THE TRANSFER OF TECHNICAL KNOW-HOW IN THE
MACHINE-TOOL INDUSTRY IN BRAZIL,

PART ONE: GENERAL BACKGROUND TO THE PROBLEM

prepared by

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Note: This report forms part of a study being undertaken by the Economic Commission for Latin America (ECLA), the Interamerican Development Bank (IDB) and the Division of Public Finance and Financial Institutions of the United Nations Department of Economic and Social Affairs on the problems of the transfer of industrial technology in Brazil.
Contents

INTRODUCTION ........................................................................................................ 1

Chapter I: CLASSIFICATION OF INTERNAL AND EXTERNAL KNOW-HOW .......... 3
  a) Internal K.H. ................................................................................................. 4
  b) External K.H. ............................................................................................... 6

Chapter II: DESCRIPTION OF THE DIFFERENT TYPES OF KNOW-HOW ...... 8
  a) Internal K.H. ................................................................................................. 8
  b) External K.H. ............................................................................................... 28

Chapter III: ORIGIN AND HISTORICAL DEVELOPMENT OF THE TYPES OF
  KNOW-HOW ..................................................................................................... 45

Chapter IV: PROSPECTS FOR THE FUTURE DEVELOPMENT OF KNOW-HOW ... 69

Chapter V: TRANSFER OF KNOW-HOW .............................................................. 79
  a) Types of K.H. that are normally transferred in the sector ......................... 79
  b) Cost of the transfer ..................................................................................... 83
  c) Time ............................................................................................................ 85
  d) Remarks on the acquisition of K.H. ........................................................... 86
  e) Imported K.H. and the general level of development of the local engineering
     industry ........................................................................................................ 89

Tables

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conceptual relationship of internal know-how to the productive sectors</td>
</tr>
<tr>
<td>2</td>
<td>The machine-tool industry and external know-how</td>
</tr>
<tr>
<td>3</td>
<td>Historical development of know-how</td>
</tr>
<tr>
<td>4</td>
<td>Relationship between internal and external know-how</td>
</tr>
</tbody>
</table>
| 5      | Type of transferable know-how and comparison of its transfer to enterprises
         in three typical cases | 81 |

/Figures/
<table>
<thead>
<tr>
<th>Number</th>
<th>Figures</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Progression of internal know-how over time</td>
<td>60</td>
</tr>
<tr>
<td>II</td>
<td>Hypothetical prospects for the rate of expansion of internal know-how</td>
<td>61</td>
</tr>
<tr>
<td>III</td>
<td>Stages in the development of internal know-how</td>
<td>63</td>
</tr>
<tr>
<td>IV</td>
<td>Influence of external know-how</td>
<td>66</td>
</tr>
<tr>
<td>V</td>
<td>Expansion of internal and external know-how - forecast for 1990</td>
<td>78</td>
</tr>
</tbody>
</table>
INTRODUCTION

The transfer or transmission of know-how from one country or one zone to another, and specifically, from the developed to the less developed areas, is a theme of great topical importance; a set of definitions is required if the subject is to be viewed with a greater degree of objectivity. The multitude of questions that relate to this topic give rise to a wide variety of explanations which, however, do not always successfully define the essence of all the problems involved.

In order to counteract the inherent limitations, special methodology has been adopted in the field of machine tools, which consists basically in establishing a universe of knowledge - or world state of the art - regarding all kinds of know-how required for the manufacture of machine tools, whether it be internal, that is, the manufacturer's own or external, that is, acquired from specialized third parties, in the form of services or parts and components. Once all this know-how has been defined and classified - assuming that it provides a fair reflection of the universe of manufacturers, logically composed of those who have a lead in technology and organization - it is possible to relate the position of the manufacturers of a given country, in this case Brazil, to the over-all situation and to the intermediate stages in the development. In this way, it will be possible to assess the past evolution of and prospects for the future development of know-how in this sector, in the world as a whole and the direction in which Brazil has to progress. As regards the national sector, it would be possible to specify fairly exactly how much know-how could and should be developed locally as part of a self-generating process, and how much could be obtained from other more advanced areas, in order to ensure that domestic supply always meets the same proportion of demand, as indicated in chapter I of the UN document "Critérios y antecedentes para la programación de la industria de maquinaria." 1/

The attempt to obtain a synthesis of the main features of the sector, whether technical or economic — a synthesis which in this work will represent the over-all situation — seems to be valid and acceptable from a conceptual viewpoint, since the synthesis reflects the advances made in the world in respect of knowledge of a given sector and how it operates, and serves as a frame of reference for studies of the strategy for development of the sector, consideration being given to the total production of all the countries rather than to the production of each one individually.

In this as in other similar situations, the sectoral study of a country must be clearly envisaged as a sub-case of a general situation. This will facilitate the statement of a whole series of problems and at the same time will give such studies a more dynamic orientation and prolong their validity. This appears to be the most suitable path to follow when the sub-cases refer to countries that are under developed but have rapidly expanding metal-transforming industries.

It is on this basis that the topic has been divided into two parts. The first will be concerned with defining the world state of the art, or universe of manufacturers, while the second will refer specifically to the current situation of the productive sector in Brazil and the way in which it should develop in the long term.

It is thus hoped to render the conclusions reached more objective and to make it possible to carry out a similar study in other areas and countries, achieving an acceptable degree of comparability.

Chapter I
Chapter I

CLASSIFICATION OF INTERNAL AND EXTERNAL KNOW-HOW

By way of reference, it should be pointed out that in these notes the same definition of machine tools has been adopted as that employed in the document quoted in footnote 1; table 1 of that document presents a classification of the types and models of machine tools.

Once the field of machine tools has been specified, a way must be found of defining the variety of expertise, or know-how \(^2\) usually employed in their manufacture.

Since we are dealing with a type of production that is not integrated, it is obvious that the manufacturers must have recourse to third parties for the services and specialized knowledge they need on the composition of their products. Thus the sphere of K.H. may be divided up as follows:

(a) Internal K.H.

(b) External K.H.

(i) Supplied by the primary infrastructure of the metal-transforming industry;

(ii) Finished components used as they stand in assembly.

It is immediately apparent that this subdivision is neither new nor exclusive to the machine-tool sector, since it covers – in varying proportions – most products of any complexity produced by the engineering and other metal-transforming industries whether they be capital goods or consumer durables. The differences from the other sectors are, however, evident from the description of the various items under points (a) and (b).

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\(^2\) In the course of the text the word know-how will be abbreviated to K.H.
By internal K.H. is meant the sum of all the knowledge that the enterprise possesses and applies in its industrial activities. External K.H. is the knowledge of third parties acquired in the form of services or component parts, the prices of which include the value of other specific K.H.

In order to classify such knowledge effectively, it is necessary to consider it in the aggregate, as a whole, as if it were a branch of learning; otherwise, the numerous subdivisions into which it can be broken down would concentrate attention on the formal classification of K.H., which would make it difficult to deal with the body of knowledge as a whole. Actually, the classification of K.H. is aimed at killing two birds with one stone.

The first objective is to arrange the K.H. according to subject, distinguishing the most significant; the second consists in using the classification as a working instrument for demonstrative purposes.

Taking account of this double objective, internal and external K.H. have been broken down as follows:

(a) **Internal K.H.**

1. Selection, definition and general conception of the product.
2. Study and design of the product.
3. Laboratory work.
4. Internal technical standards.
5. Specification of the services of subcontractors and of the parts and components supplied by third parties.
6. Design of jigs, frames and supplementary manufacturing equipment, including tools.
7. Method, instruction and time cards.
11. Intermediate checks on production and commercial parts.

/12. Assembly,
12. Assembly, painting, test-running and checking of the finished product.
13. Industrial accounting, production costs.
14. Commercial and technical sales organization.
15. Advertising, exhibitions, etc.
16. Technical assistance to purchasers.
17. Business management.

Although – as has been pointed out – these seventeen types of K.H. do not cover all the types of activity that may be carried out in a machine-tool factory, they do highlight the essence of the K.H. considered most representative of the sector. From the description of each of the above it will be clear how difficult and complex is the problem of achieving international production patterns. It is also clear that both the nature of the product and the size of the enterprise will be factors influencing the degree of importance of each of the above types of K.H. as between one enterprise and another. These aspects will be made clearer in the course of the text.

For the time being, it is essential to concentrate on certain well-defined types of K.H. which are of importance in the international sphere or, in other words, represent the current situation of the universe of world manufacturers employing a high degree of K.H. For that reason, no consideration will be given here to cases of branch enterprises or enterprises that produce goods exterior to the sector in the same workshop.

The above having been made clear, it now remains to determine to what extent manufacturers use the infrastructure of the metal-transforming sector and external supply to produce their goods. Obviously, the question of dependence or integration of the enterprises does not arise with equal force in all cases, since both from a conceptual and a practical viewpoint there may exist certain differences from country to country, between different enterprises in the same country and, of course, between different products.
However, there is no harm in showing in broad outline the situation in which most firms find themselves. Thus, any internal production of the parts tested below is usually a special case or an exception, and has little effect on the over-all trend, which is emerging increasingly clearly. Consequently, the producers of these capital goods take advantage of the external K.H. of third parties, of the following types.

(b) **External K.H.**

1. Castings of ferrous or non-ferrous metals.
2. Forgings of ferrous or non-ferrous metals.
3. Other semi-finished parts of various materials.
4. Small parts, such as nuts, bolts, springs, etc.
5. Electric motors.
6. Components for electrical circuits.
7. Components for hydraulic systems.
8. Components for pneumatic systems.
9. Components for lubricating systems.
10. Components for refrigerating systems.
11. Components for mechanical power transmission and control systems such as clutches, brakes, standardized speed reducing gears, speed-changing and other gears, etc.
12. Bearings, etc.
14. Automatization, automation, numerical checks etc.
15. Accessories.
16. Specialized servicing.

Bars, shapes and sheets of metals and non-metallic substances have not been included as a separate item, since greater emphasis has been placed on semi-finished products such as castings, and forgings and other components classified as intermediate goods. Item 16 is an exception since it comprises simple specialized servicing, with little in the way of materials.

/ The first
The first fifteen items in particular represent what may be considered as normal for the sector as regards dependence on third parties. A large amount of technical knowledge is concentrated in these items, in some cases relating specifically to the field of machine tools, in others to capital goods in general, and in yet others, to more or less common K.H. of the most diverse application. Be that as it may, they represent an important sum of K.H., some of which is inseparable from the plant where it is used; some of it, on the other hand, is of a kind which bends itself to long-distance commercial transaction, even between countries or between continents.

We have thus identified thirty-three types of K.H., seventeen internal and sixteen external. Each of these types will now be described separately, with a view to identifying their individual functions and scope in so far as they relate to the manufacture of machine tools.
Chapter II

DESCRIPTION OF THE DIFFERENT TYPES OF KNOW-HOW

The description will be very brief. In writing it, the aim has been to show in a succinct form the wide scope and/or the complexity of the different types of K.H., thus giving an idea of the level of individual or collective training that must be achieved to ensure success in this type of manufacture. The situation as it existed in 1968 will now be described, taking as a frame of reference medium-sized (employing about 400-500 persons) and large enterprises (employing 1,500-3,000 persons), and disregarding both extremes. Neither the small nor the very large enterprises would be suitable for study, the former because of their incomplete structure and the latter, of which there are very few, because many of them have technical and operational features which are exceptional compared with the average industrial structure.

