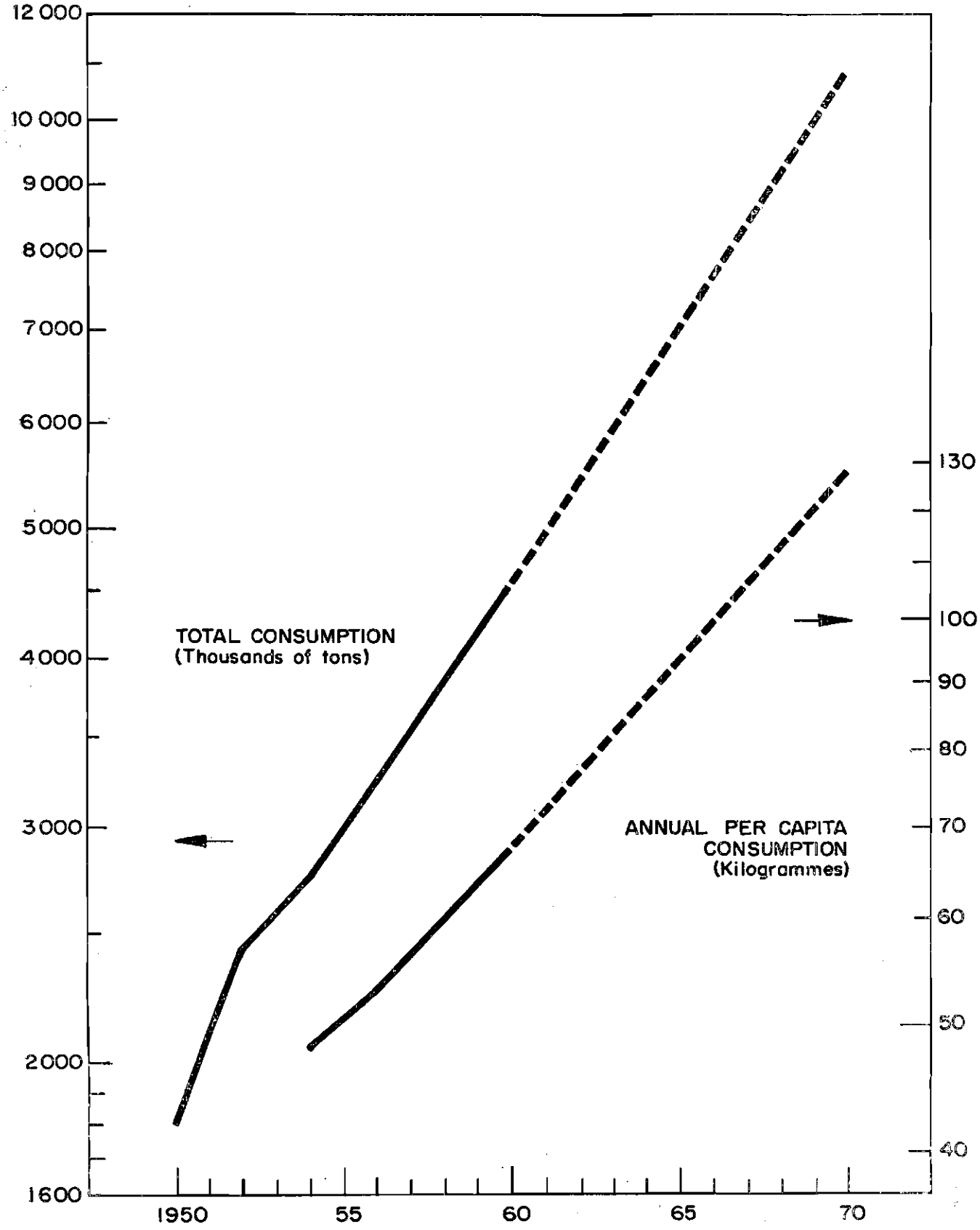


TABLE 33. BRAZIL: CEMENT CONSUMPTION BY REGIONS, 1945-65

(*Tens*)

Year	Region 1	Region 2	Total north	Region 3	Region 4	Total north-east	Region 5	Region 6	Total centre-south	Region 7 (south)
1945.....	17,620	4,136	21,756	78,844	29,666	108,510	479,204	366,556	845,760	45,487
1946.....	11,622	4,967	16,589	89,136	35,184	124,320	511,218	447,656	958,874	59,964
1947.....	17,569	3,619	21,188	70,756	35,478	106,234	554,977	466,885	1,021,862	85,408
1948.....	18,799	5,000	23,799	96,883	45,082	141,965	575,231	590,557	1,165,788	105,192
1949.....	27,566	7,956	35,522	139,244	54,721	193,965	691,070	622,359	1,313,429	125,532
1950.....	31,512	14,711	46,223	149,938	71,188	222,126	733,148	637,677	1,370,825	119,119
1951.....	28,667	12,307	40,974	179,023	56,664	235,687	915,352	765,770	1,681,122	126,826
1952.....	26,220	7,310	33,530	173,334	72,121	245,455	996,787	990,007	1,986,794	162,959
1953.....	44,083	12,868	56,951	218,384	55,433	273,817	1,174,291	1,238,002	2,412,293	246,180
1954.....	36,359	11,015	47,374	205,159	90,854	296,013	1,122,804	1,075,347	2,198,151	208,893
1955.....	61,509	11,035	72,544	244,937	100,541	345,478	1,128,020	1,097,627	2,225,647	268,221
1956.....	51,616	20,008	71,624	243,730	113,225	356,955	1,299,097	1,230,760	2,529,857	292,970
1957.....	51,364	10,258	61,622	259,066	127,418	386,484	1,353,359	1,279,958	2,633,317	276,718
1958.....	53,127	13,985	67,112	306,010	153,081	459,091	1,473,973	1,461,643	2,935,616	309,769
1959.....	53,196	17,626	70,822	258,087	154,671	412,758	1,620,971	1,451,529	3,072,500	259,937
1960.....	60,000	19,000	79,000	276,000	168,000	444,000	1,779,000	1,590,000	3,369,000	320,000
1961.....	68,000	21,000	89,000	295,000	195,000	490,000	1,956,000	1,731,000	3,687,000	363,000
1962.....	78,000	24,000	102,000	315,000	226,000	541,000	2,153,000	1,886,000	4,039,000	412,000
1963.....	89,000	26,000	113,000	337,000	262,000	599,000	2,373,000	2,056,000	4,429,000	468,000
1964.....102,000		29,000	131,000	360,000	303,000	663,000	2,619,000	2,241,000	4,860,000	531,000
1965.....116,000		32,000	148,000	385,000	352,000	737,000	2,894,000	2,446,000	5,340,000	603,000

Source: National Economic Development Bank.

Region 1: Amazonas, Pará, Acre, Amapá and Rio Branco.
Region 2: Maranhão and Piauí.
Region 3: Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas and Fernando de Noronha.
Region 4: Sergipe and Bahia.
Region 5: Minas Gerais, Espirito Santo, Rio de Janeiro, Guanabara and Goiás.
Region 6: São Paulo, Paraná, Mato Grosso and Rendônia.
Region 7: Sta. Catarina and Rio Grande do Norte.

product recorded over the last five years. This may well lead to a much more favourable rate of growth for per capita consumption in future. The following data were taken from table 32 on page 40, which shows cement consumption from 1941 onwards.

Year	Annual per capita consumption	Rate of growth[a] (%)
1952.....	43.8	—
1954.....	47.8	9.2
1956.....	53.0	10.8
1958.....	60.0	13.2
1960[b].....	68.0	13.3

[a] For two years.
[b] Estimate.

According to information from the National Economic Development Bank given in table 33, the figures for consumption in 1960 and projected demand in 1962 and 1964 are 4,212,000, 5,094,000 and 6,185,000 tons respectively. However, if it is assumed that the Brazilian population grows at the rate of 2.4 per cent annually and that there will be a moderate increase in per capita consumption, projected demand up to 1970 would be as in table 34.

TABLE 34. BRAZIL: PROJECTION OF CEMENT DEMAND

Year	Population[a] (millions)	Annual per capita consumption (kilogrammes)	Projection of demand (million tons)[b]
1960.....	66	68.0	4.5[c]
1962.....	69.5	77.1	5.35
1964.....	73.1	87.5	6.4
1966.....	76.8	99.4	7.65
1968.....	80.6	113.0	9.1
1970.....	84.5	128.6	10.85

[a] Estimate.
[b] Figure I contains the curves representing this projection.
[c] Consumption is believed to have exceeded this figure.

The figures for annual production capacity quoted in table 35 indicate recorded levels up to 1959 and those anticipated in 1960 and 1962.[19] From this table the conclusion drawn is that installed capacity in 1961 and 1962, on the basis of known plans for expansions or new plants, will be 4,869,250 tons and 5,677,250 tons respectively.

The fact that both figures tally closely with consumption projections indicates that the level of demand assumed for the purpose of evaluating equipment requirements, which is the aim of this study, will not be far from the real figure.

2. EQUIPMENT REQUIRED FOR THE CEMENT PRODUCTION PROGRAMME

The cement enterprises now operating in Brazil were planned abroad, the majority being Danish (F. L. Smidt), and the remainder American (Allis-Chalmers) and, to a lesser extent, French or Italian.

A glance at the development of cement plants in Brazil shows that the programmes for expansion of capacity approximately equal the capacity of the new units to be installed.

[19] Information supplied by the National Economic Development Bank.

TABLE 35. BRAZIL: EXPANSION PROGRAMME FOR CEMENT PRODUCTION, 1960-62

Region	Enterprise	Location	Nominal annual production capacity at 31 December					
			1955	1957	1958	1959	1960	1962
1.	Pires Carneiro S.A.	Pará	—	—	—	—	—	72,000
		— Sub-total	—	—	—	—	—	72,000
2.	—	—	—	—	—	—	—	—
		TOTAL FOR NORTH	—	—	—	—	—	72,000
3.	Cia. Paraíba de C.P.	João Pessoa—PB.	140,000	140,000	140,000	140,000	140,000	140,000
	Cia. C.P. Poty	Paulista—PE.	140,000	140,000	140,000	140,000	140,000	140,000
	Itapessoca Agro Industrial	Goiania—PE.	150,000	150,000	150,000	150,000	150,000	150,000
		Sub-total	430,000	430,000	430,000	430,000	430,000	430,000
4.	Cimento Aratú S.A.	Salvador—BA.	133,000	133,000	133,000	133,000	133,000	223,000
		Sub-total	133,000	133,000	133,000	133,000	133,000	223,000
		TOTAL FOR NORTH-EAST	563,000	563,000	563,000	563,000	563,000	653,000
5.	Cia. C.P. Itaú	Itaú de Minas	180,000	180,000	180,000	180,000	180,000	180,000
		Contagem MG.	180,000	270,000	270,000	270,000	270,000	450,000
	Cia. C.P. Ponte Alta	Uberaba—MG.	54,000	54,000	54,000	54,000	54,000	54,000
	Cia. C.P. Cauê	Pedro Leopoldo	110,000	110,000	110,000	110,000	110,000	290,000
	Cia. C.P. Barroso	Barroso—MG.	200,000	200,000	200,000	200,000	200,000	340,000
	Cia. Laminação e C.P. Paina	Arcos—MG.	—	—	—	—	75,000	75,000
	Cia. Min. de C.P. Cominci	Matozinhos—MG.	—	—	—	216,000	216,000	216,000
	Barbará S.A. Fábrica de C.P.	Cach. Itapemirim—ES.	20,000	20,000	20,000	252,000	252,000	252,000
	Cia. C.P. Paraiso	Campos—RJ.	240,000	240,000	240,000	240,000	240,000	240,000
	Cia. Nacional de C.P.	São Gonçalo—RJ.	465,000	465,000	465,000	465,000	465,000	465,000
	Cia. Cimento Vale do Paraíba	Volta Redonda	154,000	154,000	154,000	154,000	154,000	200,000
	Cia. C.P. Brasilia	Corumbá de Goiás—GO.	—	—	—	—	50,000	50,000
	Cia. P. Branco do Brasil S.A.	Rio de Janeiro—GB.	36,000	36,000	36,000	36,000	36,000	36,000
		Sub-total	1,636,000	1,729,000	1,729,000	2,177,000	2,302,000	2,848,000
6.	Cia. Bras. de C.P. Perús	Perús—SP.	401,500	401,500	401,500	401,500	401,500	401,500
	S.A. Industrias Votorantim	Sorocaba—SP.	460,000	460,000	600,000	600,000	600,000	600,000
	Cia. de Cimento Ipanema	Sorocaba—SP.	70,000	70,000	70,000	70,000	70,000	70,000
	Cia. C.P. Maringá	Itapeva—SP.	90,000	90,000	90,000	180,000	180,000	180,000
	Cimento Sta. Rita S.A.	Cotia—SP.	—	210,000	210,000	210,000	210,000	310,000
	Cia. C.P. Rio Branco	R. Branco do Sul—PR.	70,000	160,000	160,000	160,000	160,000	160,000
	Cia. C.P. Corumbá	Corumbá—MT.	90,000	90,000	90,000	90,000	90,000	90,000
		Sub-total	1,181,500	1,481,500	1,621,500	1,711,500	1,711,500	1,811,500
		TOTAL CENTRE SOUTH	2,820,500	3,210,500	3,350,500	3,888,500	4,013,500	4,659,500
7.	Cia. Cimento Brasileiro [a]	Esteio—RS.	140,000	140,000	90,000	90,000	90,000	90,000
	S.A. de CP. RGS. Cimensul	Cancas—RS.	127,750	127,750	127,750	127,750	127,750	127,750
	Cia. Catarinense de S.P.	Itajai—SC.	—	—	75,000	75,000	75,000	75,000
		TOTAL FOR SOUTH	267,750	342,750	292,750	292,750	292,750	292,750
	Brazil		3,651,250	4,041,250	4,256,250	4,744,250	4,869,250	5,677,250

Source: National Economic Development Bank.
[a] One of this plant's kilns was handed over to the Cia. C.P. Brasilia.

	Expansion (tons)	New plants (tons)
1953-55[a]	1,065,000	1,003,000
1956-57[b]	180,000	210,000
1958-60[b]	462,000	366,000
	1,707,000	1,579,000

[a] Associação Brasileira de Cimento Portland.
[b] See footnote 19.

Thus we find that demand tends to be covered in equal proportions by expansion and by the establishment of new plants. This is the premise adopted in the present study for estimating future equipment requirements despite the fact that 1961-62 marked a sharp divergence from the trend observed in the past. According to the conclusions to be drawn from table 35, the additions to capacity in 1961 and 1962 amount to 736,000 tons as against a mere 72,000 tons for new units.

Most of the kilns used have a daily capacity of 250 to 300 tons and a few of 500 to 600 tons. Exceptionally kilns capable of producing 800 tons per day, 4.2 m wide × 180 m long, are to be installed in some of the new plants that are being planned. Other characteristic items of equipment are the reducers coupled to 800-1,000 H.P. engines; these too are a very vital part of the installation.

At the present time, there are twenty-seven cement plants in Brazil, twenty-two using the wet process and five the dry process. Nearly all the cement produced is of the standard Portland type (ABNT specification EB-1), but there is also a limited output of white

cement[20] and a plant using slag from blast furnaces.[21] In view of this the only equipment discussed in the present study will be that needed to manufacture standard Portland cement by the wet process. It is believed that the indices representing the volume and value of such equipment can be used without causing any significant distortions in the figures that will form the basis of the conclusions reached in this study.

The equipment of a cement plant using the conventional wet process can be grouped in eight sections according to its general functions. Table 36 lists these items of equipment together with their relative prices and value per kilogramme in dollars. Generally speaking, the expansions involve the first five sections and some of the reducers, motors and electrical equipment, since the remaining sections are usually scaled in the original project in such a way as to permit of future enlargement.

The following data were obtained from an examination of some projects that are under way:*

1. Aratú: expansion—capacity 100,000 tons; volume of equipment: 980 tons; value of equipment: $804,800.

2. Tupí: expansion—capacity 56,000 tons; volume of equipment: 940 tons; value of equipment: $795,000.

3. Santa Rita: expansion—capacity 100,000 tons; volume of equipment: 1,680 tons; value of equipment: $1,420,000.

4. Caué: expansion—capacity 180,000 tons; volume of equipment: 3,140 tons; value of equipment: $2,600,000.

5. Barroso: expansion—capacity 140,000 tons; volume of equipment: 2,240 tons; value of equipment: $1,990,000.

6. Itaú: expansion—capacity 180,000 tons; volume of equipment: 3,000 tons; value of equipment: $2,520,000.

7. Pires Carneiro: new plant—capacity 72,000 tons; volume of equipment: 1,510 tons; value of equipment: $1,580,000.

8. Pains: new plant—capacity 75,000 tons; volume of equipment: 1,580 tons; value of equipment: $1,640,000.

9. Brasilia: new plant—capacity 130,000 tons; volume of equipment: 2,730 tons; value of equipment: $2,845,000.

10. Goiás: new plant—capacity 75,000 tons; volume of equipment: 1,190 tons; value of equipment: $1,216,000.

11. Barbará: new plant—capacity 250,000 tons; volume of equipment: 3,970 tons; value of equipment: $4,030,000.

Total expansion: 756,000 tons capacity.

Weight of equipment: 11,981 tons; value: $10,129,800.

Total new plants: 602,800 tons capacity.

Weight of equipment: 10,980 tons; value: $11,311,000.

Index value of expansion (base 100,000 tons per annum): 1,580 tons of equipment at a value of $1,340,000 (300 tons per day and $4,450 per ton per day).

Index value of new plants (base 100,000 tons per annum): 1,830 tons of equipment at a value of $1,875,000 (300 tons per day and $6,250 per ton per day).

Assuming:

(*a*) Index values of expansion projects and new plants (base 100,000 tons capacity per annum);

(*b*) Expansion capacity (50 per cent of the projected amount required to cover demand);[22]

(*c*) New plants (50 per cent of the projected capacity required to cover demand);[22]

(*d*) Estimated consumption;[23]

[20] Cimento Portland Branco do Brasil S.A. (Ducor), Rio (GB), 40,000 tons annually.

[21] Companhia de Cimento Vale do Paraíba (Tupí); slag from the Companhia Siderúrgica Nacional, Volta Redonda (RJ), 120,000 tons annually.

* National Economic Development Bank.

[22] Trend of the cement industry indicated earlier.

[23] Attempt to work out distribution on the basis of the consumption projection made in the light of projects currently under consideration.

TABLE 36. BRAZIL: RELATIVE VOLUME AND VALUE OF EQUIPMENT FOR CEMENT PRODUCTION

Section	*Equipment*	*Volume (percentage of total)*	*Value (dollars per kilogramme equivalent)*
Preliminary crushing	Conveyor feeder; hammer and jaw crushers; miscellaneous	4.0	1.10
Grinding of raw materials	Ball mills; agitators; grout elevators; miscellaneous	4.5	0.94
Grout	Homogenizing group; compressed air installations; grout elevators	30.0	0.78
Kilns	Rotary kilns; chain conveyers; tanks and burners; rotary feeders	30.0	0.78
Cement mills	Ball mills; pneumatic pumps; conveyor belts; miscellaneous	4.5	0.93
Sacking and dispatch ...	Pneumatic pumps; sackers; grout elevator (large); conveyor belts; miscellaneous	5.0	1.45
Delivery yard	Travelling crane; silos (bulk)	3.5	0.87
General	Reducers	1.9	1.40
	Electric motors and equipment	8.6	1.93
	Rolling stock for stone quarries	8.0	1.65

TABLE 37. BRAZIL: ESTIMATED DEMAND FOR CEMENT PRODUCTION EQUIPMENT, 1960-70

Year	Anticipated consumption (tons)	Installed capacity (tons)	Total[a]	Capacity to be installed		Equipment requirements for expansion		Equipment requirements for new plants		Total equipment requirements	
				Expansion (tons)[b]	New plants (tons)[b]	Volume (tons)	Value (dollars)	Volume (tons)	Value (dollars)	Volume (tons)	Value (dollars)
1960	4,500,000	4,869,250[d]									
1961	4,925,000										
1962	5,350,000	5,677,250[e]	808,000[c]	736,000	72,000	11,650	9,860,000	1,320	1,350,000	12,970	11,210,000
1963	5,875,000										
1964	6,400,000	6,477,250	800,000	400,000	400,000	6,320	5,360,000	7,320	7,490,000	13,640	12,850,000
1965	7,025,000										
1966	7,650,000	7,677,250	1,200,000	600,000	600,000	9,500	8,050,000	11,000	11,250,000	20,500	19,300,000
1967	8,375,000										
1968	9,100,000	9,177,250	1,500,000	700,000	800,000	11,100	9,400,000	14,650	15,000,000	25,750	24,400,000
1969	9,975,000										
1970	10,850,000	10,877,250	1,700,000	800,000	900,000	12,650	10,700,000	16,450	16,850,000	29,100	27,550,000

[a] Capacity to be installed in order to begin production by the year under consideration.
[b] Cumulative capacity for installation (approximate), 1955-60 (see table 35).
[c] Projects approved and under construction (see table 35).
[d] Already installed.
[e] Projects approved and in execution (see table 35).

TABLE 38. BRAZIL: EQUIPMENT REQUIRED FOR CEMENT PRODUCTION UP TO 1970

Year[a]	Expansion		New construction		Total	
	Volume (tons)	Value (dollars)	Volume (tons)	Value (dollars)	Volume (tons)	Value (dollars)
1964	6,320	5,360,000	7,320	7,490,000	13,640	12,850,000
1966	9,500	8,050,000	11,000	11,250,000	20,500	19,300,000
1968	11,100	9,400,000	14,650	15,000,000	25,750	24,400,000
1970	12,650	10,700,000	16,450	16,850,000	29,100	27,550,000
TOTAL	39,570	33,510,000	49,420	50,590,000	88,990	84,100,000

[a] Investments up to 1962 have not been considered since they relate to projects already approved and being carried out.

(*e*) Biennial programmes to make project formulation easier and enable equipment manufacture to be staggered more effectively, equipment demand may be estimated; this in principle, will have the breakdown shown in table 37.

The details given in table 38 constitute a summary of table 37.

During the period beginning in 1962-63 (so that production can start in 1964) and continuing until 1970, the following amounts should be invested:

	$	Tons of equipment
Expansion	33,510,000	39,570
New plants	50,590,000	49,420
TOTAL	84,100,000	88,990

3. DOMESTIC MANUFACTURE OF EQUIPMENT

(a) *Evaluation of production capacity*

When the equipment that comprises a conventional cement plant using the wet process is being reviewed, it is possible, by differentiating the items according to their construction characteristics, to group them by the type of metal-transforming in which each manufacturer specializes.

First group. Heavy metal-transforming, in which forged steel parts preponderate: hammer crushers; jaw crushers; ball mills; vibrating and rotating screens.

Second group. Mechanical assemblies for moving intermediate and final products: grout elevators; chain conveyors; conveyor belts; cement elevators; pneumatic conveyors; continous screw conveyors.

Third group. Boiler making, in which production of steel sheet and shapes is carried on in conjunction with machining on a large scale: agitators; homogenizing groups; rotary kilns; oil storage tanks; rotary feeders; travelling cranes; silos (metal); hoppers; cyclones, tubes.

Fourth group. Metal-transforming proper in which precision machining is the chief characteristic: fans; reducers; sackers.

Fifth group. Electro-mechanical: synchronous motors and generators; switches etc.

Sixth group. Special machinery: centrifugal and pneumatic pumps; compressors.

Seventh group. Refractory materials.

Eighth group. Instruments.

It may be said at the outset that the raw materials required for the manufacture of the above equipment can be obtained quite freely in Brazil, whatever the specifications or amounts needed. Of all the equipment listed, two items deserve special attention with respect to their manufacture in Brazil.

Air compressors. There may be restrictions on manufacture, depending on the capacity required. They will not be permanent, however, since the way in which the industry is developing indicates that high output models are going to be produced shortly.

Rotary kilns. At the present time there is one domestic manufacturer with a foreign (French) licence to manufacture kilns. The industry has the machinery and know-how to cope with technical problems arising in the course of production. There is, however, the engineering problem, to be discussed in section VI, which makes it difficult to place orders (particularly for kilns) in Brazil. The remaining equipment can be produced in the country by a number of manufacturers, the most important being those listed below, with their normal capacity and approximate production:

	Tons/year
Bardella S/A Industrias Mecanicas	1,000
Mecânica Pesada S/A	1,500
M. Dedini S/A Metalúrgica	500
Metalúrgica Atlas S/A	1,200
Máquinas Piratininga S/A	500
Others	1,000
TOTAL	5,700

No mention has been made of the manufacturers of motors, generators and other electrical equipment, since although motors of 800 to 1,000 h.p. are required, there is no limitation on their production in Brazil. If biennial demand for equipment, shown in table 37, is compared with available production capacity, the figures given in table 39 are obtained.

TABLE 39. BRAZIL: DOMESTIC MANUFACTURE OF EQUIPMENT FOR CEMENT PRODUCTION UP TO 1970

(*Tons*)

Year	Estimated demand	Production capacity	Difference
1962.....	12,970	11,400	—1,570
1964.....	13,640	11,400	—2,240
1966.....	20,500	11,400	—9,100
1968.....	25,750	11,400	—14,350
1970.....	29,100	11,400	—17,700

Even if it is assumed that the heavy metal-transforming industry will develop progressively as the result of a normal and unplanned expansion of about 10 per cent annually, there will still be a sizable gap between production capacity and the requirements of the programme outlined.

It will be necessary to have a properly planned and specially financed development process with a growth rate considerably higher than 15 per cent annually if potential production is to keep approximately abreast of demand. However, this contention should be weighed in relation to manufacturing orders for the other types of equipment to be placed with the heavy metal-transforming industry.

At the present time, because of financing difficulties and in many cases, engineering problems as well, the great bulk of equipment is imported. Nevertheless there is a tendency for an increasing proportion to be ordered from domestic manufacturers. One example is the Companhia de Cimento Portland Brasilia, which has restricted its imports to rotary kilns and a few items of minor importance.

(b) *Price level of domestically-manufactured equipment*

As most equipment has been imported up to now, it is difficult to make a valid comparison with local prices. Nevertheless the following averages based on a knowledge of the current situation as regards fairly similar manufactures may give a rough idea:

	Cruzeiros to the dollar
Crushers and mills	180 to 200
Screens	170 to 190
Conveyors	165 to 190
Cover cranes	175 to 185
Rotary kilns	200 to 220
Tanks and metal silos	170 to 175
Fans	160 to 180
Reducers	170 to 200
Pumps and compressors	210 to 230
Electric motors and generators	230 to 260
Refractory materials	170 to 190

On an average the rate of conversion may be taken as 200 cruzeiros to the dollar for ex-factory prices.

It is advisable to bear in mind the incidence of sea freight charges on prices, which will favour the conversion rate.

4. Engineering problems

First of all, some data relating to the organization and manufacturing processes of current cement producers should be examined.[24]

Installed capacity in 1960	4,869,250 tons
Number of plants in production	27
Manufacturing process:	
Dry	5
Wet	22
Sources of engineering services:	
Denmark	17
United States	5
France and Italy	3
Others	2
Fuel utilized:	
Fuel oil	26
Natural gas (petroleum)	1
Average productivity	150 kg per man/hour
Approximate cost of engineering services in relation to investment in equipment	6-8 per cent

The main characteristic, as far as engineering problems are concerned, that appears to distinguish this sector from the other sectors manufacturing heavy equipment considered in this study, is the extremely small number of manufacturers that have acquired the requisite know-how. There are not more than three or four whose equipment has a world-wide reputation —which at once makes it more difficult for agreements to be concluded on assistance based on the payment of royalties. This feature of the world market for cement equipment has led manufacturers to believe that agreements for the introduction of engineering services would immediately bring about a sharp reduction in export possibilities. For this reason the engineering has been done abroad up to the present. But the increasing difficulty of importing equipment is tending to attract this important technical branch of activity to Brazil, despite the opposition on the part of the manufacturers. According to information obtained from ABDIB, one equipment manufacturer has already signed an agreement with a French group, and a second is studying ways and means of reaching a similar agreement elsewhere in Europe.

Meanwhile there is a wide field open to exploration by Brazilian firms that specialize in this line, since, as engineering represents nearly 7 per cent of the value of investment in equipment, there will be a potential market of almost 6 million dollars for this type of operation in the next decade.

[24] *Sources:* P. M. Freire, *Industria de Cimento do Brasil; Associação Brasileira de Cimento Portland;* National Economic Development Bank.

VI. EQUIPMENT FOR PULP AND PAPER PRODUCTION

This section follows the same general scheme as was adopted for the preceding sections. Owing to the large variety of products which the present sector comprises and the fact that both finished goods and corresponding raw materials are included, they had to be grouped together so that they could be studied both for projection purposes and for the subsequent evaluation of machinery and equipment requirements. The degree of approximation adopted as a working hypothesis should not affect the conclusions of the analysis to any great extent.

In studying paper demand a distinction was made between newsprint, printing and writing paper, and other types of paper and board, the basic values taken being the consumption projections made for 1965 and 1975 by the ECLA/FAO/BTAO Pulp and Paper Advisory Group. It is expected that by 1970 the domestic market will need 460,000 tons of newsprint, 325,000 tons of printing and writing paper, and 800,000 tons of other paper and board; in aggregate terms this implies an annual growth rate of 6 per cent between 1960 and 1970. As regards production, in view of the Government's intention to stimulate the development of the pulp and paper industry and achieve greater self-sufficiency, it was estimated that by the end of the decade domestic production would be able to satisfy 80 per cent of the demand for newsprint, 90 per cent of the demand for printing and writing paper, and practically the whole of the demand for other types of paper and board.[25]

Given these assumptions on the coverage of paper demand, the corresponding production requirements in 1970 would be nearly 360,000 tons of mechanical pulp and 860,000 tons of the different chemical and semi-chemical pulps. A review of the country's possibilities of producing the necessary fibrous materials indicates that domestic industry will be able to provide all the mechanical pulp and short-fibre chemical pulp consumed and nearly 62 per cent of long-fibre pulp. A more conservative position was adopted because there is little certainty at the moment about the potential reserves of softwood. In order to give a more rounded picture, pulp demand for rayon manufacture was also taken into consideration. It is expected that this will be met by domestic production from the second half of the decade onwards.