In these terms, the position of each type of K.H. could be summarized as follows:

(a) **Internal K.H.**

1. **Selection, definition and general conception of the product**

   This is a very specific area of K.H. possessed by only a limited number of persons on the managerial staff of enterprises and some heads of department. It has two basic aspects. First, in the course of their work, the sales and technical assistance departments systematically compile basic information on their customers and classify their problems until a sufficient volume of background material has been gathered to permit a modification of the model or the conception of a more advanced product within the traditional line of the enterprise which will better meet the customers' needs. Secondly, the product may also develop from ideas germinating within the enterprise as a result of laboratory research or new designs, and the customers' interest is gauged through direct surveys, for instance, on the acceptance of a new idea which naturally has technical and economic advantages. These are the two most common aspects.

/In the
In the case of completely non-traditional production lines or of the launching of a product which was not previously manufactured in the country, market research must obviously be carried out as a safety measure. In all these cases experience and full knowledge of the technical, economic and managerial context are required, since basic and strategic decisions are to be taken which influence the proper running of the enterprise. The empirical or extremely personal decisions or choices that are still to be found in practice are not a good enough guarantee that the technology to be used or proposed really is the most suitable. The basic reference material needed for a decision to be taken on any product are abundant information on product users, the results of market research by modern methods, and micro- and macro-economic knowledge of the sectors to which the goods are destined and of the long-term trends of their technological and economic development.  

Qualified staff of the enterprise should compile the background information, and the firm's directors should co-ordinate and screen it so as finally to be able to adopt an approach capable of being turned into a programme. As can be seen, K.H. in this category represents a collective pooling of knowledge, the final decision being the responsibility of only one or a few persons; such K.H. could be called strategic and, as such, is of fundamental importance for providing the enterprise with a firm base. In order to acquire a manufacturer's licence, the manufacturer — irrespective of the amount of K.H. at his disposal — must take some responsibility and have some specific knowledge of the field under consideration; he will need to know much less about the study and design of the product than is the case when dealing with a local innovation, but the point nevertheless holds good that he requires a sound basis of knowledge if he is not to launch upon rash industrial ventures.

Some examples are to be found in ECLA publications: "The machine-tools industry in Brazil" (E/CN.12/633); "Aspectos metodológicos y operativos de los estudios sobre las máquinas-herramientas en los países en desarrollo (CID/SYM/D/C-11, Moscow, 1966), or (E/CN.12/L.14); "Las máquinas-herramientas en la Argentina" (E/CN.12/747).
2. Study and design of the product

This category logically constitutes the most complex and specialised K.H. of the sector. Tradition, experience, and knowledge of numerous approaches adopted in the past which have been more or less successful in practice are assets which cannot be properly acquired in a short time, however great the price that is paid for them. For this reason, it is always the men with wide experience both of general project formulation and of getting out the first drawings who stand out among those who possess this type of K.H. Experience, knowledge and individual inventiveness and originality required from the different categories of staff decrease as a new product goes through the different stages of manufacture, i.e., from the director of the project down to the men who make separate parts, passing through all the intermediate stages, including that of calculations. Obviously, most of this type of K.H. is possessed by the top-level engineers in charge of the project. However, the concomitant contribution made by those who back them up must not be underestimated, because there are so many of them and because of the level of schooling and technical training they must have.

This is easy to understand since the design of an uncomplicated machine requires between 5,000 and 10,000 man-hours, a machine of medium complexity between 10,000 and 20,000 man-hours and a really complex machine up to 40,000 and more man-hours. The creative and operational yield from this type of K.H. normally depends to a large extent on how long it has been applied by a seasoned team, regardless of the type of product manufactures, i.e., given the same number of men in the teams, the creative output and speed with which a product is designed is generally greater for technical offices that are already well established than for those of recent formation, as might be the case for a firm less than ten years old. In other words, the price to be paid for recently introduced K.H. in this area is a lower level of efficiency, which cannot always be determined precisely but makes itself felt indirectly in various ways – but this does not imply that this K.H. should not be spread in both developed and developing areas.

Moreover, this problem is largely bound up with the complexity of the products in question. With regard to the complexity of products and future technological trends, further remarks, both general and specific, will be
found in chapter IV. Although there is no doubt that the spread and depth of this type of K.H. depend fundamentally on the length of time it has been applied, there is no denying that the attitude of the firm in which it is developed is very important also. Where this K.H. has been applied for the same length of time, minute specialization, the way in which the available K.H. is organized, the techniques used in design research, high-level integration of several departments of an enterprise, the light which the K.H. mentioned in section I above can shed on the subject, the organization of internal and external information, and the quality of the internal technical library are factors which exert a strong influence on the forces which generate product design. Thus, a clear-sighted and progressive approach to this problem will always make for more rapid and substantial results than the application of a slow old-fashioned routine, as was the case in the not-too-distant past. In view of the above, it can be said that even though the price of trial and error must be paid for new K.H., with good guidance, it can become efficient, and spread in breadth and depth more rapidly than in the past.

Lastly, it should be noted that, compared with three or four decades ago, there have been changes in the conception of projects, and the structure of production is not so rigidly vertical as it once was. With the increasing supply of intermediate components for capital goods of all kinds, a growing use has been made of specialized external K.H., which has effectively facilitated the project work on power transmission control systems. This means that much of the increase in complexity of the products—which have steadily become more and more complex ever since the last World War—can be obtained by means that are not exclusively mechanical and through joint action with other branches of knowledge and with specialized enterprises, and through the incorporation of components. Thus, the understanding of this fact, on the one hand, and its logical application at the project stage, on the other, make for simplification, rapid assimilation and adaptation of project K.H., thus saving time and increasing efficiency, provided that management is thinking along the same lines and is receptive to these ideas. Of course, it is always difficult to decide how to utilize other K.H., but not so difficult in absolute terms as inventing from the ground up, without reference to the /existing K.H.
existing K.H. of third parties. It can therefore be stated as axiomatic that, even though experience of long familiarity with the K.H. in question continue to be a sine qua non for the achievement of high output, this is less true than in the past because of the special points mentioned above, which shows that there has been a change in the structure of this branch of K.H. Thus, a high degree of efficiency and depth can be obtained in less time than a few decades ago. The additional factor needed to make this feasible is a higher level of basic theoretical training than before, both at school and at the university.

3. Testing

Advantage is not always taken of this branch of K.H. to obtain suitable models. Moreover, experimental work is not often concerned with the machine as a whole. As far as basic invention is concerned, the only research done in the test-shop is on a few important parts or details, such as hydraulic and lubricating systems, electrical and electronic circuits, and mechanical groups and subgroups. Other experiments may be carried on without a real test-shop, without using too much or too expensive equipment. They usually take the form of operational tests on prototypes and are aimed at dealing with vibration buckling due to wear and to heat, etc. They may also take the form of tests and checks on a product that is already being mass-produced, with a view to finding out more about it and making future modifications. This is done by applying relatively simple methods of analysis, carried out under laboratory conditions.

As a result of the analysis of the performance of the prototype, modifications may be made, which may be fundamental or mere matters of detail, and recourse will again be had to the K.H. on product design, and this process will be repeated again and again until the product is approved.

The research involved may be done either within the enterprise or outside it, depending on the circumstances of the case and on whether the country is endowed with institutes specializing in technological research on machine tools which could do the research for the enterprise. However, the analysis of the performance of the product must be carried out - at least in good measure - by the firm responsible for its production. At a later
stage, recourse may be had to a better equipped national institute for a second and more detailed analysis of the results obtained by the firm.

For the stage of research, professionals trained in a university laboratory, and possibly in some specialized institute as well, are required. The testing of performance requires less scientific background, but a high degree of vocational training. In general, it should be recalled that the type of laboratory used for research and applied engineering can conveniently be replaced by a national institute concerned with the machine-tool sector or a specialized university laboratory. Except in the United States, the number of such laboratories has been increasing in nearly all the industrialized countries and there is a growing tendency to establish them in other areas. There are many reasons in favour of getting certain types of research done by national institutes: notably, the lack of continuity of this type of work in any enterprise, no matter how big, and the financial burden of permanently maintaining a team of highly specialized research workers with a great deal of expensive equipment at its disposal. Moreover, laboratories and national institutes periodically publish the results of their general research work, so that the body of literature on machine tools is not only growing but is being distributed outside the country in which it originates. Nevertheless, it is understood that the results of any specific research projects agreed upon are the exclusive property of the enterprise that commissions them.

What is important is that the K.H. on design should be properly organized and that due advantage should be taken of the research results published by the various laboratories and applied to the machine at the experimental stage, to improve some details or even the whole conception of the machine. This is another facet of the K.H. on design which can be better understood in the context of the present section.

4. Internal technical standards

In addition to those of national and international origin, every factory must have its own internal standards, and there must be standards for each product. This is both customary and essential.

(The standards
The standards may relate to the proper installation, lubrication, use and overhaul of the machines, or they may consist of certain regulations, standards of assembly, standards for test-running, etc., which must be respected by both the manufacturer and the user.

Another important group of standards, which are exclusively internal, concerns tolerances, diameters, modules, materials, the standardization of parts and components so that as many as possible may be used for several different products, whether they be manufactured within the enterprise or purchased from third parties, heat treatment and possible external servicing, to mention only a few. This type of standardization is closely related to the rationalization of projects and production, with a view to compensating for the usually too short production series. This kind of K.H. may be applied either by a specialized and independent section of the enterprise, or in conjunction with the K.H. on design but separate from it and with its own well defined character.

It is common for a new project to be revised and modified in the light of standards criteria as a prior step to approval of the design. This K.H. may also be applied in other manufacturing sectors. In any event, it is most important that this type of K.H. should exist and that it should operate to reduce the number of factors that would raise the price of the product without adding any compensatory functional advantages.

The men responsible for applying the K.H. in this way must have had a first-class scientific training and they must have a good grasp of organization and considerable experience of production processes and of tools.

5. Specification of the services of subcontractors and of the parts and components supplied by third parties

As this sector depends to a large extent on K.H. supplied by the external technological infrastructure, the firms wishing to use it must have their own specific K.H., if the foreign K.H. is to be turned to good account. Whatever the circumstances, there appears to be no easy solution to the problem.

Indeed, on the one hand, the firm must have a sound realistic approach if it is to ensure that the semi-manufactures and/or complete parts and components commissioned from third parties meet the firm's technical /requirements and
requirements and the standards specified in the order are neither above nor below what is necessary. If the standards specified are too high, the cost of supplies might soar, while, in the opposite case, the quality of the product might suffer. The constructive capacity of the suppliers must always be borne in mind, therefore, and technical discussions should be held on the subject. When the case arises, consideration should be given to the conditions on which a compromise would be acceptable to both parties. Many complications arise out of the conflict between the required technical level and the production series but, with a little adroitness, these can be avoided.

On the other hand, the opposite may also be true. The intermediate capital goods industry is becoming increasingly precise in the design, diversification and technical preparation of its goods and is constantly offering new solutions or technical improvements to older solutions which are easily available to users, who of course include users of machine tools. Thus, a branch of K.H. that is characteristic of modern times consists in knowing how to keep up contacts and to discuss these intermediate goods and how to compare and incorporate them judiciously in one's own production process. From time to time, suggestions may be put forward for some specific adaptation. The firm must then have the internal k.h. required to enable it to select and take advantage of the vast and varied range of external K.H. Every firm is to some degree dependent in this, as in the previous case. If any manufacturer tries to free himself from this dependence, he runs the risk of being unable to profit by countless technical innovations for which he himself cannot provide an equivalent, as has happened to several enterprises which used to be in the lead in this sector until a short time ago.