On the basis of the foregoing it was estimated that the machinery and equipment needed during the next ten years to reach these production targets would amount to 91,851 tons, with a value of about 159.5 million dollars. From a comparison of these figures with the production capacity of the domestic metal-transforming industry, it seems clear that the industry will be able to deal with equipment demand during the first five years but will show a deficit of some 2,200 tons annually during the second half of the period. However, the expansion plans contemplated by the different firms specializing in metal-transforming should suffice to cover requirements in the last five years as well. There are no sizable shortages of raw materials and no particular limitation on the industry's capacity to machine the large components that might be required for manufacturing the equipment in question. The only doubt that arises in this respect concerns the advisability of undertaking production of newsprint machinery in Brazil in view of the fairly small scale of demand. Apart from this reservation, the metal-transforming industry as a whole would be in a position to manufacture equipment and machinery to the value of 142.1 million dollars, which represents 90 per cent of total estimated requirements during the next ten years.

As far as prices are concerned, the industry appears to be fairly well equipped to compete with its foreign counterparts, if a nationalization dollar equivalent to about 200 cruzeiros is tentatively assumed to be representative for all the products manufactured by that industry.

The section ends with a reference to the engineering problems involved in the establishment of pulp and paper mills and the manufacture of specialized equipment, and the conclusion is reached that the introduction of foreign know-how, as in the last few years, is providing a satisfactory solution.

[25] During the final stage of preparation of this study, Decree 204 of the Currency and Credit Authority was promulgated, whereby exchange rates for imports of printing paper were fixed or adjusted. This will double the cost of such imports and thus open up even more favourable prospects for local production than those indicated in this study.

TABLE 40. BRAZIL: PROJECTION OF PAPER DEMAND, 1961-70

(*Thousands of tons*)

Year	*Newsprint*	*Printing and writing paper*	*Other paper and board*	*Total*
1961	265	185	440	890
1963	300	210	510	1,020
1965	334	235	571	1,140
1967	390	270	665	1,325
1970	460	325	800	1,585

1. PROJECTION OF PULP AND PAPER CONSUMPTION

(a) *Paper consumption*

Paper demand in 1961-70 was estimated on the basis of the projections for 1965 and 1975 made by the ECLA/FAO/BTAO Pulp and Paper Advisory Group in its regional study. These projections were effected by applying the coefficient of elasticity of demand for paper to output estimates for the two years in question, obtained from a general correlation for all the Latin American countries, Canada and the United States. By interpolation between these figures and the level prevailing in 1959, a demand series for 1961-70 was worked out, as indicated in table 40, from which it may be seen that paper consumption will probably increase about 80 per cent on an average during the next decade, i.e. at an average annual rate of growth of 6 per cent.

Before fibrous materials are considered, it should first be decided what share of demand for each type of paper is likely to be covered by the domestic paper industry.

(i) *Newsprint.* In recent years, local production of newsprint has been covering nearly 30 per cent of internal consumption, which amounted to 212,000 tons in 1959. One large plant supplies 200 tons per day and there are also five other plants of lesser capacity. At the present time it is impossible to give a reliable picture of the trend which this production will take in the next ten years since there are no definite projects on hand at present for the establishment of new plants. The only development actually taking place is the expansion of the biggest enterprise, which will enable it to increase its output in 1962-63 to 150,000 tons a year. For the purposes of this study, it has been assumed that by 1965 the project for a new plant with a daily capacity of 200 tons which has long been under study may have materialized. If so, domestic newsprint production would climb to nearly 220,000 tons by 1965 and cover almost 65 per cent of estimated consumption. For the five-year period 1965-70 a conservative production increment of some 150,000 tons was estimated, i.e. approximately the same in absolute terms as the figure accepted for the previous five years. The manufacturing level in 1970 would thus stand at 370,000 tons, supplying nearly 80 per cent of demand.

(ii) *Printing and writing paper.* Nearly 80 per cent of the volume consumed was supplied by domestic industry up to 1960. It is estimated that by 1970 the industry's contribution will have increased to 90 per cent of demand.

(iii) *Other paper and board.* During the next ten years the situation here is expected to remain the same as in the past, i.e. domestic production will supply almost 98 per cent of consumption. On the basis of these suppositions, the trend of paper production up to 1970 will be as in table 41.

TABLE 41. BRAZIL: TREND OF PAPER PRODUCTION AND ITS COVERAGE OF TOTAL DEMAND, 1960-70

	Newsprint		*Printing and writing paper*		*Other paper and board*	
Year	*Production (thousands of tons)*	*Percentage of demand*	*Production (thousands of tons)*	*Percentage of demand*	*Production (thousands of tons)*	*Percentage of demand*
1960.....	75	31	135	80	400	98
1965.....	220	65	200	85	560	98
1970.....	370	80	290	90	780	98

In order to determine how much additional production capacity will be needed and on that basis to estimate the corresponding machinery and equipment requirements, the different types of paper were divided into two major categories, one consisting of nothing but newsprint and the second comprising all other types of paper and board.

As already stated in relation to newsprint, current production capacity will have to be increased up to 1965 by 250 tons daily and by the establishment of a new factory of 200 tons a day capacity. The expected increment of 150,000 tons between 1965 and 1970 will probably be covered by two other new mills each of 200 to 300 tons daily capacity.

As regards other types of paper and board, a production increment of 225,000 tons is expected between 1960 and 1965 and of 310,000 tons in the following five years. It is not known at the moment whether there are any plans to set up new mills, and it has been assumed that the production increments envisaged during the period under consideration will come from an expansion in existing capacity—a total of sixty-one mills—since average mill size is at present very small and the trend is likely to be towards larger units in future. In any case, this assumption gives some idea of minimum machinery requirements for the smaller volume of investment needed to expand capacity as against requirements in the case of new mills.

(b) *Paper pulp consumption*

The volume of paper production indicated in the preceding paragraph would require the amounts of mechanical and chemical pulp shown in table 42.

TABLE 42. BRAZIL: MECHANICAL, CHEMICAL AND SEMI-CHEMICAL PULP REQUIREMENTS, 1960-70

(Thousands of tons)

		Chemical and semi-chemical pulp		
Year	*Mechanical pulp*	*Long-fibre*	*Short-fibre*	*Total*
1960.....	100	205	130	335
1965.....	230	310	280	590
1970.....	360	375	485	860

Mechanical pulp requirements will be entirely supplied by domestic production. The major proportion of this fibre furnish will be consumed in newsprint

manufacture, of which pulp production is an essential part. Much of the coverage of future requirements will therefore be undertaken by the newsprint mills that are being set up in the country. Investment in machinery for mechanical pulp manufacture was considered in conjunction with that for newsprint, on the assumption that the whole output would come from the newsprint sector. In making this assumption, however, due account was taken of the requirements of the small-scale producers of mechanical pulp, representing the balance of demand deriving from the processing of other paper and board.

It is estimated that chemical pulp production capacity was 130,000 tons of short-fibre pulp in 1960, including semi-chemical, and 100,000 tons of long-fibre pulp. Projects that will definitely be ready by the end of 1965, comprising both expansion of existing mills and the establishment of new units, will raise capacity to 280,000 tons of short-fibre pulp and 230,000 tons of long-fibre pulp (see table 43).

TABLE 43. BRAZIL: ANTICIPATED TREND OF CHEMICAL PULP PRODUCTION CAPACITY UP TO 1965
(*Thousands of tons*)

	Situation in 1960		*Anticipated increases in capacity, 1961-65*			*Situation in 1965*	
				New mills			
Pulp	*Number of mills*	*Capacity*	*Expansion of capacity*	*Number*	*Capacity*	*Number of mills*	*Capacity*
Short-fibre	18	130	85	2	65	20	280
Long-fibre	22	100	80	1	50	23	230

With respect to the situation between 1965 and 1970, no definite information is available on expansion plans. It was therefore provisionally assumed that output of short-fibre chemical pulp would keep abreast of demand, and that no expansion would be made in manufacturing capacity for long-fibre pulp in view of the present uncertainty as to whether soft-wood resources are large enough to meet the needs of expanded production.[26] This means that during those five years, short-fibre pulp production capacity should be stepped up by almost 200,000 tons, which would be feasible through the establishment of two or three new mills with a daily capacity of 200 to 300 tons. Self-sufficiency in short-fibre pulp would thus be maintained throughout the period in question, whereas long-fibre pulp production would amount to only 74 and 62 per cent of demand in 1965 and 1970 respectively, and some 80,000 and 145,000 tons would have to be imported to cover estimated requirements.

In addition to pulp demand deriving from paper manufacture, pulp consumption in rayon manufacture is also covered in this study. It was estimated that this would increase from about 64,000 tons in 1960 to a maximum of 96,000 in 1965 and 1970, and that domestic industry would supply all requirements. To do so, production capacity would have to be some 35,000 tons higher by 1965, which means that a unit capable of turning out 100 tons per day would have to be installed.

[26] The possibility of using the sisal or abaca resources of North-eastern Brazil should be considered in relation to long-fibre pulp production.

2. EQUIPMENT REQUIRED FOR THE PULP AND PAPER PRODUCTION PROGRAMMES

The production programmes for 1961-70 which will be considered in this study for the purpose of determining equipment demand in the next few years are given in table 44. In such a complex sector as that under consideration, which produces a wide range of types and qualities of goods, and uses a variety of manufacturing processes and raw materials, the evaluation of machinery requirements for production programmes such as those proposed cannot be more than an approximation based on general coefficients. To enter into greater detail with a view to achieving a higher degree of accuracy would be meaningless, particularly without any background information on the circumstances and technical conditions governing the implementation of

TABLE 44. BRAZIL: PULP AND PAPER PRODUCTION PROGRAMMES FOR 1961-70

	1961-65 capacity		*1966-70 capacity*	
	Daily (tons)	*Annual (thousands of tons)*	*Daily (tons)*	*Annual (thousands of tons)*
I. Newsprint				
Expansion	250	85	—	—
New mills	200	70	450	150
II. Other paper and board				
Expansion	660	225	900	310
III. Mechanical pulp				
New mills	(Included under newsprint mills)			
IV. Chemical and semi-chemical pulp				
Expansion	500	165	—	—
New mills	340	115	600	205
V. Pulp for rayon				
New mills	100	35	—	—

these projects. For the purposes of this study, the investment coefficients adopted, as specified in tables 45 to 48, are considered to have reached a reasonable degree of approximation that will not invalidate the conclusions drawn therefrom. Thus, in the case of newsprint, a mill with a daily capacity of 200 tons was taken as a representative example for estimating machinery and equipment requirements. The details given in table 45 show that such a unit would need 17.4 million dollars' worth of equipment, with a total weight of 9,558 tons, the average unit price therefore being 1.82 dollars per kilogramme.

TABLE 45. BRAZIL: INVESTMENT IN MACHINERY AND EQUIPMENT FOR A NEWSPRINT MILL[a]

	Value of equipment (thousands of dollars)	*Unit price (dollars per kilogramme)*	*Volume of machinery and equipment (tons)*
1. Mechanical pulp section	3,860	1.54	2,505
2. Equipment for preparing paper pulp	740	1.80	410
3. Paper machines, including winders	8,300	2.40	3,460
4. Finishing section	120	2.50	48
5. Electric motors and cables	440	2.00	220
6. Pipes and connexions	650	1.00	650
7. Water supply and distribution	700	1.30	540
8. Steam and electricity plant	2,590	1.50	1,725
TOTAL	17,400	1.82	9,558

[a] Daily capacity of 200 tons, including a section for manufacturing mechanical pulp.

As regards other paper and board, is was considered that expansions only would be undertaken. Table 46 gives a detailed list of the investment required in additional machinery and equipment, amounting to 34,000 dollars in value and 15.9 tons in weight for each additional ton of daily production capacity.

TABLE 46. BRAZIL: INVESTMENT IN MACHINERY AND EQUIPMENT FOR THE EXPANSION OF A PAPER MILL (EXCLUDING NEWSPRINT)[a]

	Value of equipment (dollars per daily ton of paper)	*Unit price (dollars per kilogramme)*	*Volume of machinery and equipment (dollars per daily ton of paper)*
1. Machinery for preparing paper pulp	3,160	1.80	1.8
2. Paper machines including winders	26,000	2.40	10.8
3. Finishing section	310	2.50	0.1
4. Electric motors and cables	900	2.00	0.5
5. Pipes and connexions	460	1.00	0.5
6. Water supply and distribution	750	1.30	0.6
7. Steam and electricity plant	2,420	1.50	1.6
TOTAL	34,000	2.14	15.9

[a] The total investment required for the establishment of a mill to manufacture paper other than newsprint is estimated to be nearly 80,000 dollars per daily ton of capacity on an average and 55,000 dollars for expansion of a mill. Approximately 60 per cent of these figures corresponds to machinery and equipment.

TABLE 47. BRAZIL: INVESTMENT IN MACHINERY AND EQUIPMENT FOR A PULP MILL[a]

	Value of equipment (thousands of dollars)	*Unit price (dollars per kilogramme)*	*Volume of machinery and equipment (tons)*
1. Wood storage and processing	360.0	1.10	327.0
2. Digester department	525.0	1.60	328.0
3. Washing and screening	425.0	2.00	212.5
4. Bleaching department	215.0	1.80	119.0
5. Electrolytic plant	385.0	1.95	197.5
6. Drying and finishing	610.0	2.10	290.0
7. Evaporation and soda recovery	1,205.0	1.60	753.0
8. Recausticizing department	485.0	1.40	345.5
9. Steam and electric power	800.0	1.50	533.0
10. Water supply and distribution	200.0	1.30	154.0
11. Pipes and connexions	100.0	1.00	100.0
12. Electric motors and cables	255.0	2.00	127.5
TOTAL	5,565.0	1.60	3,487.0

[a] In this case a mill of 100 to 150 tons daily capacity operating on the sulphate process was taken as typical. On the assumption that approximately half the future production of chemical pulp (including rayon pulp) will be bleached, the investment figure adopted was the mean of the figures for mills with and without bleaching departments.

TABLE 48. BRAZIL: INVESTMENT IN MACHINERY AND EQUIPMENT FOR THE EXPANSION OF A PULP MILL[a]

	Value of equipment (dollars per daily ton of pulp)	*Unit price (dollars per kilogramme)*	*Volume of machinery and equipment (dollars per daily ton of pulp)*
1. Wood storage and processing	1,800	1.10	1.6
2. Digester department	2,750	1.60	1.7
3. Washing and screening	2,400	2.00	1.2
4. Bleaching department	1,200	1.80	0.7
5. Electrolytic plant	1,500	1.95	0.8
6. Drying and finishing	3,250	2.10	1.6
7. Evaporation and soda recovery	2,850	1.60	1.3
8. Recausticizing department	1,600	1.40	1.1
9. Steam and electric power	2,300	1.50	1.5
10. Water supply and distribution	700	1.30	0.5
11. Pipes and connexions	450	1.00	0.5
12. Electric motors and cables	1,200	2.00	0.6
TOTAL	22,000	1.70	13.1

[a] The expansion of current operating capacity is estimated to cost 22,000 dollars per daily additional ton.

For pulp, a mill using the sulphate process with a daily capacity of 100 to 150 tons was considered to be sufficient. As about half the future output will be bleached, it was decided to adopt as the investment figure one midway between those for investment in mills with and without bleaching facilities respectively. As may be seen from table 47 the equipment for this mill type would be worth 5,565 million dollars and weigh 3,487 kilogrammes, its average unit price per kilogramme therefore being 1.60 dollars. The equipment required to expand capacity was estimated at 22,000 dollars per daily ton of additional pulp production capacity, which represents 13.1 tons of machinery at an average price of 1.70 dollars per kilogramme (see table 48). The application of these machinery investment coefficients to the programmes for pulp and paper manufacture indicated that machinery and equipment requirements from 1961 to 1970 would be as in table 49.

TABLE 49. BRAZIL: MACHINERY AND EQUIPMENT REQUIREMENTS FOR PULP AND PAPER PRODUCTION PROGRAMMES, 1961-70

(*Volume in thousands of tons, value in thousands of dollars*)

	Newsprint (including mechanical pulp)		*Other paper and board*		*Chemical and semi-chemical pulp*		*Total*	
	Volume	*Value*	*Volume*	*Value*	*Volume*	*Value*	*Volume*	*Value*
1961-65	19,116	34,800	10,494	22,440	21,893	35,486	51,503	92,726
1966-70	19,116	34,800	14,310	30,600	20,922	33,390	54,348	98,790
TOTAL	38,232	69,600	24,804	53,040	42,815	68,876	105,851	191,516

The figures in table 49 show that total demand for the equipment needed by the programme to expand the pulp and paper industry will reach a sum equivalent to 191.2 million dollars in the next ten years, divided almost equally between the two half decades. However, the figures for the first five-year period must be adjusted to some extent if real potential demand for equipment is to be ascertained, since they include projects that have been approved or are under way. It is estimated that the machinery already imported or to be imported for the implementation of these projects represents almost 32 million dollars in value and about 14,000 tons in weight. If these amounts are subtracted from those estimated for total requirements, real equipment demand in 1961-70 will be 159.5 million dollars in value and 91,851 tons in weight. For the first five years, the figure will be 37,503 tons of machinery, with a value of 60.7 million dollars.

3. DOMESTIC EQUIPMENT MANUFACTURE

(a) *Evaluation of production capacity*

The manufacture of machinery for pulp and paper mills is undertaken in Brazil by four large firms capable of constructing entire plants and by various other firms which manufacture individual items of equipment. The total production capacity of these firms is approximately 4,100 tons of finished goods annually, broken down as follows:

	Tons per annum
Companhia Federal de Fundiçao	1,500
Mecânica Pesada S.A.	1,000
Indústria Mecânica Cavallari S.A.	800
Bardella S.A. Indústrias Mecânicas	600
Others	200
TOTAL	4,100

It should be remembered that this capacity comprises only machinery and equipment specifically required in paper and pulp production, and excludes productive elements used by various other industries as well, such as electric motors and apparatus, boilers, tubes and connexions, conveyor belts etc., for which specialized plants with sufficient production capacity exist in Brazil. If these pieces of equipment are deducted from the figure for total machinery demand given in table 49, results are obtained for machinery specifically used in

pulp and paper production, and these are compared with production capacity in table 50.

TABLE 50. BRAZIL: COMPARISON BETWEEN PRODUCTION CAPACITY AND REQUIREMENTS OF SPECIFIC PULP AND PAPER MACHINERY, 1961-70

	Machinery production capacity (tons)	Demand	
		Volume (tons)	Value (millions of dollars)
1961-65	20,500	18,500	35.5
1966-70	20,500	31,700	65.0
TOTAL	41,000	50,200	100.5

Before any comments are made on the conclusions to be drawn from the comparison in question an explanation should be given with respect to the volume indicated for capacity of the domestic industry. This represents the amount of the final products (in tons) delivered to the users of the equipment in question and therefore includes the weight of the component parts which currently have to be imported. Most of these are used in the construction of continuous paper machines and consist of special cylinders for winders and suction presses, some calender cylinders, recording and control apparatus, and bearings. Inquiries instituted by the Brazilian Association for the Development of Basic Industry (ABDIB) to determine the scale of these imports have shown that they fluctuate from 12 to 20 per cent in value and from 4 to 8 per cent in weight. These percentages constitute such a small part of the total tonnage of equipment needed for the programme that it was not thought necessary to correct the figures accordingly, since the corrections are unimportant in relation to general assumptions adopted in the study.

From a study of the figures in table 50 the inference to be drawn is that during the first five-year period the capacity of domestic industry will be sufficient to satisfy anticipated demand for equipment, but that in the second five-year period there will be a deficit of some 11,000 tons, i.e. 2,200 tons a year, which is equivalent to 54 per cent of present capacity.

It is thought that the expansion planned by the manufacturing firms named above will be sufficient to cover the deficit in future. But to ensure that this will take place, the development of the pulp and paper industry should be programmed in advance so that orders for equipment can be placed in good time, thereby preventing demand from exerting undue pressure on equipment manufacturers, many of whom have to meet orders from other sectors as well, such as the petroleum, electric power and cement industries.

There will be no limitation as regards the size of the parts required for pulp and paper machinery in future either, as the manufacturers' plans for expansion include the purchase of large machine tools which will enable all machine-part requirements to be satisfied, inlcuding even larger sizes than those needed for pulp and paper machines.

The only doubt that arises in this respect concerns the advisability or otherwise of manufacturing newsprint machines in Brazil. In view of the technical characteristics of these machines and the small number likely to be ordered during the period under consideration, their manufacture is probably economically unjustifiable.[27] Subject to this possible limitation, production of machines for the paper and pulp industry will be 83.1 million dollars in value and 42,900 tons in weight, i.e. about 83 per cent of the value of estimated requirements in the next decade. Thus during the second half of the decade the gap in capacity will be reduced from about 2,200 to 1,300 tons annually. The metal-transforming industry as a whole will therefore be able to supply 142.1 million dollars' worth (90 per cent) of the machinery required to expand and establish pulp and paper mills, which is estimated at 159.5 million dollars.

(b) *Price level of domestically-produced equipment*

On the whole, manufacturing prices stand at reasonable levels. They are definitely favourable in the case of all equipment for which only domestic raw materials are used and which are not mass-produced. But the need to import such raw materials as stainless steels and copper—chiefly for brass alloys—which are required for certain machines, and the small scale of some production series, are tending to aggravate the situation as far as certain types of equipment are concerned. The financing difficulties by which equipment manufacturers are currently beset, on the one hand, and the long-term foreign loans obtained by the users of such equipment, on the other, have been mainly responsible for the importation of equipment that could have

[27] According to information obtained after this study was finished, it may be possible to manufacture newsprint machines domestically, since they do not differ substantially from those used in the manufacture of other types of paper. The same sources indicate that domestic production of such machines may ultimately have a nationalization index of 80 to 85 per cent in value and 85 to 90 per cent in weight.

TABLE 51. BRAZIL: PRICES OF SELECTED ITEMS OF PULP AND PAPER MACHINERY MANUFACTURED IN BRAZIL

	Price in Brazil (cruzeiros per kilogramme)	Ex-factory price United States (dollars per kilogramme)	Nationalization dollar (cruzeiros per dollar)[a]
Digesters	150 to 170	1.00	160 to 170
Stock pumps: cast iron	280 to 310	1.50	180 to 210
Stock pumps: brass	560 to 620	2.10	260 to 280
Centrifugal screens	600 to 800	3.10	190 to 230
Refiners	420 to 500	2.20	200 to 230
Selectifier screens	830	4.40	188

[a] These figures represent rates of equivalence obtained by comparing the f.o.b. factory prices for each kind of equipment in Brazil and the United States respectively.

been manufactured in Brazil, and this has been instrumental in restricting production series even further. The favourable price situation enjoyed by this industry is confirmed by the fact that it is exporting a certain amount of equipment in competition with foreign firms. A rough check can be made on the foregoing statements by comparing the price per kilogramme of some items of machinery manufactured in Brazil, as listed in table 51, with those of similar imported products. Although no definite conclusions can be reached from table 51 with respect to the competitive status of domestic industry, an average production dollar of nearly 200 cruzeiros may be taken as representative of machinery and equipment manufactured in Brazil.

4. Engineering problems

In the installation of a pulp and paper mill, engineering services represent from 5 to 8 per cent of the value of the machinery and equipment. At the international level there are many reputable firms, which fall into two clearly distinguishable groups: a small group which renders services independently of equipment production, and another larger group connected with machinery production and licensed to manufacture many of the items.

On different occasions both groups have been active in Brazil, and during the last few years various firms connected with the construction of machinery have established themselves there or have granted manufacturing licences to local firms. Thus the following foreign companies providing engineering services for the installation of complete units are now to be found in Brazil: Black-Clawson (United States) represented by the Companhia Federal de Fundiçao (branch); J. M. Voith (Germany), associated with Bardella S.A. Indústrias Mecânicas; Millspaugh Ltd. (United Kingdom) connected with Indústria Mecânica Cavallari S.A. (technical assistance): Escher Wyss GMBH (Germany) represented by Mecânica Pesada S.A. In the near future these firms may be joined by another important United States company which is already taking the first step to establish itself in Brazil.

In view of the prestige of these firms, and the production capacity and experience of the local firms representing them, it seems fair to say that engineering problems deriving from the establishment of new mills or the construction of the requisite machinery are being satisfactorily solved in Brazil. It may be added that in a number of mills constructed recently, all the calculations of equipment dimensions and other problems deriving from the construction itself were handled by engineers belonging to the firms' staff, who have already acquired a wide experience and technical knowledge in their field.

VII. SOME GENERAL PROBLEMS RELATING TO THE MANUFACTURE OF BASIC EQUIPMENT

1. Brazil's basic equipment requirements for the 1961-70 decade

In the previous sections an attempt has been made to project the growth of demand for the end products in the petroleum derivatives, electric power generation, steel production, cement, and pulp and paper manufacturing sectors, with a view to evaluating the equipment requirements arising out of expanded production in these sectors. The annual demand estimated for these products was translated into terms of the industrial equipment required to make this production possible.

These estimates showed the probable over-all demand for equipment in the 1961-70 decade to ensure the necessary expansion in the five basic production sectors considered, as being in the neighbourhood of 905.7 million dollars at current prices, broken down as follows:

	Millions of dollars
Petroleum derivatives	138.1
Electric power (1961-71)	410
Steel (1966-70)	114
Cement	84.1
Paper and pulp	159.5
TOTAL	905.7

The sectoral data on which this over-all demand for equipment is based are summarized below.

(a) *Petroleum derivatives*

On the basis of the projection prepared by the National Petroleum Council, adjusted by the adoption of more conservative growth rates (principally in view of the higher sales prices resulting from the exchange reform), the following figures were arrived at for probable consumption in 1970: 390,000 barrels per day of crude petroleum, 110,500 of motor spirit, 76,000 of Diesel oil ond 111,000 of fuel oil. For 1960 the corresponding figures were 260,500, 52,600 and 82,100 barrels per day, respectively; this gives a growth of about 40 to 50 per cent by the end of the decade.

The existing refinery plant, together with the expansion now under way at the Cubatão and Mataripe refineries, and the new refinery at Duque de Caxias, almost completed, will be sufficient to meet the demand for petroleum derivatives up to 1962, when the demand should reach the level of 295,000 barrels per day. From 1963 on, a new refinery, with a capacity of between 30,000 and 40,000 barrels per day, will be needed, together with the use of the national petrol contained in the gases of the Recôncavo (Bahia) oilfields, if the present policy of keeping the country self-sufficient with respect to petroleum refining capacity is to be followed.

In addition the problem of transporting petroleum and petroleum derivatives was considered; this will involve the construction of terminals and pipelines for São Paulo and Belo Horizonte, and the terminal for Ilhéus. Furthermore, account was taken of plant for the petrochemical industries, such as the production of synthetic rubber and plastics. The estimates obtained gave a figure of 138 million dollars as representing the equipment needs for the expansion in question.

(b) *Generation of electric power*

Assuming an annual growth rate of approximately 10 per cent in the demand for electric power, as indicated in the studies conducted by the Development Council, the projection carried out shows a probable demand by the end of the period of approximately 13,148 MW—which should be fully met by the work already under way on expansion of installed capacity—together with other hydroelectric projects already drawn up, and calculated, if successfully completed, to raise the installed capacity level to 14,078 MW.

If account is taken only of equipment to be produced by the metal-transforming industry for generating energy, requirements for the carrying out of the expansion planned are estimated at 410 million dollars.

(c) *Steel products*

The survey of steel requirements up to 1970 was based on a correlation established between national output and per capita steel consumption, since it has been noted that this consumption closely follows the variations in output. The figure thus arrived at was 6.1 million tons, representing consumption requirements in 1970, on the basis of a probable population of 84.4 million and an average per capita consumption of 72 kilogrammes of steel.

Taking account of the expansion of some plants already under way, and the entry into production of two plants, USIMINAS and COSIPA, expected in 1962-63, it is calculated that by 1965 the available production capacity will be in the neighbourhood of 4.6 million tons; plans will have to be made to increase this capacity, in order to attain the consumption envisaged for 1970, by 1.5 million tons, the increase being allocated, on the basis of observed trends in demand, in the form of 500,000 tons of flat products and 1 million tons of non-flat products.

For flat products the deficit could be met fairly easily, since it is expected that a small additional investment will make possible a higher level of utilization of the production capacity at COSIPA and USIMINAS which, although planned to produce eventually 2.5 million and 2 million tons respectively, will begin production at the level of only 500,000 tons each. With respect to non-flats, it is estimated that the deficit of 1 million tons might call for the execution of the USIMINAS programme for the production of light, medium and heavy shapes, requiring about 600,000 tons of ingots. The remaining 400,000 tons

TABLE 52. BRAZIL: MAIN CHARACTERISTICS OF SOME FIRMS IN THE HEAVY METAL-TRANSFORMING INDUSTRY

Firm	*Approximate fixed capital (thousands of cruzeiros)*	*Floor space (sq. m.)*	*Total operatives and employees*	*Production for the sectors studied*		*Percentage of production for sectors studied*	*Technical limitations on production*
Bardella S.A. (Indústrias mecânicas)	288,000	16,000	465	Electric power	Hydraulic turbines		Dimensions of metal-working machines
			135				
			600	Pulp and paper	Complete plants	100	
				Cement	Crushers and mills		Working space
				Steel	Rolling mills		
				General engineering	Travelling cranes and lifts		
Cia. Brasiliera de Material Ferroviario (COBRASMA)	624,000	180,000	2,000	Petrochemical	Heat exchangers; surface condensers		Dimensions of metal-working machines
			300				
			2,300	Casting	Steel castings	18	
				Forging	Steel forgings		Auxiliary installations
Babcock & Wilcox (Caldeiras) S.A.	150,000	15,000	350	Petrochemical	Pressure vessels		
			150	Thermal power	Steam generators	100	
			500	General engineering	Metal structures		
Mecânica Pesada S.A.	375,000	25,000	350	Electric power	Hydraulic turbines; generators; sluices and ducts, pressure vessels	100	
			130				
			480	Petrochemical	Heat exchangers		
				Paper and pulp	Complete plants	100	
				Cement	Complete plants		
				Steel	Mixer ladles; steel furnaces; cupola blast furnaces		
				General engineering	Travelling cranes and lifts; metal structures		
Cia. Brasileira de Caldeiras	180,000	26,000	640	Petrochemical	Pressure vessels; heat exchangers	60	
			100				
			740	Thermal power	Steam generators		
				General engineering	Metal structures		
Mecânica Jaragua S.A.	50,000	6,000	180	Petrochemical	Pressure vessels; heat exchangers	91	Dimensions of metal-working machines
			60		LPG tanks		
			240		Vertical furnaces		Working space

			95
			375
Industria Mecânica Cavallari S.A.....	60,000	4,000	260
			40
			300
M. Dedini S.A. Metalúrgica.....	300,000	25,000	950
			85
			1,035
Cia. Brasileira de Construçoes— Fichet & Schwartz-Hautmont.....	230,000	25,000	1,000
			180
			1,180
Maquinas Piratininga.....	140,000	14,500	480
			130
			610
Industria elétrica Brown Boveri S.A...			
General Electric S.A. (Campinas) (under construction).....	24,000		

			working machines
	Pressure vessels	60	Working space
General engineering	Metal structures		Auxiliary installations
Paper and pulp	Complete plants	85	Dimensions of metal-working machines
			Working space
			Auxiliary installations
Petrochemical	LPG tanks; pressure vessels	55	Auxiliary installations
Thermal power	Steam generators		
Paper and pulp	Digesters-autoclaves		
Petrochemical	Storage tanks; horizontal furnaces		
Electric power	Sluices and ducts	78	
General engineering	Travelling cranes and lifts; metal structures		
Petrochemical	Pressure vessels		Dimensions of metal-working machines
General engineering	Travelling cranes and lifts	45	
	Conveyors		Working space
			Auxiliary installations
Electric power	Generators; transformers	100	Dimensions of metal-working machines
Steel	Steel furnaces		Auxiliary installations
Electric power	Generators		Up to about 160 MVA
	Transformers		Up to 380 kV & 300 tons
	Circuit-breakers		Up to 380 kV
	Switches		Up to 380 kV
Steel and heavy industry	Motors, DC and AC		Up to about 7,000 HP
	Motor generators		Up to about 7,000 HP
	Generators, DC and AC		Up to about 5,000 kW
Heavy engineering generally	Heavy metal structures, tanks, heavy mixers, machine-finishing of large parts		

could be supplied partly by the expansion of other plants, and partly by the establishment of two small 100,000-ton plants, in properly selected areas, operating with modern processes for ore-smelting and steel rolling, obviating the use of charcoal. This expansion would require equipment to an estimated value of 114 million dollars, 14 million for flats and 100 million for non-flats.