Although few staff are required for this branch of K.H., they must be highly qualified to tackle the problems involved. They should of course form a kind of link between the buying section (K.H.9) and the project design section (K.H.2). To get a quick idea of the importance and scope of this branch of K.H., all that is needed is a glance at the long list of types of external K.H. The fact that the staff required for its application is small is only an apparent contradiction, since it may be assumed that the solution of completely new problems involves only a fraction of all the problems, which means that certain types of solution are lasting.

The personnel
The personnel concerned with this type of K.H. are also required to take part in the preliminary discussions relating to new projects. In many cases their contribution may prove to be very valuable.

Lastly, those who possess this type of K.H. are responsible for co-ordinating their knowledge with K.H.4, the K.H. on standards, in so far as many products of external origin are concerned. This is important to ensure that the firm's specifications and requirements are realistic from the technical or the economic point of view.

6. Design of jigs, frames and supplementary manufacturing equipment, including tools.

It is a well-known fact that the medium- or small-scale production of capital goods raises a variety of problems requiring a tried and judicious K.H. if acceptable production times are to be achieved in spite of the high quality and complexity of some of the parts. And yet, with very few exceptions, the stock of machine tools used by the manufacturing firms is generally of a more or less all-purpose type. Even though, admittedly, the technical refinements on this type of machine have increased considerably of late, with a consequent reduction of idle capacity, fewer adjustments and fewer change-overs, etc., and even when means are available to cut down on the equipment used indirectly in manufacture, there is no doubt as to the importance of this type of K.H. for turning the machines to better account. To a greater or less extent, a large number of parts require jigs, frames, auxiliary equipment of all kinds, special and precalibrated tools, etc., for machining and at times also for assembly. All told, this is a very large quantity of K.H. which can reach a high degree of efficiency only slowly. The most difficult thing is to achieve a balance between the amount of the auxiliary equipment, designed for multiple use with a few variations and its cost, on the one hand, and the value of the service it provides and the production series it helps to manufacture, on the other. The K.H. in question therefore is a mixture of technical knowledge, imagination, practical experience and common sense; although it is subject to certain general rules, it nevertheless has characteristics which are peculiar to each enterprise. On occasions, owing to the complexity of the design and the precision required for the manufacture of the part, exclusive reliance is placed on the capacity and skill of those who possess this K.H., without which it would be unrealistic
to think important advances could be made in the sector. If this K.H. is used too parsimoniously, it keeps production at irretrievably low levels of technical skill. Together with the K.H. on design, K.H.6 is one of the most personal and characteristic types of K.H. employed in the sector. It is therefore natural that, even at the project stage, there should be an exchange of ideas on the product or part of it between those concerned with the two types of K.H., with a view to reducing the time spent in manufacture.

As can be seen from the descriptions given above, the first five types of K.H. bear no relation to the volume of production, but the opposite is true of the K.H. discussed here. When production is very small, unrepetitive, or - an extreme case - consists of a single unit, the importance of this K.H. decreases, although it never completely disappears, but the effects are obvious: the number of hours spent directly on the production of 100 kg. of the product is very high. On the other hand, when the scale of production is normal for the sector, there is a noticeable drop in the number of hours of direct work per 100 kg. of product, as can be seen from various parts of the ECLA document E/CN.12/L.15 already cited.

In principle, this type of K.H. could be entrusted to the personnel responsible for making special equipment and the machines for manufacturing it, which are generally kept separate from those used for the construction of the machines for sale. Such personnel must have a high degree of professional skill and basic technical training. Conceptually, this subject belongs to one of the branches of production engineering.

7. Method, instruction and time cards

This type of K.H. was late in being accepted by enterprises manufacturing capital goods as compared with those concerned with mass production of consumer goods. Its cost is undoubtedly high, but manufacturers have found its adoption essential for the rational organization of the work. It consists in establishing the complete range and sequence of all operations affecting parts and choosing the production equipment for each part and the auxiliary equipment and tools used in each operation. It also involves estimating the total time - productive and unproductive - required for carrying out all operations or, in other words, calculating the basic productivity of each operator, on the basis of which it will be possible to assign work contracts for each individual task.
If this type of K.H. is to be developed, those concerned with it must know what solutions have been adopted under K.H.6, and the two must be closely co-ordinated. It is important to realise that this section of K.H. is very specific and is possessed by persons with a suitable technical background who have been trained by the enterprise to fit its peculiarities. They range in background from mechanical and/or production engineers to staff with intermediate-level technical training who do the calculations.

The essence of this type of K.H. consists in knowing in advance the total time to be spent on the manufacture of the products and on each line of products, establishing the work load for each machine and/or production section, in a word, determining the objective bases for the planning of production.

8. Planning of production, work orders and progress checks. Flow of production

Once the information provided by K.H.7 is known, it may be put on papers and cards which follow the whole flow of production, part by part and operation by operation. It is not difficult to establish an order of magnitude for the operations with which this type of K.H. is concerned or for the difficulties which the manufacturer has to overcome. A manufacturer producing two or three types of machine, for instance, each with four or five different variant in models and sizes, may have to manufacture 5,000 to 8,000 separate parts.

Supposing that the manufacture of each part involves an average of four or five operations, the magnitude of the series of operations which the manufacturer will have to undertake can be understood. Moreover, since in general production is not continuous but broken up into several bursts during the course of the year, the complexity of the problem of maintaining an exact picture of the real situation on each working day can be readily deduced. Nevertheless, this is being done more and more in the well organized enterprises. It is therefore a question of co-ordinating the work load of each machine or job in advance, following the distribution and termination of the work, and noting the results in the form of one of the numerous tabulations used for the various types of programming. Purchase orders for both raw materials and semi-finished products and for parts and components are also co-ordinated with the rest of internal production, in accordance with a parallel set of /concepts. In
concepts. In this way, even when there is a large variety and number of parts, they continue to flow regularly to the assembly line, whether their production takes a few seconds or half an hour, whether they weigh a few grammes or several tons, and whether they are manufactured internally or purchased from others. On the basis of this co-ordination, it will be possible to predict accurately the date of completion of each product, permitting firm commitments to be made for delivery to the national or international customer. Thus, advance knowledge of exact delivery dates is actually the reflection of a set of conditions involving various types of K.H. In this connexion, it should be borne in mind that lead times of from six to eighteen months are quite common. Thus, it is quite usual to tabulate a detailed programme of work for up to, say, 300 or 400 working days; naturally, persons with special knowledge and experience are required to organize and follow the work flow.

The rationalization of the form and lay-out of the cards for work orders, deliveries of materials, instructions, etc., and their distribution, collection and compilation are functions of this type of K.H. Obviously, once the specific function of planning has been completed, all the cards and papers are passed on to other departments for the fulfilment of different and complementary objectives.

K.H. 7 and 8 therefore make up the heart of the organization of production and an important part of the management context of the enterprise. Out of the continuous process of perfecting these two branches of K.H., new ideas will arise which will pave the way for rationalized production, which may be made more complex and more precise if necessary, which provides a sound framework for the structural changes or expansion which all enterprises are obliged to carry out sooner or later.

9. Buying

Once the preceding branches of K.H. have been well defined and organized, buying will not present a difficult or important problem compared with others. It is axiomatic that those responsible for applying this K.H. are not free to interpret it. Their only aim is to supply the factory with what it needs in accordance with previously determined technical specifications and to ensure that these supplies are received within the time-limits established /in the
in the plans. However, they will have to possess enough technical knowledge
to be able to discuss purchases with suppliers, so as to channel towards the
factory any external K.H. that may be of interest from the point of view of
innovation, variation, etc. The buying section is also responsible for
making claims and complaints and for specifying technical and economic
requirements, time-limits, etc. This section also normally deals with
imports of special components for machines, which are being increasingly
used and may be of foreign origin. The K.H. required for such tasks is
easily available and the selection of qualified staff presents no problems.

10. Production, selection of production equipment, lay-out

This section comprises K.H. which is shared with other capital good
manufactures and other K.H. which is peculiar to the machine-tool sector.
Just as the theoretical, dynamic and functional characteristics of the
products are largely decided by the project K.H.2, such practical aspects
as quality and precision are worked out in the production workshop. A good
product is therefore always the result of the felicitous combination of
K.H.2 and K.H.10. All other conditions being equal, several factors must be
combined to obtain the best results from production, namely: the equipment
must be well selected, the machinery must be in perfect running order and
properly adjusted, suitable tools must be available and the tools section must be
properly equipped, there must be a comprehensive scheme for checking tools
and for supervising work in progress, a rational lay-out, good internal
transport facilities, etc.

Given the large variety of different parts to be machined and the
numerous types of operation to be carried out, it is not easy for those
involved this K.H. to ensure that all the factors involved are operating
with maximum efficiency. Thus, compromise solutions are frequently found,
even in the best enterprises.

Not all the component parts are equally complex and difficult to produce.
The production of some parts of products, which may be small, medium or large
in size, involves only very ordinary problems, compared with others, which
call for really difficult and complicated solutions. These arise in
connexion with what are generally the most important parts of the product,

/and a
and a well-tried K.H. is therefore required, the possessors of which must have an excellent theoretical background and be quite clever at achieving good results without too much delay. In many cases practical experience is the best guide. The increasingly stringent requirements in respect of the quality of machine tools oblige the workshop, on the one hand, to work with quite small tolerances and, on the other, to correct all the distortions and tensions which arise during machining. The planes, guideways, right angles, parallels, the alignment of supports, etc., all present difficulties which are typical of those encountered in building machines to specific dimensions and with the utmost precision. Although it might seem so at first sight, good results here do not depend solely on the quality of the equipment available. Unless the firm has at its disposal men who possess a well-tried K.H. and who are familiar with these problems, it will be impossible to attain the desired objective. In summary, there is a specific combination of K.H. and productive equipment which might be called a K.H.-machinery binomial that is absolutely necessary for certain parts or components. Further, as the manufacturers do not renew their stock of machine tools and bring out new models with the same speed and frequency as manufacturers of consumer durables, replacements are more infrequent, so that those responsible for production often have to overcome this handicap by means of their own inventiveness and experience.

The account of the present K.H. would not be complete without some mention of the significant contribution of foremen, craftsmen, and many skilled workers. Since a low turnover of such staff is desirable and highly advantageous, it is understandable that much weight is placed on experience in this field.

11. Intermediate checks on production and commercial parts

Despite the fact that producers may differ as to methods of checking their own production and on that of others, they all agree on the fundamental importance of checking. For instance, when an operator checks his own work, there is much less need for the centralized control of all operations and of all parts as a specialized autonomous service, which is used when the operator is not responsible for checks of the work he has done. In other
cases, the two types of control are combined. Whatever the system used, the control K.H. must be on the spot, effective, critical and well thought out so as to ensure the level of precision required for the products.

Whether it is part of the job, separate therefrom or a combination of both, this K.H. is more effective and produces quicker results if it is applied by staff with the necessary educational background, since the gap between theory and practice is much less in this case than in that of the other types of K.H. dealt with here.