(d) *Cement*

Given the annual growth rate of 2.4 per cent for the population and the recorded per capita consumption level, it was estimated that cement consumption, from about 5 million tons in 1960, would rise to a little under 11 million by 1970. In view of the additions being made to plant capacity, it was expected that the self-sufficiency recorded since 1956 would be maintained up to 1962, when production and consumption would be about 5.35 million tons each.

From 1962 onwards, domestic industry should be strengthened by new plants or expansions, the deficit in supply being covered, in accordance with the trend already observed, by the establishment of new plants and additions to existing capacity in equal proportions. Existing units number twenty-seven, twenty-two of them using the wet process and five the dry process.

Equipment requirements for both expansion and new plants were estimated at 84.1 million dollars, and would mainly consist of units for crushing, grinding raw materials and homogenizing the cement paste, kilns and accessories, and units for the final milling.

(e) *Pulp and paper*

Taking the basic figures established by the ECLA/FAO/BTAO Pulp and Paper Advisory Group for 1965 and 1975 and assuming an aggregate growth rate of 6 per cent for paper and pulp products in 1960-70, it was estimated that in 1970 the market would require 460,000 tons of newsprint, 325,000 tons of printing and writing paper and 800,000 tons of other paper and board. In view of the expansion of production under way or planned, their supply would be assured by domestic production to the respective extent of 80 and 90 per cent and nearly 100 per cent for newsprint, printing and writing paper and other paper and board.

In order to cover paper demand in the proportions indicated, production would require nearly 360,000 tons of mechanical pulp and 860,000 tons of chemical and semi-chemical pulp of different kinds, domestic industry being equipped to supply all the mechanical and short-fibre pulp needed but only 62 per cent of the long-fibre pulp requirements.

The value of the equipment required for the effective use of the production capacity indicated in both cases, i.e. for paper and pulp, would be 159.5 million dollars, of which 60.7 million dollars would be needed for machinery during the first half of the period (1961-65).

2. Outlook for the domestic heavy metal-transforming industry

The account given in the previous sections shows that there is a promising field for the development of the heavy metal-transforming industry in Brazil. This prospect is part of the general picture of the country's intensified industrial development, which has become a matter of urgency in view of the need to provide work for the appreciable number of persons added to the economically active population every year.

Moreover, the favourable outlook for the development of basic industry is a logical outcome of the great increase in recent years in the manufacture of all consumer goods, especially durable goods, culminating in the speedy establishment of the automobile industry, which provides a strong stimulus to other industries. The consolidation and steady growth of consumer goods production depends on an adequate supply of equipment, such as metal-working machines, processing plant, electrical and mechanical gear, and all types of production, control and checking equipment.

On the assumption that such would be the industrial stage through which the country would pass during the next few years, the Brazilian Government decided to establish an organization to study the subject, and set up the Executive Board of the Heavy Metal-Transforming Industry (GEIMAPE), within the Development Council, by Decrees Nos. 46,753 and 47,034 of 1959 and 50,522 of May 1961, to plan, control and promote measures taken in this sector.

GEIMAPE is made up of representatives of bodies whose activities relate to industrial development, namely, the National Economic Development Bank, the Customs Policy Council, the Currency and Credit Authority, the Foreign Trade and Exchange Departments of the Bank of Brazil, and ABDIB. It is responsible for drawing up plans and programmes for establishing or expanding production lines in the heavy metal-transforming industry, and for studying projects submitted, in accordance with a schedule established in advance, by firms in this sector that need to import equipment or need financial support to expand. These projects are studied and, when appropriate, approved immediately, at weekly meetings by the bodies referred to, and the successful firms receive customs concessions (exemption of duties on imported machinery), market guarantees, recommendations for domestic financial support etc.

The heavy metal-transforming industry in Brazil is made up of about thirty principal firms, with considerable technical experience and well equipped with large-scale machinery, which in many cases manufacture both equipment or parts to order, and other metal or machinery products and equipment to list specifications. Table 52 summarizes the main features of some of the firms that make up the basic nucleus of the industry.

(a) *Size of the market and large-scale sub-contracting*

One of the factors limiting the contribution of domestic industry in supplying the capital goods market is the fact that although the market is considerable for all such goods considered as a whole, it is not yet big enough to justify establishing special plants to supply each of the sectors discussed previously.

However, the problem is being successfully dealt with by the system of distributing production work and sub-contracting servicing among the various engineering units, thus pooling the resources available

in the heavy metal-transforming sector to cope with orders. This has proved to be the most suitable system and it has been developing steadily, especially since the establishment in 1955 in São Paulo of ABDIB consisting of nearly forty of the leading equipment manufacturers. Although the Association does not look into the internal economy of each member firm, it seeks solutions to common problems, especially with respect to specifications, standards and engineering know-how with a view to ensuring maximum utilization of the existing infrastructure in the sector. The freedom of action of each member is respected, so that it can establish its own terms with the client, but the Association makes possible a co-ordinated effort to solve common manufacturing problems.

According to its statutes, the purpose of ABDIB is to promote the development of basic industry in Brazil and to co-operate to ensure its technical progress. With this aim, it maintains contact with the Government and with various public and private bodies; it promotes surveys, reports, studies, lectures and conferences on subjects of interest to the industry, and it organizes and publishes statistics, information and opinions relating to the activities of its members.

But the Association's main activity is to organize the distribution of work to be carried out by its members on large-scale complex projects, dividing the main project into a number of smaller projects representing the constituent parts and components, with their various specifications. This means that there is proper utilization of the productive capacity that is in short supply in the industrial infrastructure, such as iron and steel casting, boiler making, forging, heavy metal work, manufacture of machine parts, manufacture of control instruments and manufacture of motors and electrical equipment.

Although this system often makes it possible to use whatever capacity may be available, it should be noted that it is limited by the fact that the firms which take part have their own industrial programmes, arising out of orders from other branches of activity, and that consequently they cannot devote themselves exclusively to the sectors under consideration.

Thus far ABDIB has applied the system mainly to the manufacture of equipment for petroleum refineries, pipelines and the petrochemical industries. Its general application to the other sectors considered in the present study depends essentially on the establishment of favourable conditions with respect to internal financing, the abolition of privileged imports and the availability of technical engineering standards which can be adapted to Brazilian conditions.

With respect to the manufacture of equipment for the petroleum industry, use of the system of distributing production work and sub-contracting servicing will make it possible, in existing circumstances, to supply about 64 per cent of the value of the demand projected for the 1961-70 decade. There are a number of items which can be supplied entirely from domestic production, such as storage tanks, heat exchangers and surface condensers, metal structures, welded tubes, cyclones, travelling cranes, lifts and lifting tackle, and mixers. On the other hand, supplies for some other categories, such as turbo-generators, steam turbines, special instruments and valves, and special ejectors and filters, have all to be imported.

It should be added that for certain of the more complex items the factor limiting domestic capacity to manufacture them is really the small size of the market in question, which prevents the establishment of an industry specializing in such production; moreover in these cases the sub-contracting system cannot be used. This applies, for example, to control instruments. The technical problem does not in itself constitute an insuperable obstacle, since industrial development in Brazil has revealed a great capacity to absorb technological improvements, once the volume of production is sufficient to justify the technical effort and investment required. Thus it may still be hoped that increased demand for such items, including demand from other branches of industry not considered in the present study, may make it possible in the future to establish production series for them on an economic basis.

The conditions of supply of certain raw materials which are not yet available in the country, also have the effect of reducing the productive capacity of domestic industry—although to a lesser extent—because of their high cost, attributable to an exchange system which imposes the payment of a high surcharge when foreign currency is obtained for import purposes. This affects particularly non-ferrous metals—especially copper, which is not produced in Brazil; aluminium, of which the domestic production is insufficient; and to a lesser extent zinc, for which there are medium-term prospects of production; and nickel. The output of lead and tin is sufficient, although it is based on an ore which is largely imported. There are also a number of special steels and steel alloys for which Brazilian industry depends on supply from abroad.

(b) *Price levels in domestic industry*[28]

The studies made show that for many types of equipment the Brazilian heavy metal-transforming industry can compete fairly well, as far as prices are concerned, with imported equipment. This is mainly due to two factors. The first is the lower level of real labour costs in Brazil compared with those in more industrialized countries. As the nature of basic industrial equipment —in most cases—precludes mass production, the incidence of the labour input in its production is an important factor in determining the comparatively low final cost of Brazilian production. In many countries that are in an early stage of industrial development this favourable factor is cancelled out by an unfavourable factor of equal or greater effect, namely, the high cost of the raw materials used in the industry, mainly ferrous metals. However, this is not so in Brazil, where the raw materials produced domestically are on the same level as, or very little above, international prices.

The prices of Brazilian raw materials used in the manufacture of heavy industrial equipment, such as cast iron, and bar and sheet steel, are practically the same

[28] All the comparisons made here represent the situation with respect to domestic prices, labour costs and exchange rates on the free or import market prevailing in October-November 1960.

as those prevailing in the industrialized countries (comparison made on the basis of the free exchange).[29]

However, imported raw materials cost the domestic manufacturer of heavy equipment in Brazil about 50 per cent more than they cost the foreign entrepreneur (comparison again on the basis of the free exchange). With respect to labour, the average physical output of the Brazilian operative in the heavy metal-transforming industry is comparable, for the same machinery, to the output of United States or German operatives. However, this comparison is not wholly realistic. In the Brazilian metal-transforming industry there is a considerable amount of machinery which is inferior to that in the United States and Germany. Thus broadly speaking the physical output of the Brazilian operative represents an average of 80 per cent of what it is in those countries.

On the other hand, labour in the United States costs nearly five times as much (on the basis of the free exchange) as Brazilian labour, and for certain types of boiler-making operations (welding operatives) nearly six times as much. In Germany the average cost of labour is about three and a half times that of Brazilian labour. Thus the real cost of the labour used in the metal-transforming industry in Brazil is about a quarter of that in the United States and about a third of that in Germany.

[29] Iron and steel castings are slightly cheaper in the United States, but prices of domestic sheet steel are similar to those in the United States. Special and alloy steels are 50 per cent cheaper in the United States than in Brazil, and so are bearings, bronze, aluminium and various other metals.

TABLE 53. BRAZIL: PRICE COMPARISON OF DOMESTIC PRODUCTION WITH UNITED STATES PRODUCTION
(*Cruzeiros per dollar*)

Equipment	*Equivalence value of domestic production prices*
Petroleum and petrochemicals	
Metal structures	160
Direct-fired furnaces	160
Pressure vessels	163
Storage tanks	172
Steam generators	172
Heat exchangers	183
Surface condensers	183
Pumps and compressors	220
Tubes and valves	220
Electric power generation	
Turbines	247
Transformers	263
Generators	270
Cement	
Blowers, cyclones	170
Mills, screens, crushers, reducers, transformers	185
Rotary kilns	210
Paper and pulp	
Digesters	165
Complete pulp unit	200
Complete paper unit	250
Steel	
Heavy structures	160
Travelling cranes, conveyors	170
Refractories	170
Buckets	170
Blast furnaces (not assembled)	172

Thus it can be concluded that for machinery and equipment made to individual order or in small production series, not requiring special jigs or special machinery for particular operations, and where the manpower factor is unusually high, the Brazilian heavy metal-transforming industry is generally in a fairly good competitive position with respect to prices on the world market. This conclusion is confirmed by the data relating to the equipment specifically considered in the present study. Table 53 summarizes the price comparisons between domestic production and United States production made in previous sections. To appreciate the significance of the data given in table 53, it should be noted that at the time to which they relate (October-November 1960) the average rate of exchange on the free market was 180 cruzeiros to the dollar, and the rate for general-category imports was 245 cruzeiros to the dollar. The comparison between these values is shown in figure II.

The sector covering equipment for petroleum refineries and the petrochemical industries provides a good illustration of the observations made earlier on the influence of labour and raw materials on the production costs of Brazilian metal-transforming. For equipment using exclusively Brazilian raw materials whose production requires a substantial labour input, and which both in Brazil and in the United States is made to order, such as direct-fired furnaces, pressure vessels, heat exchangers etc., prices in Brazil compare favourably with United States production, on the basis either of the free exchange, which applies for manufactured exports, or of the exchange rate for imported goods. Where the raw materials are partly imported and the goods can be mass-produced (the labour input thus being lower, e.g. pumps and compressors or tubes and valves) the comparison with United States prices is less favourable, although the resulting equivalence value of the dollar is not as high as the value of the dollar for general-category imports. For all equipment for petroleum refining and the petrochemical industries taken together, the comparison is still reasonably favourable—192 cruzeiros to the dollar—as a result of the high proportion of the total value of a petroleum refinery and of a petrochemical plant represented by the first group of equipment referred to above.

The exact opposite is true of equipment for the generation of electric power; here production (of the largest equipment, which is what constitutes the greater part of the requirements for the ten-year development programme) calls for heavy fixed plant, of a type only just beginning to operate in Brazil and at a low level of utilization because of the lack of proper programming of orders. The great extent to which imported raw materials, notably copper, is used in such equipment is a powerful factor contributing to its high cost. As a result of these unfavourable factors, only the production of hydraulic turbines shows prices approximately at the same level as the import exchange rate, those of generators and (heavy) transformers being higher.