As regards the quality control of purchased parts, how thorough and detailed it is will depend on many factors, such as the strictness of the controls applied by the suppliers, the established mutual confidence, etc. Obviously, this control is not exclusively a matter of checking dimensions, but also extends to a wide range of other things: tests of hardness, chemical, functional and dynamic controls, etc. As a result, it is natural that there should be a working relationship between the control and buying sections which will make it possible to iron out any difficulties that may arise.

12. Assembly, painting, test-running and checking of the finished product

In order to simplify, all these sections have been re-grouped under a single K.H. heading, which relates to the final phase of production. It is generally possible to begin assembling a machine by assembling the parts and sub-groups of parts separately. For this task it is essential to have on hand, section heads with wide experience and a competent and careful labour force. It is difficult to make do with anything less.

The features of the complete assembly which follows this stage are even more rigid. In the final phase of assembly an operation typical of the sector is carried out: the scraping of flat surfaces. Although at first sight this may seem out of line with advanced production techniques, it cannot be replaced altogether. The manual adjustment of alignments, angles, surface irregularities, etc., is therefore a normal operation and it can only be carried out by specially trained staff with a great deal of patience. Slightly different decisions are normally taken about the scraping of each machine produced; and the more precise the product must be, the more delicate will be this operation.

/The geometrical
The geometrical controls are applied successively during the course of assembly, according to the design, up to the time of the final check on the assembled product in accordance with established international standards, to which may be added stricter standards depending on the nature of the product, the tradition of the enterprise, etc. Another aspect of the problem concerns checks of moving parts, both of sub-assemblies and of the finished product, while they are being run-in or subjected to cutting stress. This is an increasingly common practice among manufacturers and at the same time it is demanded by users. After the final checks have been carried out, the manufacturer issues a check-card giving the results of the checks and the names of those who carried them out. It is obvious, therefore, that there can be no improvisation with this type of K.H. and that it must be slow to accumulate, requiring staff who have worked for a considerable time in the enterprise, sometimes in various sections, and who have a good technical background.

The painting of the product comes within the final phase. In itself it is not a complex operation and the K.H. is not hard to find. However, it may involve a disproportionately high number of direct working hours, particularly for certain types of machine. The important thing is to organize the different stages of painting efficiently, spacing them out rationally in the process of assembly so as not to have to disassemble, touch up or cover up too many surfaces while the painting is being done. This problem is overcome by the use of managerial K.H.

Lastly, it must be borne in mind that the final phase of manufacture is always full of all kinds of surprises, for this is where any faults that have been allowed through the various checks—either by mistake or on purpose—eventually come to light; and faults can slip through the checks even in the best organized enterprises. Although this is not very important, it shows the desirability, from all points of view, of being able to count on the experience of those who apply this type of K.H., and this holds good for all the categories of staff that apply it.
13. Industrial accounting: production costs

This section is fairly conventional, that is, it functions in the same way as in any other plant that produces capital goods or consumer durables. Because of the great variety of internal and external components and the fierce competition on the world market, the manufacturer must keep very precise accounts, and also analyse his accounts regularly, so as always to be able to identify those departments where productivity could be improved and to promote discussion of the reasons for this and possible benefit from remedies, if they are applied. It is well known that a very large number of direct working hours per 100 kg go into the production of machine tools, and that there is a tendency for them to increase because of the growing complexity of manufacture. Thus, internal costs are constantly being discussed, which leads to useful recommendations and measures in respect of all the K.H. involved. The results of the cost accounting K.H. are sent up to the higher administrative and management level, where they are used to work out a suitable management policy.

14. Commercial and technical sales organization

It would be superfluous to demonstrate here the importance of this item and of the relevant K.H. It is hardly worth stressing the fundamental importance of not separating the commercial from the technical aspect and vice versa. Although its importance varies according to the type of product, there must be such an interrelationship. It may be embodied in one person who is competent in both fields or it may exist between experts in each of the fields. The clientele, the product and the size of the enterprise determine how broad and detailed this K.H. must be. However, to identify a trend that is now pretty well established, it can be said that it is more often the technical man - in this case the engineer - who invades the field of commercial transactions than the other way round. It is therefore easy to see what this K.H. should consist of if it is to produce the best results from the point of view of users' requirements: it is nothing but salesmanship.

Nor is this the place to make more detailed comments on how sales should be organized, through a pool of firms that do not compete with each other, or in some other way. What should be mentioned is the importance of the technical literature that should accompany and support the sales drive, which in the
last analysis should provide the user with information on the prospects, suitability and advantages of the product he is acquiring. A well-printed and well-thought-out booklet introducing the product will always be a much appreciated visiting card.

Lastly, another factor that must be taken into account if this K.H. is to be effective is adequate practical training within the enterprise; refresher courses could be given from time to time so as to bring staff up to date on new products.

15. *Advertising, exhibitions, etc.*

This type of K.H. is easily accumulated these days, since there is an abundant supply at all levels. Something which the sector finds difficulty in accepting is the need to be always spending money on advertising to show the vitality of the enterprise. Generally speaking, the large enterprises can support this financial burden, but not the smaller firms.

The most common channels of advertising are specialized national and foreign journals, authoritative technical articles written by the managerial or other highly qualified staff, in which reference is made to the writer's position in the enterprise, the enterprise's own periodical publications, more substantive technical literature than that generally used for sales purposes, advertising surveys among users, practical demonstration centres for the products, visits to the manufacturer's factory, and lastly, the participation of the enterprises in some of the numerous national and/or world exhibitions of products in this specific sector or related fields. Such activities can easily be thought up and carried through by persons with drive and vision. The skill consists in knowing how to budget properly with funds that are usually quite modest, in what directions to channel them, depending on each particular case, and when, so as to produce the maximum effect.

16. *Technical assistance to purchasers*

This is an important, though not necessarily an extensive service. It may involve the replacement of parts or components, assistance in the assembly and final adjustment of the product (this is required on some occasions), periodic checks on high-precision and/or special machines, and so on.

/Depending on
Depending on the individual case and the sales volume of the enterprise, these services may be taken care of by persons from different departments in the factory, or by a separate specially created department endowed with its own K.H. In the latter case, the K.H. in many respects resembles the K.H. acquired by staff dealing with assembly and checking.

17. Business management

The administration and management of anything upwards of a medium-scale enterprise in the field of capital goods is by definition a task which, above all, requires good strategy. This requirement is very pronounced in the case of machine tools. Indeed, the growth of the enterprises and the technological development of the products, separately or together, raise technical and financial problems that are difficult to solve, since demand is constantly fluctuating and is particularly sensitive to the economic situation, both internal and external. The manufacturers of the sector must make technological improvements in their products if they are to survive, and the users must buy them for the same reason. This brief outline therefore shows the advisability of applying, in the sector, the most progressive management and organizational techniques, which as far as quality is concerned, are very close to the techniques used in mass production. However, that does not imply that they can dispense with the remarkable flexibility of their production or with their great adaptability to changing circumstances, which may be quite different from those foreseen when the plan of action was drawn up. The strategic aspect mentioned above naturally involves a definition of the technological goals that are to be pursued in the development of the product.

Since the direction of this strategy largely decides the technological level of the user, a knowledge of the problems and the technical and economic trends of the user's world and of the possible extrapolation of these trends deserve considerable attention, requiring a very complex K.H. combining in varying proportions, culture, technical, political and economic information, and intuition.

It is therefore not easy to manage and direct a machine-tool factory producing worth-while products. Improvisation and hasty decisions have the same negative effect as the old-fashioned family type of management. The enormous number
enormous number of top-level policy problems, which is out of all proportion to the number of square metres of factory area and to the number of persons employed, make this one of the sectors where the highest standards of management are required, and this is even more out of proportion to the financial benefits, i.e., the net return on capital that it is capable of generating, which is generally modest.

It would be pointless to discuss here the cultural background where this type of K.H. may best be sought; it is enough to know that the managing director and his immediate subordinates possess a kind of K.H. that is difficult to build up and those possessing it must have a number of qualities and qualifications that are not always found together. In short, this is a K.H. in which personal talents, intellectual capacity, energy and character are factors which, given equal internal opportunities, can be brought to maximum fruition in persons of different ages and with different academic backgrounds.

When the type of product is technologically secondary or non-dynamic, that is, when it remains within a fairly traditional scheme or pattern of supply for a market or part of a market, which does not require advanced products, the management and administrative K.H. is usually much simpler. But it should be stressed that the proportion of such cases in the over-all context of world manufacture of machine tools is shrinking as time goes on, although it is not expected to disappear altogether. This branch of K.H. will be further discussed in relation to the specific case of the manufacture of machine tools in developing countries and particularly in Brazil. This brief description of the most important types of K.H. in the sector is illustrated in table 1. Since not all the types of K.H. analysed are exclusive to the sector, the table is used to show the conceptual link between the seventeen types of internal K.H. and the sectors producing capital and durable consumer goods.

In some cases, the K.H. is described as a "more or less autonomous branch", meaning that - as in the case of K.H. 7, for instance - it is sufficient unto itself, and as such has its own rules, its own type of professional training, and is applied to industry in one of its various forms, as appropriate. It may be more or less perfected, modern, precise and well /organized, but
organized, but it is not totally dependent on the type of good produced. Obviously, there are always certain qualifications to this statement. The same is true of K.H.8, 9, 11 and 13. The situation of the other types of K.H. is different since there is a total or partial identification with the product, as is shown in table 1.

(b) **External K.H.**

External K.H. will be described giving due consideration to the over-all supply to the whole sector, it being understood that the degree of use made of this K.H. will vary from one manufacturer of machine tools to another in respect of variety, quantity and quality.

1. **Casting of ferrous and non-ferrous metals**

For the manufacturer this represents a fundamental external activity, since castings, especially iron and steel castings, make up much of the weight of machine tools, with very few exceptions.

The huge variety of shapes, sizes and qualities in iron castings, and the generally small production of each one, are the problems which commonly confront the foundries, which must supply them at fairly low prices per kg. A knowledge of the requirements relating to hardness, relief of stresses, homogeneity of materials, construction and conservation of models, smelting tolerances and the extra thickness of the parts to be machined is another aspect of the K.H. that suppliers must possess in order to satisfy a very demanding clientele. Moreover, for the sake of the foundry's prestige, the manufacturer must have at his disposal a staff with special K.H. that is particularly concerned with those problems; and if they are to be solved, the foundries must also be able to draw on adequate up-to-date technical resources and experience. Even in this rather conservative field, it is always possible, as experience has shown, to apply new ideas and improve the quality of supply. The important thing is that foundries should have experimental departments that are efficient, and that these should maintain a constant exchange of information with the technical staff of the manufacturers' project departments.