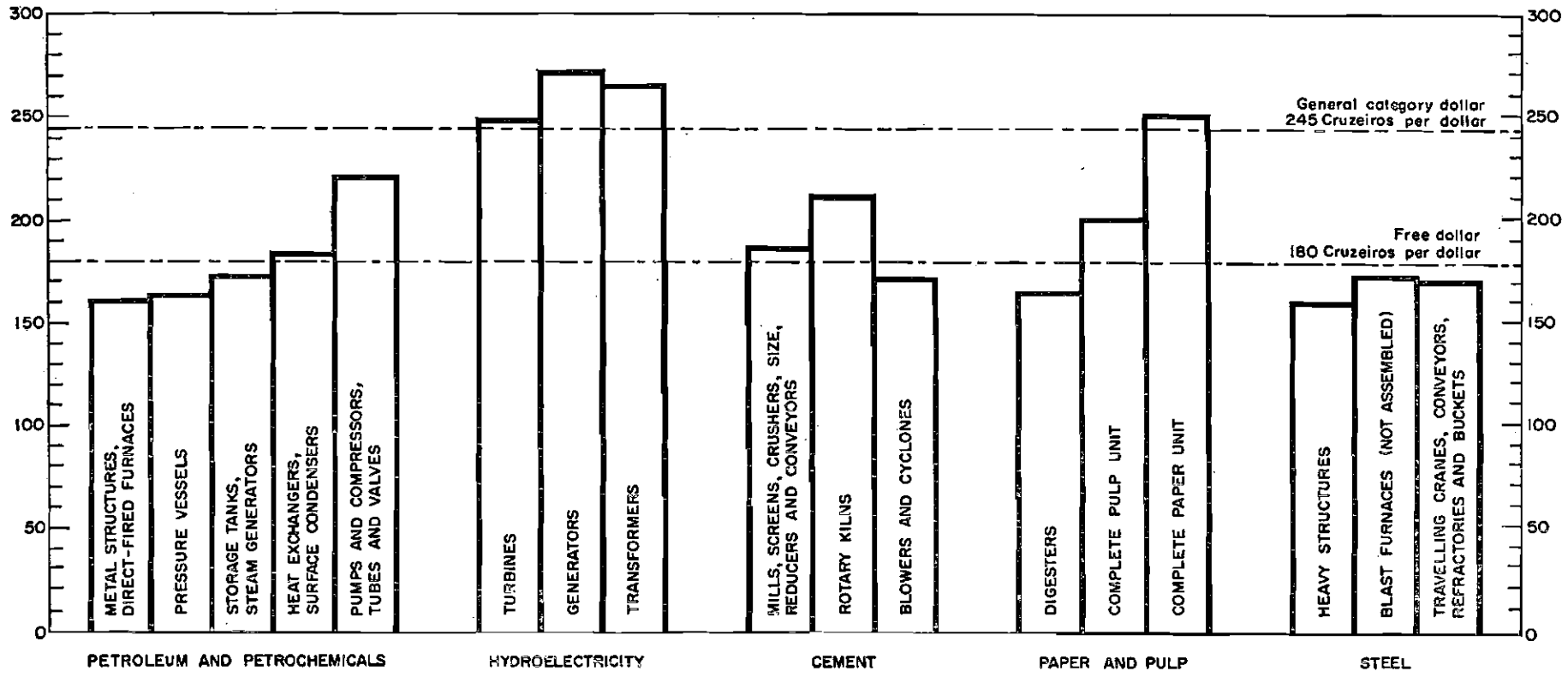
In the case of equipment for the production of cement, paper and pulp, and steel, the comparison gives a result midway between the two extremes represented by equipment for the production of petrochemicals, on the one hand, and electric power, on the other.

Figure II

Brazil. Comparative value of the nationalization dollar for various types of equipment, 1960

(Cruzeiros per dollar)

Natural scale



Lastly, it should be pointed out once more that the sole purpose of the values and comparisons referred to above is to give an indication of the order of magnitude valid for the period October-November 1960 when the studies were carried out.

(c) *Possibilities for domestic production*

A direct survey of present conditions and prospects in the Brazilian heavy metal-transforming industry and of the increase in these prospects as a result of expansion already programmed, for each category of equipment analysed, leads to the conclusion that the industry is equipped to meet about 80 per cent of the demand for the equipment indicated above (1961-70 decade), to the value of 721.9 million dollars, broken down as indicated in table 54.

The extent to which the Brazilian heavy metal-transforming industry contributes to the manufacture of the equipment required during the next ten years for the expansion of the five basic sectors, varies from one sector to another according to the kind of manufacturing process and to other conditions mentioned in earlier sections. The large share to be taken by domestic industry in meeting the country's heavy equipment needs, although established with the greatest regard for what is realistic and on the basis of actual performance in recent years, is nevertheless of a conditional nature, and this needs to be underlined. First, the total productive capacity of the heavy metal-transforming industry can only satisfy the extensive needs for equipment implied in the programme outlined above if its growth rate is increased and certain organizational norms are adopted that will permit greater yield from existing plant. Secondly, in Brazil there are at present certain factors of an institutional nature, or relating to economic policy, that might make the target figures representing this high proportion of domestic manufacture difficult to attain, and hence appropriate administrative measures will be required to eliminate such factors or reduce their effect. This is bound up with the various problems concerning the gradual establishment of domestic engineering services; the establishment of technical standards for engineering work that are appropriate for the working conditions and types of raw materials found in the country; the competition represented by the importation of similar equipment from abroad on exceptional terms; and the almost complete absence of any internal long-term and medium-term financing for domestic equipment.

Let us first consider the question of the capacity of the Brazilian heavy metal-transforming industry to supply the equipment needs arising from the expansion programme in the five basic industries. There are two aspects to this question: the industry's technical capacity (accumulated experience and available production equipment) to deal with the work arising out of the programme in the various special branches of the heavy metal-transforming industry, and the total productive capacity, on the basis of existing plant and of the expansion expected (not specially programmed) during the course of the next decade.

(d) *The industry's technical capacity*

In earlier sections of the present study heavy engineering work was grouped into the following eight principal sectors: (1) iron casting; (2) steel casting; (3) forging; (4) boiler making; (5) heavy metal work; (6) precision engineering; (7) electrical appliances; (8) control instruments.

In some cases the sectors listed above were typically suited for the sub-contracting of parts and components (casting, forging, boiler making, metal work and machine work). In others the sectors produce finished materials or complete equipment for incorporation in the final plant as separate units (electrical appliances and control instruments). Limitations of a technical nature on the production of parts and components for basic equipment for each sector are indicated briefly below.

(1) *Iron casting.* There are no limitations with respect to quality of casting. The largest parts cast in Brazil (in a number of foundries) are over 40 tons, a size which is hardly likely to be included in the specifications for parts of basic equipment. Generally speaking the demand is for cast iron that is tested for chemical composition and mechanical properties, and this constitutes no difficulty for the better suppliers. The type specified is frequently nodular cast iron, which is produced by at least eight foundries in Brazil.

(2) *Steel casting.* The demand characteristics are the same as for cast iron. The larger parts, required for electric power generating equipment are generally not more than 20 or 25 tons. There is a foundry in São Paulo that can produce parts of this size, and a number of foundries in the country are capable of producing parts of 8 to 12 tons.

(3) *Forging.* For basic industrial equipment mass-production forging of parts (drop forgings in particular) is not used. The demand is mainly for forged axles, which are produced by forging hammers or hammer presses. At the present time Aços Villares can forge axles of up to 20 tons, and before long

TABLE 54. BRAZIL: SHARE OF DOMESTIC INDUSTRY IN THE SUPPLY OF BASIC EQUIPMENT

Sector	*Equipment required for projected expansion in 1961-70 (millions of dollars)*	*Equipment that could be made by domestic industry*	
		(Millions of dollars)	*(Percentage)*
Petroleum and petroleum derivatives	138.1	88.8	64.1
Electric power (1961-71)	410.0	351.0	86.0
Steel	114.0	88.0	77.0
Cement	84.1	52.0	61.8
Paper and pulp	159.5	142.1	90.0
TOTAL	905.7	721.9	79.7

MAFERSA and COBRASMA will be able to produce similar parts.

(4) *Boiler making.* For the work required there are practically no limitations of a technical nature imposed by the machinery available. The large boiler works (six in number) can all easily produce flat sheets up to 1½″ (37.1 mm) thick. One boiler works can produce thicknesses of 3″ (75 mm), and another thicknesses of 4″ (100 mm), with lengths of 5,000 mm. Consequently thickness is not a limiting factor, since the equipment or parts ordered do not generally call for sheets more than 1½″ or 2″ thick. In this sector the auxiliary machinery (presses and large vertical lathes) and supplementary equipment (travelling cranes and heat-treatment furnaces) may constitute limiting factors, and the possibility of using them may determine the method of construction to be adopted. Boiler making may be regarded as a field where there are practically no limits on the production of equipment in common demand. The only exceptions are high-pressure reactors, subject to serve conditions of pressure and corrosion, which require special steel alloys, notably clad steel.

(5) *Heavy metal work.* For the industry as it exists at present there are no limitations arising out of the technical nature of the operations involved.

(6) *Precision engineering.* This includes in particular precision machine-finishing done by the manufacturers of such autonomous units as pumps, compressors etc. It appears that the limitations in this field arise mainly from the smallness of the market for certain particular items of equipment.

(7) *Electrical equipment.* Production is adequate to supply demand for the bulk of standard requirements. There are limitations with respect to induction motors above 1,200 h.p.—3 phase; explosion-proof motors (for refineries) above 50 h.p.; certain special motors (where special features have to be taken into account in each case); certain transformers and alternators (see the reference to important limiting factors in the section on equipment for the generation of electric power); and electrical switches, circuit-breakers etc. (see same section).

(8) *Control instruments.* There is no domestic production of whole units on a mass-production basis. Some odd separate items are produced, for the direct control of pressure (manometers), temperature (thermometers), and electric current (voltometers, ammeters and wattmeters). Gauging apparatus and complete control units—precisely the equipment required for basic industries—are not produced.

(e) *Total productive capacity*

In this first study on the production of basic equipment in Brazil the comparison of equipment requirements with the capacity of the existing heavy metal-transforming industry is of secondary importance. In none of the five sectors considered does the equipment concerned represent production that is not undertaken at all in Brazil, or is purely at the introductory stage. On the contrary, the Brazilian heavy metal-transforming industry already has considerable experience in the manufacture of equipment of each of the types referred to, or of very similar types. In recent years there has been increasing production of equipment for petroleum refining and the chemical-processing industries, the generation and transmission of energy, and the manufacture of pulp and paper. However, there is much less experience of the production of equipment for cement plants and steel mills (blast furnaces, rolling mills and auxiliary plant). But it is perhaps more true of these sectors than of the others that the equipment in question can be produced by engineering workshops that are not specially equipped to do so, but have wide experience in similar types of production.

Thus in no case does the problem posed in the five sectors concerned consist of starting a line of production that is wholly new to Brazil. The Brazilian heavy metal-transforming industry consists of a group of firms whose productive plant and technical experience is undergoing a marked expansion. The annual growth rate of the industry as a whole in recent years can be estimated as between 10 and 15 per cent. This margin of expansion represents spontaneous and unprogrammed growth resulting from the individual decisions taken by each firm and—an even more important point—reflecting solely the firms' reaction to the immediately available market. Thus far there has been no attempt to exploit the market for basic industrial equipment that Brazil's development may provide for the heavy metal-transforming industry in the more distant future, and the industry's expansion is based on the paramount aim of meeting immediate needs. However, in the recent past the industry has proved very flexible in adapting itself to new tasks in the manufacture of equipment, within very short periods and in the absence of any deliberate promotional measures by the public authorities; it has shown a great capacity to absorb technology, and a high level of auto-capitalization, and has succeeded in reaching a number of agreements with important foreign firms or industrial groups, either for the simple acquisition of technical know-how against payment of royalties or for the establishment of joint financial ventures. Consequently there are grounds for assuming the existence of a much higher growth potential than is revealed by the actual growth recorded in the immediate past—one that could respond to the challenge of programmed production of basic industrial equipment reinforced by an integrated set of government measures.

This is why in the case of Brazil the comparison between equipment needs and the capacity of the existing industry to supply them is of secondary importance. The factors referred to above show that the industry's more or less unprogrammed growth will probably be sufficient, under the stimulus of market demand, to keep pace with the progressive expansion of the market. The two essential requirements for the rapid and balanced growth of Brazil's heavy metal-transforming industry are a foreknowledge of the total volume of demand for each type of equipment over a sufficiently long period, and a coherent and stable government policy, not so much with respect to protection (as has been shown, only a very small measure of protection is needed for this type of activity), as with respect to the regularizing of the system governing foreign competition.

These comments will explain why so little space was devoted in previous sections to evaluating productive

capacity in relation to the demand arising not only from the ten-year programme outlined here, but also from the requirements for the same type of heavy metal-transforming work in other sectors not included in the present study. It should be added that most of Brazil's heavy metal-transforming establishments work only one daily shift of eight to ten hours.

The productive capacity of the metal-transforming industry could be substantially increased by introducing one or two extra shifts, which would also have the effect of achieving better utilization of large-scale machine-tool equipment (which should operate for not less than sixteen hours a day, and is at present underutilized), and increasing the machine/hour coefficient. However, there are some difficulties in the way of doubling or tripling the working day, namely:

(1) There are not enough auxiliary metal-working machines (production machine lathes, welding machines, shaping planers etc.) to do the supplementary work;

(2) Sub-contracting is not yet sufficiently developed to ensure programming of production;

(3) For the large parts there is not enough space in the workshops to allow the equipment to be assembled (space under travelling cranes, working space);

(4) The programming of operations in the workshops is not yet accurate enough to ensure the continuous progress of all the operations up to the final assembly;

(5) Possible shortage of raw materials, and difficulties arising from an insufficient and unprogrammed supply to the workshops, make it necessary to proceed by production stages that are not in step with the availability of machines and working space;

(6) Because the delivery of the equipment is urgent, the project and design work is done under a degree of pressure which does not allow of proper programming in the workshops (the purchasing orders are usually passed to the manufacturers very late in relation to the project time-table);

(7) The shortage of skilled workers, especially foremen and shift leaders, militates against the continuous supervision of two shifts, and rules out the possibility of undertaking any delicate finishing operations outside normal working hours.

3. Problems of engineering and technical assistance[30]

As may be concluded from this study, the domestic manufacture of equipment for the transforming industries is closely connected, on the one hand, with engineering, i.e. the conditions in which the engineering projects for the plant required by these industries are prepared and, on the other, with the technical standards or specifications governing the actual manufacture of such equipment.

The term engineering is taken to mean the complete plan of an industrial plant, ranging from the establishment of the general lines of processing to the estimate of the final investment figures and covering all specifications of the equipment and raw materials required for the work as well as the interrelation of all the services involved in the execution of the undertaking.

Within this broad definition of the term, two main divisions are distinguished: first, the use of the plant (or process engineering) comprising the whole flow of operations from the introduction of the raw materials to the emergence of the finished product, and second, the actual construction of the plant or the mechanical engineering. Although the two parts of the project differ quite considerably from each other, and the latter is more important for the purposes of the present study, they will have to be considered together since the design of the process has a decisive influence on the design of the equipment and consequently on the possibility of manufacturing it locally. A complete blueprint for the processing industry (petroleum, pulp and paper, cement, steel) may be schematically divided into the following stages:

(*a*) Study of general production conditions and preparation of preliminary flow-sheet;

(*b*) Study of the technological characteristics of the various phases of the processing (thermodynamic balance, where applicable) and of the materials involved, in order to prepare the initial specifications for the equipment;

(*c*) Detailed specifications of the equipment, together with the issue of requisition sheets, so as to allow the placing of purchasing orders.

This breakdown actually gives only a very sketchy indication of the duties of project engineers, who, after receiving the manufacturing designs for the different equipment ordered, have to revise the preliminary data and make the necessary adjustments in the details so that the different units can be assembled without undue difficulty.

The responsibility of the engineers is just as great in the following stage, that of the execution of the work. Although the plans may have been meticulously prepared and subjected to constant analysis, the requisition sheets are revised countless times during the course of the work and, in addition, the specifications for small-scale purchases are drawn up. This shows the heavy burden of responsibility carried by the project engineers during the execution of the work; they must continue to shoulder it until the whole plant has entered into operation. It should be noted that the equipment is itemized specifically in the third stage, although the general lines of the work are laid down in the second stage.

In order to attain a proportion of domestic manufacturing that would make full use of the possibilities offered by the Brazilian equipment industry, it would seem indispensable that the third phase of the project at least should be carried out in Brazil. If not, it would be difficult to adapt the specifications to the particular conditions prevailing there. This adaptation is of prime importance if manufacturing is to take place locally, and it does not imply any falling-off in the standard of quality or any change in the technical characteristics of the equipment. If the whole project is prepared abroad, the specifications of raw materials are often based on conditions prevailing in the country of origin

[30] The treatment of this question is very sketchy. A more searching analysis of the problems deriving from the introduction of technical know-how from abroad is being undertaken as a separate project.

of the project and more often than not are also determined in the light of the habits and requirements of producers and consumers in that country.

It is understandable that foreign engineers should have no particular interest in giving work to Brazilian industry. In principle, it might seem a matter of indifference where an order is placed; but, to adopt the same line of reasoning as the engineers, where the country in question is starting an industry, if its engineering methods have not yet been clearly defined, the supervision and inspection work might become very burdensome and the existence of a sizable manufacturing risk threaten the success of the whole project.

The solution to the problem seems to depend basically on whether the process of preparing the engineering project is regarded as entirely passive or detached in relation to the industrial development of the countries in which it is to be applied, or as an instrument capable of exercising a decisive influence on the tempo and direction of their development. The second view is undoubtedly the more suitable for countries such as Brazil which have undoubted possibilities in the field of heavy metal transforming and are taking the first steps towards their realization.

In these circumstances, the preparation of an engineering project should serve as an incentive for industry to promote, by individual and collective means, the introduction of the different technological improvements required for full participation in the installation of new enterprises.

In order to plan the construction of an industrial plant, it is essential that the requisite equipment and machinery should be manufactured in accordance with certain definite standards or specifications. It would be superfluous to dwell on the obvious technical need for a single standard; it has only to be remembered that the same equipment manufactured on the basis of two distinct standards will have two technical approaches, two prices and probably two different delivery dates. Engineering firms usually adopt the engineering standards that prevail in the country where they are established. In certain specific cases, however, they often adopt the standards of the country that has best developed the industry concerned. For instance, in the case of petroleum refining, United States specifications are commonly used for projects.

In Brazil, which is just beginning to industrialize and still lacks the material resources to be found in other countries, strict observance of foreign standards is not always easy. However, within the spirit of the engineering code other standards may be adopted that favour local production conditions. The purpose of an engineering standard is to keep manufacturing within the limits that are acceptable in the execution of a project, adjusting the solutions and processing methods adopted with a view to making the best use of available production resources. In this way, without diverging from the aims pursued, the standards call for different requirements from one country to the next, according to the relative importance of the factors involved. For instance, in the United States, labour costs are much higher than in Brazil, whereas raw materials are generally cheaper. A solution that would be satisfactory in the former country might easily be inapplicable for a Brazilian manufacturer.

This is, in fact, one of the main impediments to the development of the equipment industry in Brazil, given the still rudimentary state of Brazilian engineering standards. The Brazilian Technical Standards Association (ABNT), which should cope with this task, has failed to keep pace with the rapid development of the heavy metal-transforming industry for reasons connected with the inflexibility of its own organization. As a result, equipment manufacturers, under pressure from project engineers, adopt foreign standards and specifications.

With the solution of the technical problems arising from the first orders for equipment and the expansion of the metal-transforming industry, supplies have improved technically and the collaboration of Brazilian industry has increased substantially.

Nevertheless, in order to obtain even better results in future, the project engineers will have to possess a thorough knowledge of the Brazilian equipment industry and be willing to arrange the engineering in such a way that the equipment can be manufactured in Brazil.

A brief attempt will now be made to define a practical policy for using engineering as an incentive to industrial development, on the basis of local technical standards guaranteeing a certain level of quality for the equipment manufactured.

The first observation to be made concerns precisely the importance that attaches to the preparation of specifications for domestic equipment (third stage in the outline given) making it possible to eliminate the supervision and inspection work that causes concern to foreign project engineers. If the engineering were geared from the outset to what could be definitely produced in the country, the problems of inspection and risk would loom less large. Moreover, the constant contact between equipment manufacturers and project engineers would make it easier for the former to understand what engineering methods were essential for participation in a project. To the limited extent that such contact exists in Brazil it has proved itself to be extremely useful.

The progress seen in the higher standards of quality achieved, in conjunction with the difficulty of importing,[31] has brought about a tendency to transfer to Brazil some of the engineering work that used to be carried out entirely in the United States or Europe. The type of engineering services that could be transferred fairly soon is the mechanical engineering of the equipment, with special reference in this respect to the petroleum, pulp and paper and cement industries. The projects for hydroelectric plants can already be fully carried out in Brazil and initial action is being taken to establish enterprises capable of undertaking all the engineering work for the steel industry within the country. Subject to this reservation, the process engineering for the three industries mentioned will have to come from abroad for some time, since Brazil's dependence on foreign sources cannot be removed until there is a sounder knowledge of the subject in the

[31] Difficulties of this kind have, however, been offset to some extent by offers of financial assistance from foreign groups for the purchase of equipment.

country and research work is in full progress in laboratories and industrial firms.

However, if the mechanical engineering is undertaken in Brazil on the basis of a knowledge of domestic production, it will represent the solution of the following problems which are vital for the development of the basic industries:

(*a*) Specification of equipment so as to reduce costs to a minimum either by integral utilization of the raw materials available or by the adoption of suitable manufacturing methods that are widely used in Brazil;

(*b*) Exploration of the possibility of replacing some raw materials by others with a view to selecting those which cost less locally and do not always follow the same price trends as foreign market quotations;

(*c*) Knowledge of local transport conditions from the different plants to the work site, so that large installations can be properly designed;

(*d*) Knowledge of the suppliers, with a view to assessing properly their technical and financial capacity and placing orders with those really in a position to construct the equipment without overburdening their plants;

(*e*) Rapid consideration and approval of manufacturing designs for each type of equipment in order to shorten the time required for carrying out raw material orders and manufacturing;

(*f*) Insistence on the production of high quality goods by the Brazilian manufacturers and the development of new types of equipment so that manufacturing methods can be improved and production encouraged, with consequent benefit to industry;

(*g*) Reduction in purchases of spare parts through the specification of domestically-manufactured equipment and knowledge of technical assistance possibilities on the part of the manufacturers, which would mean less of a drain on capital and would guarantee continuous operation.

When engineering services involve the use of foreign patents, the problem can be solved quite easily in most cases by means of an agreement and payment of the appropriate royalties by the user (purchaser of the equipment) or by the manufacturer hmiself. As a matter of fact, this problem has been disposed of satisfactorily by the Brazilian manufacturers, who have made it their business to acquire foreign manufacturing rights, promoting basic agreements with the project engineers on technical matters, and guaranteeing the placing of orders.

The following would therefore seem to be the cardinal requirements for the expansion and consolidation of the Brazilian heavy metal-transforming industry through the manufacture of equipment for the processing industries:

1. Once the preliminary flow-sheet has been prepared and the general production characteristics of the plant laid down, arrangements should be made to ensure that the auxiliary equipment for the project can be manufactured without difficulty in the country;

2. When the preliminary specifications of the equipment are being prepared, the possibility of obtaining raw materials in Brazil should be investigated, so that the project need not be jeopardized by questions of deadline and cost, which might prove inacceptable if the materials had to be imported;

3. After the two preceding points have been settled, the final specification of the equipment and issue of the requisition sheets will lead almost automatically to the placement of orders for the equipment in the country.

As regards technical engineering standards, a request might possibly be made to the United Nations Special Fund to provide assistance for the project on the subject; this has already been outlined by ABDIB as follows:

(*a*) The adoption at the outset of foreign standards, to be translated or adapted so that they can be followed by project engineers and manufacturers and accepted by purchasers;

(*b*) The organization in ABNT of permanent commissions at a high technical level, with instructions to review manufacturing standards and methods regularly;

(*c*) Such commissions would consist of engineers engaged on a full-time basis and United Nations technical experts provided through the technical office of ABDIB, which would subsidize ABNT for the purpose of carrying out a minimum work programme.

These measures would be extremely helpful in developing industry and gaining the confidence of purchasers, who would enjoy the advantages of higher quality goods and earlier delivery dates.

4. Problems relating to foreign competition

Efforts to establish a thriving heavy metal-transforming industry in Brazil must necessarily be supplemented by measures that will conduce to its consolidation and survival by enabling it to cope with foreign competition. The intention would not be to eliminate such competition, which is on all counts salutary for the manufacturer and beneficial for the consumer, but simply to remedy existing distortions in Brazil's foreign policy which tend to place domestic industry at a competitive disadvantage. These distortions are observable in the fields of tariff and exchange policy.

(a) *Customs régime*

Apart from certain existing anomalies in the system of *ad valorem* charges—e.g. higher duties payable on raw materials than on the finished product—which the Customs Policy Council will gradually eliminate, the most important problem for the basic equipment industry is that relating to the so-called "registration of similar domestic products". This institution was established by Legislative Decree No. 300 of 24 February 1938 in order to prevent the granting of exemptions or reductions in respect of import duties on goods when domestically-produced counterparts would suffice, in the view of a commission of government technical experts, to supply the market.

Article 6 of the Decree, which was promulgated by the Executive as a form of customs tariffs control, stipulates that customs privileges are not applicable to "goods, raw materials or equipment for which counterparts are produced in Brazil in sufficient quantities to supply the regular requirements of the services and undertakings enjoying exemptions or reductions in respect of import duties".

For the purposes of this registration, the domestic producer had to present a series of certifications, including evidence of his "production capacity, and of the industry's being in a position to supply the markets with sufficient quantities to meet consumer demand, so that the goods in question may be easily obtainable in Brazil".

With the promulgation of the new Tariffs Act (Act No. 3,244, dated 14 August 1957), the institution was maintained and its effects were amplified, since apart from the prevention of exemption or reduction of duties in respect of imported goods of which the equivalent could be obtained within Brazil, under the terms of the said Act (article 3c) the registration privilege also implied a change in the corresponding aliquot. Furthermore, the Customs Policy Council, created by the same Act, became the registration authority.

The procedure for securing the registration of similar domestic products and the establishment of a higher tariff aliquot in respect of their foreign counterparts may be broadly outlined as follows. The producer interested in obtaining customs protection must submit to the Customs Policy Council a detailed statement on his industry, specifying the articles manufactured, production capacity, costs and sales prices, and distribution network, and must support his application with documentary evidence of the quality and popularity of his products. The Council, which is composed of members of the various federal agencies concerned, together with representatives of industry, agriculture and trade, publicly invites interested parties to submit objections to the request for registration within a stated time-limit, upon the expiry of which it considers the grounds for the application and the objections received, and so reaches its decision. When registration has been granted, the custom houses are notified and instructed to refuse exemptions or reductions in respect of duties on similar imports.

The general regulations on customs exemptions and reductions contemplated in article 62 of the said Act No. 3,244 will no doubt establish criteria for admission to the register of similar domestic products; but they have not yet been issued, and industry, particularly the metal-transforming industry, feels some concern as to the principles adopted in relation to these concessions, which are still based on the provisions of Legislative Decree No. 300 requiring the applicant for registration to submit evidence that his production capacity is sufficient to supply the market with quantities such "that the goods in question may be easily obtainable in Brazil", or, in other words, to demonstrate the commercial availability of the product. As is common knowledge, the heavy metal-transforming industry manufactures to order, producing equipment to meet the requirements of previously-prepared plans, and therefore cannot show proof that its products are available for sale. Moreover, specification of the articles it can manufacture is no easy matter, since more often than not it produces complete installations or parts of large industrial units.

The policy referred to, deriving from a rigid interpretation of provisions laid down at a period in Brazil's evolution (1938) in which industrial development had not yet begun to make its influence felt, would have to be modified—as in fact seems to be the current trend—with a view to bringing it up to date and basing registration on the over-all capacity of the firm or the sector of production manufacturing such equipment. Consequently, the new procedure might consist in requiring the party interested in importing with benefit of tariff concessions to produce evidence of the non-existence of domestically-produced supplies, thus transferring to him the onus of proof hitherto borne by the domestic producer.

Still in relation to the policy of preferential treatment for domestically-produced equipment similar to that manufactured abroad, it should be noted that GEIMAPE included in its Basic Directives (approved by the Government in Decree No. 50,522 of 3 May 1961) a provision determining that exchange or fiscal concessions would be granted only to imports of equipment affected by governmental, parastatal and autonomous bodies, mixed companies, and public utilities concessionaires upon production of evidence that the equipment concerned could not be manufactured in Brazil. According to these directives, such bodies would give priority to tenders in which the equipment offered has the smallest proportion of imported parts or components, and this condition must be set forth in the corresponding open or closed invitations to bid.

These are measures aimed at reserving the domestic market for internal production in the case of purchases effected by public bodies, a policy pursued in other countries, e.g. in the United States, where the pertinent regulations are established by law, constituting the well-known "Buy American" Act, which will be discussed later. As an illustration, a few *ad valorem* tariffs affecting industrial equipment are mentioned in table 55.

TABLE 55. BRAZIL: SELECTED *ad valorem* CUSTOMS DUTIES ON INDUSTRIAL EQUIPMENT

Equipment	Ad valorem *duties (percentage)*
Conveyor and roller belts	60
Jaw crushers:	
Up to 5,000 kg	60
Over 5,000 kg	30
Rotary kilns	80
Storage tanks (not assembled)	80
Metal silos (not assembled)	80
Sackers:	
Up to 1,000 kg	30
Over 1,000 kg	20
Machinery and equipment for the pulp, paper and board industry	
Up to 5,000 kg	60
Over 5,000 kg	40
Centrifugal water pumps	80
Air or gas compressors:	
Up to 5 atmospheres	80
Over 5 atmospheres	40
Electric motors:	
Up to 3,000 kg	100
Over 3,000 kg	50
Transformers:	
Up to 10 tons	80
Over 10 tons	30
Storage tanks with or without thermal insulation	80
LPG tanks	60
Condensers, evaporators, heat exchangers	60
Freight wagons and tank-wagons	60

(b) *Exchange régime*

Another factor of distortion in estimating the degree to which the domestic industry can compete with its foreign counterpart derives from the exchange subsidy granted to imports of equipment for activities regarded as highly essential, through the so-called "cost rate". For such imports, foreign exchange is supplied by the Government at the price at which it is purchased from exporters; the level up to a short time ago stood at about 100 cruzeiros to the dollar, whereas in the case of general-category imports, the prevalent rate for foreign exchange obtained through the normal channels of the auction system was approximately 240 cruzeiros to the dollar. This placed Brazil's own basic equipment at a disadvantage in price comparisons and open bidding, since the device from which it arose was an artificial one whereby the final price of the similar foreign product was entirely divorced from reality.

Justly acknowledging the undesirability, from the standpoint of the Brazilian economy, of a subsidy to purchasers of equipment which operates to the detriment of domestic industry, GEIMAPE itself, since its purpose is to promote the development of the industry under discussion, decided to refrain from taking advantage of the subsidy for the heavy metal-transforming industry's own imports for expansion or replacement purposes. Thus in its Basic Directives it included a clause stipulating that governmental, parastatal and autonomous bodies, mixed companies and public utilities concessionaires must, in making their purchases, give preference to domestically-manufactured equipment when its price was the same as that of the similar foreign product, comparison being based on c.i.f. prices calculated without exchange privileges and including all import duties.