/Table 1
Table 1

CONCEPTUAL RELATIONSHIP OF INTERNAL KNOW-HOW TO THE PRODUCTIVE SECTORS

<table>
<thead>
<tr>
<th>Type of K.H.</th>
<th>Degree of specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To the sector</td>
</tr>
<tr>
<td>1. Selection, definition and general conception of the product</td>
<td>Total</td>
</tr>
<tr>
<td>2. Study and design of the product</td>
<td>Total</td>
</tr>
<tr>
<td>3. Laboratory testing</td>
<td>Total</td>
</tr>
<tr>
<td>4. Internal technical standards</td>
<td>Fairly high</td>
</tr>
<tr>
<td>5. Specification of the services of sub-contractors and of the parts and components supplied by third parties</td>
<td>Medium</td>
</tr>
<tr>
<td>6. Design of jigs, frames and supplementary manufacturing equipment, including tools</td>
<td>Fairly high</td>
</tr>
<tr>
<td>7. Method, instruction and time cards</td>
<td>More or less autonomous branch of K.H.</td>
</tr>
<tr>
<td>8. Planning of production, work-orders and progress checks, Flow of production</td>
<td>More or less autonomous branch of K.H.</td>
</tr>
<tr>
<td>9. Purchasing</td>
<td>More or less autonomous branch of K.H.</td>
</tr>
<tr>
<td>10. Production, selection of production equipment, lay-out</td>
<td>High</td>
</tr>
</tbody>
</table>

/Table 1
### Table 1 (Conclusion)

<table>
<thead>
<tr>
<th>Type of K.H.</th>
<th>Degree of specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To the sector</td>
</tr>
<tr>
<td>11. Intermediate checks on production and commercial parts</td>
<td>More or less autonomous branch of K.H.</td>
</tr>
<tr>
<td>12. Assembly, painting, test-running and checking of the finished product</td>
<td>Total</td>
</tr>
<tr>
<td>13. Industrial accounting, production costs</td>
<td>More or less autonomous branch of K.H.</td>
</tr>
<tr>
<td>14. Commercial and technical sales organization</td>
<td>Fairly high</td>
</tr>
<tr>
<td>15. Advertising, exhibitions, etc.</td>
<td>Fairly high</td>
</tr>
<tr>
<td>16. Technical assistance to purchasers</td>
<td>Fairly high</td>
</tr>
<tr>
<td>17. Business management</td>
<td>High</td>
</tr>
</tbody>
</table>

/The manufacturer
The manufacturer must be able to rely on the quality of these parts. This is obvious since any high-quality machine-tool product begins with the castings that form its basis; for this reason badly or imperfectly equipped foundries whose K.H. is too general or which are too stick-in-the-mud should be completely disregarded. Moreover, many manufacturers need special parts for certain products which can only be manufactured satisfactorily after much research, testing and trial and error. Thus, if they are to meet all the conditions that favour and safeguard the manufacturer, the foundries must be well-known and large and should have among their clients other producers of capital goods with similar requirements. This will provide a guarantee in the sense that the foundry will have to have experience in finding the most appropriate solution for a very wide range of problems. The technical experience that is thus accumulated will be useful to many different sectors. Naturally, this implies that the K.H. must be available in whatever area the manufacturers may be operating.

2. Forgings of ferrous or non-ferrous metals

There are very few forgings in the total number of parts in machine tools. The number of production series is also very small. Although this is not a handicap where the parts are beaten out, it certainly is so when they have to be stamped out. Unlike castings, forgings of this kind may be obtained from medium-sized forges, which have enough K.H. and know how to deal with orders for small series. The degree of K.H. needed for such semi-manufacture is not so vital as other types of external K.H.; as a rule nevertheless, it imposes certain requirements and rules, and this distinguishes this type of manufacturing from any empirical or artisan-type service. For instance, in some types of heavy and extra-heavy forming machines this type of K.H. may become relatively important. In any event, this is a type of K.H. which is not even partially specific to the machine tool sector, which is tantamount to saying that the knowledge acquired from other processes is applied to forging, nothing more.

3. Other semi-finished parts, of various materials

A long list of cases could be mentioned. By way of illustration, reference may be made to a category of parts made of plastic, fibre glass, etc., the textolite type of synthetic material used in the guideways, the materials
used to protect the guideways, such as blowers, filters, rubber, tubing, connexions, etc. Another important and basic group comprises bars, shapes and sheets of metal, especially steel.

In general, the parts and components of the first group are employed directly in assembly and require little value added for their termination. On the other hand, metallic materials obviously go through a wide range of processes before being converted into functional components. Attention will be devoted therefore, on the one hand, to the K.H. relating to semi-processed raw material and, on the other, to that relating to raw material with no value added. Both types are important to the manufacturer, regardless of how much use he makes of them.

In respect of this important category of K.H., two main types of reaction may be noted on the part of the manufacturer of machine tools. In the first case, which is the more common, he adapts his requirements to what is available on the local market in terms of quality, variety, price and technique, even though in fact he would sometimes prefer something different. In the second case, he has recourse to imports as the most suitable solution; this is not of great importance when only raw material is involved, but it becomes something of a disadvantage when semi-finished products have to be imported.

In this group, there is no external K.H. which has come into existence specifically because of problems in the machine-tool sector. It is rather the sector itself that accepts and adapts the available types of K.H., which grow and flourish on the fringes of the sector, under the impetus of stimuli from various sectors. Thus, under this heading the builder of machine tools can be supplied with the K.H. he requires in direct proportion to the development of other types of demand in the country. That part of the K.H. that can be obtained more easily through trade can therefore be satisfied through imports, without any great drawbacks from the point of view of the use of K.H. from a distance, especially when the technical literature which usually accompanies the imports proves to be a satisfactory instrument for the transfer of K.H., (as is the case, for example, for run-of-the-mill and special steels).
4. **Small parts, such as nuts, bolts, springs, etc.**

The manufacturers of machine tools have no special requirements in this category of simple parts. On the contrary, they are able to derive maximum benefit from what is available on the market, which is manufactured according to specific national standards in respect of dimensions and quality. There are very few exceptions. This is one of the least complex types of K.H., since the parts are commonly used in any branch of engineering or metalworking. No further comments are therefore required.

5. **Electric motors**

These naturally provide the driving force for the machine tools. Since the requirements of users have become increasingly strict, those who apply this type of K.H. have very specific responsibilities. In brief, the field is made up of standard motors, generally of limited use, that are manufactured according to common norms, standard motors manufactured according to advanced standards of balancing, and motors with special operational features. The last two categories account for the bulk of consumption, and include the Ward-Leonard groups, motors for changing speeds, reducing speeds, etc.

K.H. relating to the most common types of motor is widespread and easy to come by, but K.H. relating to the more specialized types of motor is more difficult to find. Manufacturers tend to draw as much as possible on local resources and to maintain constant contact with the suppliers, which is profitable to both sides. However, they may always import particularly specialized items, without serious technical drawbacks. In general, the technical capacity of motor manufacturers can be relied upon, so that the acquisition of this type of K.H. is backed up by what are normally thoroughly dependable guarantees.

Among the producers of capital goods, the manufacturers of machine tools are nowadays considered good customers for electrical motors. In fact, the number of motors housed in each machine unit has been rising owing to the increasing complexity of the functions performed by the machines and the resultant trend towards replacing a single power source—which provided the drive for both rotary and transforming movements—by various independent units. Because producers of machine tools are big consumers, a great deal of attention is usually paid to their requirements.
6. Components for electrical circuits

Most of what was said under the previous heading is applicable here. However, there is a very wide variety of material classifiable under the present heading, as a result of which it is quite common for the same machine to comprise components from different suppliers, who have different types of K.H.

The formation of high-level internal K.H. in the electrical field has been somewhat neglected by manufacturers in favour of engineering K.H. So much for the general outline of the problem. But now, with the increasing complexity of machine tools, particularly in respect of the role of electrical components for automatic and semi-automatic processes, the manufacturers have been obliged to accumulate and maintain a high-quality K.H. in order effectively to assimilate and apply all the resources that can be supplied under this item. There are, however, arrangements under which the supplier provides the manufacturer with technical assistance; the manufacturer thus receives sets of parts that have already been assembled and tested, the project and design K.H. having been provided by the supplier of the components. This co-operation may relate both to prototypes and to mass-produced goods. The consumption of electrical components per machine unit is increasing constantly and in some cases accounts for a large part of the value of the machines. It is naturally advantageous for manufacturers to buy as much as possible on the local components market, as contacts that are profitable to both parties can thus be established and maintained.

However, the manufacturer of machine tools is obliged to depend on imports, if the local products do not meet certain standards of functionality or durability of materials or if he cannot find certain specific components which somewhat complicates his problems. This dependence on foreign suppliers must be kept within bounds.

As to the manufacturer of machine tools' responsibility for his product, whatever electrical or other components he incorporates in his machines will be taken by the user as part of the machine itself. Any defect or abnormality that comes to light will be the responsibility of the producer, who must solve the problem himself, although he may be aided indirectly by the supplier of the component. In the case of machines for export, this is even more obvious. It can thus be seen how difficult it sometimes is for the manufacturer /of machine
of machine tools to select the most suitable K.H. and harmonize specifications, types, etc., so as to need as few suppliers as possible. If the amount of electrical K.H. possessed by the manufacturer has been increasing, so has the supply in all respects. Components with an enormous variety of functional characteristics have been produced with the assistance of renowned companies with an established reputation in the scientific, technical and financial spheres which have been able to combine complex electrical K.H. with business organization and high-quality technical publicity. Thus, the business structure of the suppliers has come to constitute both a guarantee and a source of substantive aid to the manufacturer of machine tools in dealing with the numerous problems that beset him in this field.

Lastly, another point that must be stressed is that, in this field also, there are very few items that are designed specifically for producers of machine tools or requested by them. The manufacture of electrical components is developing within a much broader technical framework, which is to the advantage to every particular case and sector. It is easy to see the advantages or facilities obtained by manufacturers of machine tools in this field when they operate in a varied and technologically developed industrial environment.

7. Components for hydraulic systems

In this field the manufacturers fall into two groups: those who by tradition and/or necessity manufacture in their own enterprises all or nearly all the components they require, and those who acquire them from specialized enterprises. In the first case, the K.H. will be included in the section responsible for internal projects and design; in the second, it will be limited to an understanding of the applications of hydraulic components and of their combinations, composition and testing for specific purposes, which may be to drive or control a machine or both, separately or in conjunction.

The application of hydraulics has provided brilliant solutions for both old and new problems, and it now constitutes a whole approach, or at least a very marked trend in the sector, backed by manufacturers who have made systematic use of it in the manufacture of their products. As applied hydraulics is a complex subject, involving performance at different pressures - low, medium and high - and using a wide variety of components /that are
that are difficult to produce, the K.H. relating to it has become the purview of a small number of enterprises of high technical and technological capacity. Notwithstanding this fact, such K.H. is easily available since there are good channels for its dissemination, including the distribution of the instructions that are essential to its correct application. Thus, in practice, there are no major problems in respect of the manufacturers' dependence on this type of K.H.

Components for mixed systems, oil and compressed air, for instance, could be included under this or the next heading. There is nothing much to say about them that differs substantially from what has been said about exclusively hydraulic systems.

3. Components for pneumatic systems

By and large, the remarks made about the previous type of K.H. are valid here, which makes further comment superfluous. The only point that might perhaps be added is that there are fewer cases where internal K.H. of this type is used than there are for K.H. on hydraulics, which shows that manufacturers are widely dependent on this particular type of specialized K.H.

9. Components for lubricating systems

As the manufacturing techniques for machines have developed, greater emphasis has been placed on their lubrication; the lubricating system has been conceived, as far as possible as a closed circuit linked to a lubricating centre. This conception has acted as an incentive to the study of lubrication as a separate subject providing the basis for an industry that would relieve the various builders of machines of the task of dealing with each and all of their lubricating problems. This has given rise to a specialized type of K.H. that can be easily acquired, even on the international market.

Since the manufacturer has to find solutions for a wide range of different problems in this field, the same machine will often have mixed components, some suggested by the manufacturer's own K.H. and others purchased elsewhere. Since lubrication is a very delicate matter for the manufacturer, especially where certain parts of machines are concerned, such as guideways, he must use his own experience to interpret the new K.H. that he acquires. In any event, the commercial availability of such K.H. facilitates the task of the manufacturer and saves him time and he can also take advantage of the advances achieved in other capital goods sectors.

10. Components
10. **Components for refrigerating systems**

Manufacturers have always depended upon specialists in this field, and some solutions have been evolved specifically for the machine-tool sector. Mechanical pumps, regulators, filters, tanks, magnetic separators, etc., form part of the system, which is purchased elsewhere. Specialised K.H. of this type is easily obtained and it can be purchased without any of the problems that arise in connexion with other types of components.

11. **Components for mechanical power transmission and control systems, such as clutches, brakes, reducing and speed-changing and other gears, etc.**

These are parts which generally form a mechanical chain for the transmission of power and control. Manufacturers used to produce all the parts they needed in this wide and varied category; but as the intermediate components for capital goods began to arouse the interest of large enterprises with high levels of technical skill, the manufacturers of machine tools, seeing possibilities of obtaining, at more advantageous prices, better equipment that was available with a wide range of performance, came to depend, at first somewhat warily but now completely, on external K.H., which is easily accessible nowadays. This is indirectly of advantage to the user, who finds standard parts that are easily interchangeable when necessary, available on the market. These are, in fact, components in general use in other machine-manufacturing sectors; they are produced on a large scale, which brings down the production cost.

Thanks to testing and experimental departments and the high concentration of K.H., the development of this whole group of components has been much more rapid than would have been the case if they had continued to be produced separately by the different manufacturers of machine tools. When the enterprises manufacturing these components are highly skilled in the technical field and have an efficient sales organization for their products, as is true of the majority, the goods that they supply involves a K.H. of undeniable value providing guarantees of reliable operation that meet the strict requirements of machine-tool manufacture. The experimental departments which handle this type of K.H. provide a solid basis for the preparation of very detailed technical literature on its application, which has the advantage /that this
that this kind of K.H. can be acquired anywhere without any great difficulty. However, for technical reasons, direct contact between manufacturer and supplier is essential in certain very special cases.

12. **Bearings, etc.**

This is a traditional item on which manufacturers have depended and continue to depend. The K.H. relating to it is highly specialized and for that reason it is concentrated in the hands of a few enterprises.

The requirements of the manufacturers of machinery fall into two distinct categories. One comprises the standard or common types, for minor uses, and the other, the high-precision type, for important applications, as in the case of chucks (mandrels), for instance. In general, there is no question of accepting less than the best in quality for such products; the high level of K.H. of the manufacturers of bearings in itself constitutes a guarantee for this delicate item. The technical literature placed at the disposal of the users, which applies to all bearings, regardless of make or use, amply facilitates the marketing of the components. Besides standard bearings, similar products have been coming increasingly into use, such as large ball bearings, needle bearings, guideways with rollers, low-friction right-hand and left-hand screws with ball bearings, etc.

Knowledge of the correct application of this K.H. under the most varied working conditions and within extremely diverse patterns of design is an irreplaceable part of the internal K.H. of machine-tool producing enterprises. In the last analysis, therefore, the responsibility for the results largely falls on the machine manufacturer, since the high technical grade of these components is in general undeniable.

13. **Measurement and control parts**

The number of these components varies enormously according to the type and design of machine. Some typical examples of this type of part are the palmers incorporated for tool adjustment, different types of indicators which show measurements while the work is being carried out, the high-precision rulers with or without optical and/or other measuring equipment, electrical instruments, pressure gauges, etc., to mention only a few. Here, all the machine manufacturer generally does is to engrave the lineal and circular measurements on the most common parts of machines. This means that the /great majority
The great majority of components of this type are bought elsewhere, from firms that have long years of experience of measurement and control equipment and whose K.H. is quite irreplaceable. Despite its variety and the large number of suppliers, this type of K.H. is easily accessible on either the national or the international market, where it is widespread, because of its many and diverse applications in all sectors. In practice, there are not many cases of materials with specific requirements. On the other hand, the suppliers have a profound knowledge of the problems in this field, with the result that they have often been able to provide manufacturers with brilliant solutions even before the problems had come up. For many components, the suppliers have been able to rely on the parallel market of the users of machine tools, a market of which they are still taking the utmost advantage.

14. **Automation, automation, numerical checks, etc.**

Some of the problems connected with automatic operation can be solved by the use of the various components classified and described above, with which it is possible to achieve a certain degree of complexity. However, the nature of this new branch of K.H., which includes the significant contribution of electronics, remains to be considered.

Under the specific, if not very far-reaching impetus of the machine-tool sector and of the other industries producing capital goods, and with the marked influence of problems connected with the armaments industry, large enterprises have come to offer material in this category that is increasingly varied, efficient and safe. It is no cause for surprise, therefore, that thanks to their enormous technical, scientific and financial resources, these enterprises have opened up new creative and practical horizons for the machine-tool sector, with prospects of highly spectacular progress to be achieved through this fast-growing and active type of K.H.

Numerical control, direct readings in thousandths of a millimetre of the dimensions of moving parts, a single programming centre for several machines, machines for printing programmes, etc., already used for various types of machine tools, are examples of the existing K.H., which will continue to be improved, for this is the most dynamic external K.H. at the service of the sector. An incontestable contribution is therefore made by external experts.
external experts and there is no substitute for their K.H., although the

effort being made by some manufacturers to produce their own equipment from

less complex components is worth noting. The solutions thus provided are,

however, usually temporary.

In view of the fact that this is really an extremely specialised K.H.,
it is not surprising that the most important innovations have come and
continue to come from the producers of electronic equipment themselves. The
supplying firm must obviously be of a very high level, given the complexity
of the subject and the huge financial and research resources needed to cover
the subject. On the other hand, an undeniable contribution has been made by
those manufacturers of machine tools who have taken a lead in assimilating
and applying these advances in certain lines of products. Apart from the
exchange of K.H. between the parties, it is obvious that if this branch of
K.H. is to be extended beyond its present bounds, this will call for a
sizable contribution in the way of techniques, financing and K.H. by the
producers of machine tools, certainly a greater contribution than that
required for other types of external K.H. both within and outside the field
of automation.

Every supply of new intermediate materials for incorporation in
machine tools relieves the manufacturer to some extent, and at the same time
puts pressure on him to review the basic principles he applies in his
projects and his productive infrastructure. Thus, the structure of his own
K.H. evolves in direct proportion to the creativity and dynamism of the
external K.H. that he receives, and it also adds to the special problems
already existing in the sector. It can therefore be seen that the
manufacturer of machine tools is always either under pressure or being
relieved from pressure, and his success depends on his mentality, his
training and experience, and his level-headedness.

Some of this type of K.H., which comes from large enterprises, may be
exported, and more of it certainly will be as time goes on, which proves that,
for the present, it is not always possible to acquire and apply this K.H.
without any exchange and local co-operation between the parties concerned.
However, it is clear from what little has been said about this type of K.H.
that there are prospects for its application to many more cases, when the K.H.,
in the form of technical literature, is widely enough distributed; this is
equally true of the K.H. relating to the intermediate components for other
capital goods.

/15. Accessories
15. **Accessories**

Many enterprises make a habit of acquiring standardized parts, whether or not of special manufacture, from sub-contractors or others. This applies to such items as plates of all kinds, tailstocks, stands for special and standard tools, clamps, manual and automatic dividers and many others. The K.H. of the manufacturers of such accessories is similar in terms of quality to that of the machine producers, and they generally have specific knowledge of that sector, which comes out in original ideas that have an important bearing on the development of certain details.

However, when components are designed by the enterprise, they are normally ordered from subcontractors so as to economize on direct hours of manufacture, which are reserved to more complex tasks; thus another objective is achieved, that of being able to count on small auxiliary enterprises. The subcontractors must have a basic minimum amount of K.H. in order to be able to meet the precision requirements for the products requested of them. Obviously, the production teams must be able to cope with these problems. In this connexion, it is the manufacturer's own K.H. which enables him to decide whether the auxiliary enterprises are of the right technical level, since such firms are generally small in size. Unlike the former group, in this case there is a flow of K.H. from the manufacturer to the subcontractor, and not the reverse, or at least there is an equal flow in both directions.

16. **Specialized servicing**

For some technical services, owing to their very nature, the lack of adequate trained manpower or equipment, the impossibility of achieving economies of scale, etc., the manufacturer has to depend on the industrial infrastructure of the area in which he operates. By way of example, mention may be made of heat treatment, surface plating, engraving, indicator plates of all kinds, etc. The importance of such services varies according to the product involved, and the complexity of the services and degree of responsibility of the staff are somewhat limited, except in the case of heat treatment, which requires the selection of highly competent and well equipped staff.

/This brief
This brief description of the sixteen types of external K.H. gives only a rough idea of their true inherent complexity. It is hoped, however, that a clear idea has been given of the wide scope and variety of specialized K.H. and of the manner in which this K.H. is presented to the manufacturer. As has already been stressed, all the manufacturer's problems are not necessarily solved even when he has at his disposal an ample supply of high grade external K.H. Moreover, it is for the manufacturer to compile detailed information on the parts that can be acquired elsewhere, and to select at the appropriate moment, adapting - to suit his products - the creative ideas emanating from the manufacturers of capital goods components or the suppliers of services and processes. In contrast to this flow of external K.H. from the outside in, there is an opposite flow, from the manufacturer to the supplier which, though it is not so big, of course, is nonetheless conceptually significant and important in view of its global orientation. In any event, what emerges clearly from the items listed above is that if the manufacturer is to receive such a tremendous and varied amount of K.H., he must also have a sound conceptual and theoretical grounding if he is to select the most efficient combinations and achieve the best practical results. This is always valid for all the types of external K.H., though more so for some than for others. It may therefore be said that reception of this type of K.H. is not completely automatic and that a certain amount of effort must be made to take it in, since there are few cases in which there are few or no side-effects.

Not all the exchanges that are actually carried on have been discussed under the sixteen categories of external K.H. given above. However, what has been said is fairly close to the truth; apart from the great industrial complexes, there are a very small number of other firms that do not fit into the context described. The nature and conception of the product will obviously be the determinants of the degree of dependence on external K.H. in each case.

Table 2 provides a summary of some of the concepts contained in the sixteen categories of K.H. A comparison of column (2) with column (1) clearly shows that the machine-tool sector amply benefits from the solutions that have been found to the problems that arise in the manufacture of other capital goods
capital goods to which should be added the influence of the manufacture of consumer durables, which is not dealt with here. Consequently, a comparison of columns (4) and (3) shows that, on the whole, there is a greater flow of external K.H. from outside in than the reverse. Lastly, columns (5) and (6) show the location of the types of external K.H., and show which might be imported and which are inseparable from the place of manufacture of the machines.

Now that the sphere of action of the various types of external and internal K.H. that go into the manufacture of machine tools has been defined, in so far as this can be calculated at the present time within the context described, it remains to be seen how these types of K.H. have reached the manufacturers over the years. Indeed, what has been described above is the result of a long and complex process of development, a knowledge of which is essential if the second part of this work is to be seen in proper focus.