The aims of this provision are parallel to those of the "Buy American" Act, although the latter is distinctly more drastic in its measures for the protection of United States production.

Under the terms of the United States Act, only domestically-produced equipment and manufactured goods can be purchased for public use, unless the domestic products are inadequate in quantity or quality, or their prices are unreasonable. The same provision extends to entrepreneurs responsible for public works, under penalty of inclusion in a black list excluding them from further transactions with the Government.

It is important to note that equipment whose cost breakdown shows 50 per cent or more of imported products is regarded under the Act as being of foreign origin. It also establishes formulae for comparison between bidders' prices for domestic and foreign equipment, according to which prices of domestic products are to be considered unreasonable only if they exceed a figure 6 per cent or 10 per cent higher than the bidders' price for imported goods plus customs duties and internal expenditure, or 10 per cent higher than the foreign bidders' price plus only customs duties, in the case of purchase whose value is less than 25,000 dollars.

It should be noted here that the "cost exchange" problem was a good deal mitigated by the Brazilian Government's recent measures raising the rate to 200 cruzeiros to the dollar, by Instruction No. 204 of the Currency and Credit Authority.

(c) *Foreign investment policy*

Three aspects of Brazil's policy in connexion with the admission of foreign capital in its industrial activities are of interest for the domestic heavy metal-transforming industry. Essentially, the basis of this policy is the entry of equipment without exchange coverage for the establishment or expansion of industries, as provided for in SUMOC's much-discussed Instruction No. 113, now incorporated in Decree No. 42,820, chapter V, of 16 December 1957.

It may be noted in the first place that because of the shortage of foreign exchange for imports, the regulations have implied unequal treatment of the foreign and the domestic entrepreneur as regards re-equipment of their industries with imported items. Thus, as foreign investment does not require exchange coverage, since it is effected on a capital contribution basis, much more liberality is shown in admitting it than in dealing with applications for foreign exchange for domestic investment, the response to which is dependent on the available supply of foreign currency, even though external financing is generally obtainable for the imports to which the application relates. Furthermore, should the domestic investor be refused the exchange concession, he will have to resort to buying foreign currenccy at high rates, and is thus placed at a disadvantage vis-à-vis the foreign investor, whose investment is usually shown on his books on the basis of the rates prevailing in the free exchange market. But this situation should now improve, in view of the most recent government measures providing for stricter selection of foreign investment, as well as for the entry of imports against foreign exchange purchased on the free market (Instruction No. 204).

A second problem is that of the admission of foreign investment which will compete with existing enterprises, in cases where such investment does not represent the introduction of technological advances or other advantages of special benefit to the Brazilian economy.

Thirdly, once admission of the investment has been decided on, care should be taken to ensure that:

(i) The schedule of equipment to be imported without exchange coverage does not include items that can be obtained from existing industries, on satisfactory terms as regards price and technical characteristics;

(ii) Generally speaking, used equipment is not included in the schedule, although exceptions may be made where they are justified.

In respect of used machinery, the treatment accorded is unequal, inasmuch as in the case of foreign investment without exchange coverage, such machinery has been granted entry, which in practice is equivalent to its being imported through the free exchange market; whereas, if a domestic enterprise wishes to import used machinery without recourse to foreign investment, that is, through the purchase of foreign exchange, it can do so only in accordance with the regulations in force for the special category in question, paying very high agios.

It would seem that the entry of used machinery ought not to be entirely eliminated, since it is sometimes justifiable to import such items, and the heavy metal-transforming industry itself may ultimately need to avail itself of the right to do so. This is a problem which will not be discussed here on its own merits. However, not only should used equipment be imported subject to the usual precautions as regards price valuation and condition of the machinery, but account should also be taken of the desirability of according the same treatment to domestic and foreign firms. It should be pointed out, however, that this applies more to operational machinery in general than to the equipment considered in the present study.

5. Medium and long-term internal financing

A problem of major importance for the consolidation and development of Brazil's heavy metal-transforming industry is the question of the medium and long-term internal financing of its sales. Besides facing the problem of financing for fixed capital formation, not yet completely solved despite the considerable efforts made in this direction by the National Bank for Economic Development (BNDE), the Industrial Department of the Bank of Brazil, and to a lesser extent the private banking network, the industry is finding itself up against the difficulty of financing its circulating capital and its sales. This is due to the fact that Brazil's banking system is not equipped to grant medium and long-term credits.

The economic development which has taken place in Brazil during recent years has demonstrated that the country's banking system, set in the mould established by a markedly agricultural economy and confronted with a strongly inflationary situation, has not been capable of meeting the credit requirements—especially those of a longer-term character—of the capital goods and durable consumer goods industries.

It is quite understandable that the persistence of inflationary conditions on the one hand, and on the other the legal restriction of the rate of interest to a maximum of 12 per cent per annum—which is lower than the rate of devaluation of the currency—should seriously discourage time deposits and should increase the rapidity of movement of sight deposits. Thus, the banks have not been able to assemble sufficient resources to meet the expanding credit requirements, nor have they possessed any means of remedying the situation by attracting new deposits, and they have therefore been compelled to limit the term of their credit operations to 90-120 days, or, in exceptional cases, 180 days.

As events have shown, the trouble has been not so much a shortage of savings that might be applied for the purposes of medium and long-term credit operations, as an inability on the part of the banking system, for the reasons noted above, to attract such savings on a basis which would enable them to be used for the operations in question. Faced with the uncertain possibilities of broadening their range of customers, the durable consumer goods industries, which have been steadily expanding since the end of the Second World War, have been compelled to accept, in association with the retail trade, the system of sales on credit. Alongside this development, investment and credit or financing agencies began to emerge, based on casual legal provisions, with no body of institutional regulations to govern their activities, and started to operate in acceptances and other security transactions, besides participating in capital ventures through "jointly-owned funds". By skilful evasion of the legal restriction of interest rates, these organizations offered the owners of savings higher yields than could be obtained on bank deposits, so as to mobilize the savings in question for their own business transactions.

In view of the mushroom growth of these enterprises, which soon numbered several dozen—to the detriment of the banking system proper—the Government decided to control their activities, so that they became a credit system subject to inspection by the Currency and Credit Authority, supplementing the action of the banks in the work of stimulating the overall development of Brazil. Thus, the Minister of Finance issued Directive No. 309 (30 November 1960), which established the basic rules of procedure for credit or financing and investment agencies. These rules of procedure constituted a body of fairly flexible regulations, grouping the enterprises in two categories, but not excluding the possibility of a mixed type, which seems to be generally favoured. Thus, under the terms of the directive in question, two basic groups of operations are permissible for such agencies, namely:

(*a*) Investment operations, i.e. transactions in the bearer securities market, partnership in other enterprises, purchase and sale of private or government securities, payment and receipt of yields from such securities, and other subsidiary operations;

(*b*) Financing operations, i.e. money loans to productive activities through contracts, discounting of securities connected with sale and purchase transactions, with or without guarantees, negotiation of credit instruments (promissory notes, certified and negotiable copies of invoices, bills of exchange etc.) by endorsement or conveyancing, business under the head of participation in specific transactions, acceptance operations, financing of rural activities etc.

Directive No. 309 authorizes the agencies to operate either on their own account or on behalf of third parties, stipulating that in receiving their shareholders' deposits or utilizing the resources of third parties they must conform to specific regulations in force for banking institutions; including the requirement of a minimum of 50 million cruzeiros capital, as well as the obligation to transfer to the order of the Currency and Credit Authority deposits received and third-party resources raised in excess of certain given limits.

Since they are of major interest in relation to the question of financing sales of production equipment, the credit or financing agencies must be studied in greater detail. They have to be organized as corporations, in the interests of proper publicity for their activities, as prescribed by the specific legislation concerning corporations or joint stock companies. In their operations credit or financing agencies can use, in addition to their registered capital, resources derived from their own shareholders' deposits and those obtained from third parties, either for predetermined ends, or for miscellaneous purposes, through the organization of common funds under their administration; furthermore, they

can raise resources by means of credit operations. However, the regulations restrict the volume of shareholders' deposits and third-party funds to an amount equivalent to five times the paid-up capital and free reserves.

The legislation also stipulates that the proportion of their paid-up capital held by credit and financing agencies as fixed assets must not exceed 30 per cent, and that they may not hold shares in other enterprises to a value of more than 10 per cent of their own capital or of that of the firm with which they are associated; moreover, they may not apply in the interests of any one client more than 5 per cent of the value of their aggregate funds, nor raise the average sum applied per client beyond 2.5 per cent of the total resources used.

Again, under the official regulations they may only set up common funds, for the purpose of financing long or medium-term sales and purchase operations in respect of machinery and equipment or of consumer goods, when these transactions are attested by certified and negotiable copies of invoices or by loan contracts.

As regards time-limits for their operations, the regulations establish a minimum of six months for active transactions, i.e. applications, and a minimum of twelve months for passive operations, i.e. those relating to the raising of funds. In the case of sales on credit terms, the legislation stipulates that the financing arranged shall not exceed 70 per cent of the value of the transaction and shall cover a term of not more than twenty-four months, if the relevant contract establishes a lien on the goods; otherwise maximum financing is 80 per cent of the value of the transaction, for a term of twelve months. The aim of all these regulations was to ensure satisfactory application of the savings mobilized, to split up operational risks and to avert inflationary consequences.

To prevent encroachments on the territory of the banking sector, Directive No. 309 prohibits the receipt of deposits other than those of the agencies' own shareholders, movements of funds in their accounts by means of cheques, transactions in immovable property or real credit operations, recourse to rediscounting or appeal to the Caixa de Mobilização Bancaria. It should be noted in this connexion that the enterprises under discussion are actually closely linked to the banks, since most of the latter have associated themselves with the credit and financing institutions or were responsible for their organization.

Assuming that in Brazil's case the regular bank system is not in a position, for the reasons set forth above, to promote the financing of the production and sales of the basic equipment industry, which entails long-term credits and low rates of interest owing to the high unit value of the articles concerned or the project requirements and time-consuming processes of their manufacture, the alternative would seem to be the possibility of recourse to the credit financing agencies. However, their supporting influence is not yet making itself felt, at least to any market extent, for a variety of reasons. In the first place, the prices of heavy equipment would not stand the high interest rates at present charged by the institutions referred to. These rates are well above 20 per cent per annum, simply because such bodies have to distribute annual dividends far exceeding 12 per cent if they are to attract the available savings and mobilize them for the purposes of their transactions.

Secondly, the period of financing, restricted by the above-mentioned regulations, as has been seen, to a maximum of twenty-four months, is unsatisfactory for the heavy metal-transforming industry, since such terms are not attractive to its customers in view of the high prices of its products and the length of time required for their manufacture.

Lastly, it would seem that internal savings are not yet sufficient to cover the substantial volume of financing required, in view of the fact that they are already being used on a considerable scale for financing sales of durable consumer goods. To form some idea of the magnitude of the credit resources needed by the basic equipment industry, it is enough to recall that probable domestic production of equipment in the next ten years, solely in respect of the five sectors with which the present study is concerned, is valued at about 721.9 million dollars, or approximately 180.5 thousand million cruzeiros (at a rate of 250 cruzeiros to the dollar). As was mentioned above, the electric power and steel programmes relate to the periods 1961-71 and 1966-70 respectively.

It thus becomes essential to seek the support of external resources and mobilize them for the purpose in question. In this context, consideration must be given to ways and means of utilizing the system of credit or financing agencies, the expansion of which is in full swing, and adapting it to the requirements of the heavy metal-transforming industry in such a way that both internal and external savings can be attracted for the financing of the latters' sales. To this end, the essential requisite would probably be security as regards transactions, to make up for the lower rates of yield and longer terms of application, as well as safeguards against the risk of fluctuations in the exchange system, in the case of funds from abroad. Private enterprise would hardly be able to fulfil these requisites completely. This is a task incumbent upon the Government, with the support of course, of the private organizations.

It should be recalled that when tenders are invited for the supply of equipment to public or private enterprises, the domestic basic equipment industry has been unable to compete with the financing terms and rates of interest offered by foreign manufacturers, since virtually all the latter can obtain adequate credit support from government financing agencies in their own countries.

The best solution, in order to give the basic equipment industry the financial support it needs for its development, might be the establishment of a system which would combine official and private effort within the existing framework of credit associations, in other words, the institution of a credit system specializing in financing for terms of more than twenty-four months, and operated by a government body in conjunction with the agencies in question.

Following the example of Mexico, where the Nacional Financiera S.A. is the dynamic force behind the action of the specialized credit agencies, the National Bank for Economic Development (BNDE) might pursue a similar course, introducing such modifications as might seem advisable and effecting the necessary reorganization. Thus, a "basic industries sales financing fund"

might be set up within BNDE, with the participation of the Bank itself, the credit and financing agencies and the manufacturers of equipment.

Broadly speaking, the active operations of such a fund would consist in negotiating, either by endorsement or conveyancing, and either directly or by means of refinancing through the credit agencies, bonds representing effective sales of domestically-produced equipment, for terms of over twenty-four months. Thus BNDE's function in relation to the credit agencies would be similar to those of the Rediscount Department in relation to the bank network and the Reinsurance Institute in relation to the insurance system. The restriction consisting in a minimum term of twenty-four months for the securities admissible in financing of this type means that BNDE would be concerned solely with long-term credit and would not intervene in the present field of operations of the credit agencies. The passive operations of the basic industries sales financing fund would consist in the issue of securities or bonds for disposal, either directly or through the agencies under discussion, in the domestic or foreign capital markets. The series of bonds intended for sale on the international financial markets would of course be issued in foreign currency, with a guarantee of payment of dividends in the same currency.

To raise funds abroad, BNDE might establish liaison with the Inter-American Development Bank, in order to obtain resources for internal financing of sales in the heavy metal-transforming industry by means of bonds issued for this purpose by BNDE and bought by IDB. This would undoubtedly be one of the best ways in which IDB could contribute to the economic development of Brazil, since the problem of financing its sales is the bottleneck in Brazil's basic equipment industry, which can already compete with its foreign counterparts as far as prices and quality are concerned. The formula put forward does not of course exclude other types of operations, such as the endorsement by BNDE of bonds representing sales of equipment, with a view to their disposal by the credit agencies.

Obviously, a thorough study would have to be made of the structure of the proposed fund; the contributions of BNDE, the credit agencies and the manufacturers; rates of interest; devalution tables; guarantees etc., as well as of the necessary agreements with the Currency and Credit Authority for the establishment of the fund on a proper footing under the extant regulations.

A searching examination of the structure and method of operation of the Mexican institution referred to above —the Nacional Financiera S.A.—would be extremely useful for the purposes of organizing the fund. The Mexican institution, which has produced magnificent results, is responsible for all negotiations of securities for terms of more than one year and for the handling of medium and long-term credits with foreign institutions, always with the aim of promoting the country's economic development.

A considerable step towards the solution of the problem under review was taken by the state authorities in São Paulo when by Act No. 5,444 of 17 November 1959 they instituted, *inter alia*, the "Capital Goods Financing Fund", with a view to the medium-term financing, up to 50 per cent of their value, of sales of equipment produced within the territory of the state. This Fund, whose aggregate for the financial years 1959-60—1961-62 is 5,125 million cruzeiros, unused allocations being transferable to the following financial year, is shortly to be controlled and operated by the Bank of the State of São Paulo.

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