/Table 2
<table>
<thead>
<tr>
<th>Externally known-how</th>
<th>Exchange of know-how</th>
<th>Location of external know-how</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific solutions</td>
<td>From the industry to the outside</td>
<td>Regional or imported</td>
</tr>
<tr>
<td>for the machine-tool sector goods</td>
<td>From the outside to the industry</td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>1. Castings</td>
<td>Partial</td>
<td>A fair number</td>
</tr>
<tr>
<td>2. Forgings</td>
<td>--</td>
<td>A fair number</td>
</tr>
<tr>
<td>3. Other semi-finished parts</td>
<td>Few</td>
<td>Very many</td>
</tr>
<tr>
<td>4. Small parts</td>
<td>--</td>
<td>A moderate number</td>
</tr>
<tr>
<td>5. Electric motors</td>
<td>Not many</td>
<td>Quite a large number</td>
</tr>
<tr>
<td>6. Components for electrical circuits</td>
<td>Not many</td>
<td>Quite a large number</td>
</tr>
<tr>
<td>7. Components for hydraulic systems</td>
<td>Some</td>
<td>Many</td>
</tr>
<tr>
<td>8. Components for pneumatic systems</td>
<td>Some</td>
<td>Many</td>
</tr>
<tr>
<td>9. Components for lubricating systems</td>
<td>Very few</td>
<td>Many</td>
</tr>
<tr>
<td>10. Components for refrigerating systems</td>
<td>A fair number</td>
<td>Some</td>
</tr>
<tr>
<td>11. Components for mechanical systems</td>
<td>Some</td>
<td>Many</td>
</tr>
<tr>
<td>12. Bearings, etc.</td>
<td>Several</td>
<td>Many</td>
</tr>
<tr>
<td>13. Measurement and control parts</td>
<td>Some</td>
<td>A moderate number</td>
</tr>
<tr>
<td>14. Automation, numerical control, etc.</td>
<td>Several</td>
<td>Many</td>
</tr>
<tr>
<td>15. Accessories</td>
<td>All</td>
<td>--</td>
</tr>
<tr>
<td>16. Specialized servicing</td>
<td>Very few</td>
<td>Many</td>
</tr>
</tbody>
</table>
Chapter III

ORIGIN AND HISTORICAL DEVELOPMENT OF THE TYPES OF KNOW-HOW

There will be no attempt here to adopt the conventional historian's approach. All that will be attempted is to give a little information that characterises the fundamental stages of industrial, creative and organizational development.

Against that background, the over-all view of the productive sector can be more easily and more objectively extrapolated towards the future, and at the same time the more recent structures of the countries with developing engineering industries can be seen within that perspective.

On the basis of this premise, the starting point must be internal K.H. thus tackling the problem from its simplest angle, that is, giving the dates that approximately correspond to the most characteristic stages of the development of internal K.H.

If the current situation of each branch of internal K.H. is given a rating of 100, going back in time, each separate stage of knowledge and development could be given ratings of 25, 50 and 75, respectively. Table 3 summarizes the data that have been arrived at on the basis of individual assessments of each type of K.H. Despite the fact that the information for table 3 was not collected systematically through surveys covering the majority of the industries in the various countries the general documentation that is available on the sector /1/ seems sufficient to trace a historical outline that is not totally arbitrary. Postponing further speculation on the ratings, we can now go on to consider the different types of internal K.H. with a view to showing the manner and speed with which they have developed.

K.H. 1. General selection of the product

For a long time this was identified with K.H.2. Market studies, systematic information on the technical and economic problems of the users and detailed knowledge of the attitude of competing firms,

\[\text{This general documentation includes considerable material collected by the author in the international industrial sector and constantly brought up to date.} \]

/Table 3
Table 3

HISTORICAL DEVELOPMENT OF KNOW-HOW

(Rating: 1968 = 100 for all types of K,Ha)

<table>
<thead>
<tr>
<th>Types of know-how</th>
<th>Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25</td>
</tr>
<tr>
<td>1 Selection of product</td>
<td>1940</td>
</tr>
<tr>
<td>2 Design of product</td>
<td>1860</td>
</tr>
<tr>
<td>3 Laboratory testing</td>
<td>1910</td>
</tr>
<tr>
<td>4 Internal standards</td>
<td>1920</td>
</tr>
<tr>
<td>5 Specifications for subcontractors</td>
<td>1920</td>
</tr>
<tr>
<td>6 Auxiliary tools and equipment</td>
<td>1920</td>
</tr>
<tr>
<td>7 Instruction and time cards</td>
<td>1925</td>
</tr>
<tr>
<td>8 Planning of production</td>
<td>1925</td>
</tr>
<tr>
<td>9 Purchasing</td>
<td>1860</td>
</tr>
<tr>
<td>10 Selection of equipment</td>
<td>1830</td>
</tr>
<tr>
<td>11 Intermediate checks</td>
<td>1890</td>
</tr>
<tr>
<td>12 Assembly and finishing</td>
<td>1830</td>
</tr>
<tr>
<td>13 Industrial accounting</td>
<td>1910</td>
</tr>
<tr>
<td>14 Technical sales organization</td>
<td>1900</td>
</tr>
<tr>
<td>15 Advertising and exhibitions</td>
<td>1900</td>
</tr>
<tr>
<td>16 Technical assistance to buyers</td>
<td>1925</td>
</tr>
<tr>
<td>17 Business management</td>
<td>1890</td>
</tr>
</tbody>
</table>

/ have demonstrated
have demonstrated the need for this K.H., especially after the last World War, when suppliers had to face certain sales difficulties. Compared with the pre-war period, important structural changes concerning technology and productivity in the metal-transforming sector forced the enterprises to separate (to a greater extent than in the past) project and design skills— which had hitherto been sovereign in decisions and the exclusive determinant of the technological level of products—from entrepreneurial strategy. This branch of K.H. was soon consolidated and defined, practically within a decade, during which time there was an important and effective modification of the manufacturers' attitude in a growing number of firms. One of the practical results that can be easily appreciated is the greater degree of specialization which many enterprises have set out to reach. In many countries government promotion of the sector has helped to produce these results.

K.H.2. Design of the product

Like K.H.10 and K.H. 12, this is obviously one of the oldest branches of K.H. Although it is possible to identify types of machine that preceded it, Wilkinson's boring machine (1770) may be considered as the first important machine for industrial use. After the introduction of the first screw-cutting lathes designed by Senet (1795) and Maudsley (1798) there was a rapid increase in types and models in several countries. The choice of 1860 for a rating of 25 is justified by the fact that by that year one stage of development had been consolidated, and shortly afterwards the sector was launched into the realm of the semi-automatic and automatic, and at the same time the complexity of the universal machines was increased, while others of a fundamental type were created. Some examples confirm this fact: the turret lathes designed by Hartness (1862) and Brown and Sharpe (1867), Spencer's automatic lathe (1870), Schweizer's
turret lathe (1872), and so on. It seems realistic therefore to place the rating of 50 between the famous Universal Exhibition held in Paris in 1900 and the eve of the First World War, as characteristic of a new stage of development, during which the pattern for large-scale manufacture of durable consumer goods and military equipment was already set. The third stage would therefore correspond to the period after the Second World War, when the results of the technological advances derived from the war needs were felt on the world market. The rating of 75 corresponds to the idea of special and transferring machines designed for the most diverse products, in particular for asymmetrical parts machined by rotating tools, thus raising the concept of automatic machining of such parts to the same stage of advancement as parts machined in rotation, which had preceded them by more than half a century.

Kne3. Laboratory

Experiments with new applied engineering ideas in the factory itself obviously date back to the second half of the last century; but the concept of the laboratory as a place for carrying out theoretical studies and/or practical work for testing out theories as an independent and complementary branch of project work, has been evident ever since the First World War. It became more pronounced at the beginning of the Second World War and more common and important around 1950. It is still not very widespread in enterprises, however, either because it has not been necessary or because it has not been a suitable solution. Indeed, as has already been mentioned, the growing importance of government and private research institutes, which make it less necessary for all enterprises to maintain laboratories, should be borne in mind.
**Internal standards**

This K.H. was a late-comer to the engineering sector in general and even more so to the machine tool sector.

The first steps have already been taken to apply national and international standards in respect of performance, standardization of types and models of machines, etc. This is the most complex aspect of the problem, which affects the interests of all manufacturers; there is still far to go in order to achieve a high degree of over-all application, but the first steps have been taken. Although these standards are external, they are mentioned because they are assembled by committees, associations, etc., in which the enterprises are represented by persons with specialised K.H. As regards certain internal standards of more limited application, some have become more generally accepted, while others, on account of their special character have continued to apply only within the enterprise because they are inherent to the organization and rationalization of production.

In this case, it is obviously not easy to apply the three ratings with respective dates. The first rating, of 25, might correspond to the machines placed on the market after the First World War; the second, of 50, may be said to be a result of the Schlesinger standards on geometrical control in respect of a good number of machine models.

The third phase, starting around 1950, may be identified with the tendency of manufacturers to conceive of their products as a combination of functional units or blocks made up of the greatest possible number of standard parts, in contrast with previous products which were totally monobloc, in which power transmission and control were inseparable. This change of concept has given a greater stimulus than in the past to internal standardization of all kinds, just as Schlesinger had an indirect influence on the standardization of manufacture—materials, tolerances, surface finishing, assembly, etc.—to ensure a high degree of precision in the product.

/There is
There is an undeniably subjective slant to the data provided here; but for this not to be so an amount of field work would be required that would certainly be out of proportion to the aims of a paper such as this. Moreover, the difference of a few years one way or the other would not alter the general picture, mainly in view of the way in which the phases and ratings are arranged, as will be seen at the end of the chapter.

K.H.5. **Specifications for purchased parts**

The same trend as for K.H.4 should be assumed here, since there is a recognized conceptual affinity between the two. The above remarks are therefore valid for this item also.

K.H.6. **Design of auxiliary tools and fixtures**

The different types of components grouped under the heading of indirect manufacturing equipment have been becoming better defined as time has gone by under the impetus of the large-scale production of durable consumer goods and armaments. Such equipment, a natural complement to machine tools, was late in making its appearance in machine shops from the point of view of the users. The manufacturers of machinery have adopted this equipment and are still doing so, not with mass production in view, but in order to achieve a certain degree of precision in their work and to ensure the interchangeability of the parts and components manufactured, objectives which can obviously be achieved in this way with reasonable lead periods.

The manufacturers took a first joint step in this direction in 1920, as a result of the applications of this K.H. during the First World War in the mass production of military equipment. The same is true for the rating of 75 (1945) after the Second World War. It is more difficult to define an intermediate stage for the 50 rating. It has been estimated to correspond to the year 1932.

/The situation
The situation of the enterprises with respect to this type of K.H. has been so varied that it is difficult to determine the average position at each stage with any exactitude; but if it is agreed that the machine-tool manufacturers were some years behind the mass-production industries in introducing indirect manufacturing equipment, the situation selected would not appear to be too far from the truth.

K.H.7. Instruction and time cards
This is among the newest types of K.H. adopted by the sector. In the first phase of its formation, method and planning are indistinguishable, but they later emerge as independent disciplines. After their initial publication in 1895, it was a long time before Taylor's ideas and early work were accepted and before they spread to manufacturing circles. The capital goods sector was certainly not one of the first to adopt them. When at last it did so, some time after the mass-production enterprises, it was able to take advantage of the successful results already obtained by others, which facilitated the adaptation of rational methods of organization to the circumstances of the enterprises themselves.
This type of K.H. was already manifest in rudimentary form in a few cases around 1925, the year to which the lowest rating is given here. It passed through the intermediate stage in the course of the last World War, and by 1950 can already be assigned the rating of 75, if account is taken of the percentage of persons occupied in that branch of K.H.
As with K.H. 6., the sector was late in adopting K.H.7. compared with the mass-production enterprises.

K.H.8. Production planning
This is closely related to the previous K.H., and in the particular case of the manufacturers of machine tools, the same dates as those mentioned above are valid.

/K.H. 9. Purchases
K.H.9. **Purchases**

Trying to assign dates to this section of K.H. is a somewhat thankless task. Although data on some old enterprises are available, the background information is scarce and unreliable. It does not therefore seem advisable to waste time on trying to fix them. Among the various positions that could be defended, preference has been given to that which relates this K.H. to the increase in the complexity of the design of products (K.H.2) for the first two ratings, and for the last rating (75), to K.H.5, which concerns specifications in subcontracts for services and components to be supplied by third parties.

K.H.10. **Selection of equipment**

By definition, this is one of the branches of K.H. that helped to start the sector. It should be no cause for surprise that the points which characterize the stages of its development come somewhat earlier than those of project K.H. (K.H.2). In fact, in the phase of artisan-type activities (first rating) manual skill in the fabrication of parts was more important than theory, which finds its typical expression in design. In the periods with ratings of 50 and 75 also, the physical processes of manufacture continued to be more important than K.H.2, which meant that some of the real problems, whether expected or unexpected, had to be solved in the workshop, without really adequate documentation, such as is required nowadays. Meanwhile, the time-lag between the two types of K.H. in a period with one rating has been reduced with time, and lately, thanks to the intervention of supplementary types of K.H., such as K.H.6 and K.H.7, the time-lag may be said to have disappeared altogether.

Once these facts are recognized, the next thing to do is to try to lay down the periods to which the ratings relate. The lowest (25) would be around 1830, with the influence of Whitworth, Lamoriniere, [Whitney,]
Whitney, Bodmer and others, The second (50) could also perfectly well fall in the last century, in 1895 for instance, if account is taken of the increased complexity of the models, the already widespread use of castings, the difficulty of manufacturing them, the ingenuity of certain mechanical systems and the consequent difficulty of producing them with the means available and the high-precision manufacture of those machines that were already beginning to work to tolerances of a few tenths of a millimetre. It should also be added that certain practical results achieved with machines of the period show that cutting speeds could already have been three or four times greater, but this did not become a fact until just after the appearance of high-speed steel in 1900.

The third stage would concern not only the actual process of production but also the degree of precision in the operation of the machine and, by extension, the degree of precision in its manufacture.

This type of K.H. now relates to a much broader context, previously non-existent, which is characterised by the selection of appropriate manufacturing equipment, attention to lay-out, internal transport, choices between different and equally efficient alternative means of producing certain parts and components, time and motion studies, the organization of jobs, cutting tools, the maintenance workshop, etc. This stage may therefore be said to have been well established around 1935, half-way between the productive structure of the period with the third rating and that of the present.

K.H.11. Intermediate checks

This type of K.H. is closely connected with the history of industrial metrology. In this case, measurement of work is of course a practice as old as the machine itself; but what should be stressed here as a specialized and independent branch of K.H. within the terms already defined is the fact that the general knowledge of metrology and the technique of its application form part of a continuing interaction
between the machine, which permits greater precision in production as it improves in quality, and the instruments capable of measuring that improvement. However, over a century and a half of this interaction, the degree of precision of the measuring equipment—which was constantly improving—always kept ahead of improvements in the operational capacity of the machines.

The manufacturers' efforts to produce machines that would work with smaller and smaller tolerances obliged them to introduce increasingly rigorous controls at all stages of work, with a view to obtaining the best possible final composition of the product. In this way—starting from production stocks with a certain degree of precision—the manufacturers always aimed at producing machines which would be more precise in operation than the average machine used in their manufacture.

Within this general framework, therefore, the different stages to which a rating is applicable could be summarized on the basis of the following observations and facts, recognizing in advance that there were many disparities in the average situation of the first two periods from country to country, according to the product and the enterprise concerned. The lowest rating might correspond to 1890, when the mass-production industries and the machines for those industries made an appearance. The use of micrometer gauges (Palmer, 1848), the influence of the Société Génévoise d'Instruments de Physique with its rectilinear (1865) and circular (1880) dividers, the widespread use of the nonius ⁵ for readings of fractions of a specific unit of measurement, plane metrology and the influence of the precision of clock-making are some of the reasons for fixing this date.

As in other cases, the second stage might be taken to coincide with the efforts deployed by the sector during the First World War. The third stage corresponds to 1940, the year which saw the definition and spread of controls between operations that were applied elsewhere than where the job was done; the final control of each part, and the emergence of properly equipped metrology departments.

⁵ Invented by Pedro Nunes, a Portuguese (1542-1577), and Pierre Vernier, a Frenchman (1580-1637), for their publication, "Quadrant nouveau de mathématiques" (1630).
K.H.12. **Assembly and finishing**

It is obvious that the first stage of this kind of K.H. is much the same as production K.H. (K.H.10), although, admittedly final controls were not of great significance in that period. The second stage may also be related to K.H.10, with the same date. The situation is different for the third stage, however, the year 1930 being more correct in this case owing to the influence of Schlesinger's early recommendations (1928). The period is characterized by the adoption of a code of standards for machine testing, accepted by both suppliers and users, which combined the proposals of the former and the demands of the latter. From this third stage onwards, more or less, the K.H. is better defined in the sense that it includes the final control of products, their adjustments and the partial or total test-running of the machines.

K.H.13. **Industrial cost accounting**

The first stage of the development of this kind of K.H. would be around 1910, that is, somewhat behindhand compared with some branches of technical K.H. A considerable advance is noted at the date of the second rating, a little before the Second World War (1935), while the last rating plainly applies to methods and planning, which supply the basic elements for a more objective solution to the problems of this branch of K.H. (1950).

K.H.14. **Technical sales organization**

The famous International Exhibition held in Paris in 1900 may be considered to have been a really decisive national and international trade show, since a very extensive range of products, including machine tools, was exhibited. The structure of land and sea transport at that time provide another reason for choosing that date as indicative of a stage of development. With the increase in the volume of supply after the First World War, the growth in the average size of enterprises, and also because of competition, commercial and technical sales organization was adapted to new circumstances around 1922. The manufacturer must have a forward-looking approach, on account of both the multiplicity of types and models and the
complexity of the machines themselves, and at the same time his commercial organization must be extensive so as to maintain a constant rate of production as far as possible, despite fluctuations in demand, which are practically inevitable in a sector so sensitive to economic and other problems, both on the international and the national plane.

The growing number of users, particularly in the metal-transforming industry, their increasing decentralization with respect to the first industrial centres, also pose problems of sales organization which, if they are to be solved, require increasing amounts of funds and sophisticated organization.

Although the K.H. of this second stage was already fairly advanced it has continued to progress. That means that the problems involved are gradually becoming more complex, so much so, indeed, that a notable effort is required to overcome them. Thus a third stage can be pinpointed, shortly after the Second World War (1947).

K.H.15. Propaganda

Although several large international exhibitions were held in Europe in the last century in which machine-tool manufacturers participated, it is the Paris exhibition of 1900 that should be taken as the point of reference for the first stage in the development of this type of K.H. From then on, there was a growth in advertising media of all kinds, including exhibitions, and the second stage can be situated in 1935, following a natural recession owing to the First World War, which was repeated after the Second World War. The year 1950 marks a starting point for renewed activity in the field of advertising and exhibitions.

Exhibitions were now held periodically and for specific sectors, thus becoming characteristic of the present day. They provide an opportunity for seeing a real sample of international production techniques and the various trends in respect thereof, including conservative approaches.
conservative approaches. It is well known that, apart from bringing advertising to bear on potential users, they present the undeniable danger of industrial espionage; manufacturers are aware of this problem and adopt a tolerant approach.

**K.H.16. Technical assistance to customers**

Since this type of K.H. grew out of a combination of necessity and reasons of prestige, it is mainly bound up with the complexity of some or all of the products, particularly those that are mass-produced (where wastage is proportionately greater), with innovations that have not yet been fully tested in practice, and lastly, with high-precision machines (jib-boring machines, for instance). This kind of K.H. varies widely in intensity and scope according to the product and the attitude of the enterprise, and has emerged somewhat late in comparison with the other types of K.H. Nowadays, however, it has taken on dimensions that go far beyond the mere preservation of the efficiency of the products sold, and it might now be defined as an organized maintenance service. This service therefore also includes the checking of the technical performance of the products in specific circumstances, maintaining a constant technical dialogue with the users, collecting and organizing information on their production problems, analysing the actual performance of intermediate goods acquired from other suppliers, pointing out defects, and/or indicating improvements to be made in future series, and channelling all information to the internal K.H. bank; in short, this service should become the technical eye of the producer in the user's workshop.

K.H. with such a broad definition as this was, of course, late in emerging. It is therefore not surprising that the first stage of development is situated around 1925. The second well-defined stage took on a very pronounced form at the time of the last war, within what was still mainly a national context. As from 1950 - third stage -

/
the K.H. became more complete and international in character and it has continued to expand up to the present day.

**Business management**

Although this type of K.H. dates back to the dawn of the machine-tool industry, it was not until 1880-1900 that production was on a scale that called for anything much in the way of business management.

An intermediate date has been chosen for the first stage of development, owing to the expansion of the industry in the United States, where the ten largest manufacturers employed 1,560 persons in 1877, and in view of the examples of industrial stocks of the Chemnitz type, in which, according to available data, 22 manufacturers, with 5,000 employees, shared in 1898, that is, rather more than Brazil in 1961. 6/ The second rating would apply to the whole range of industrial situations faced by the enterprises after the First World War, 1920 being a fairly representative year.

The third, on the other hand, would be situated around 1945, when, for various reasons, the enterprises once again had to modify and rationalise their whole structure. These reasons include, for instance, a more dynamic approach to management, the increase in the cost of labour, the complexity of products, in brief, the spur given to development by all types of internal and external K.H. which was felt particularly throughout in the engineering industry after the last war. The art or science of business management is therefore a reflection of the problem of industry in all its aspects - technical, economic and strategic - on which all the business techniques and available types of K.H. converge at a given date, and can then be defined in intensity and scope, according to the problems of each enterprise.


/This kind
This kind of K.H. acts as a catalyst to the others described above and is responsible for their quality; in brief, it is the most delicate and important of all the types of K.H. and it decides whether their interrelationship will be good, bad or indifferent and provides the machinery for it.

Table 3 summarizes the stages described above through which each branch of K.H. has passed; figure I gives the same information in the form of a chart.

On the basis of table 3 or figure I it would be easy to give free rein to speculation. However, seeing how subjective the ratings are - particularly some of them - it is better not to. There will probably not be much disagreement about the extent to which the ratings correspond to the real situation, taken as a whole, but there may be more about their applicability to more limited aspects of the whole picture. This is easy to understand since there are other ways of proving a point, although these would be more appropriate for an institute or a university research centre than for a private consultant.

Aside from these theoretical considerations, rather more practical and strategic objectives have been pursued. It might be maintained, for instance, that the constant increase in the ratings from one stage of development to another implies that K.H. grows by arithmetical progression. Actually a geometrical progression could also have been adopted, by changing the corresponding dates accordingly. Whichever progression is chosen, the over-all picture will not be altered substantially, at least up to 1940-1945, but then the trend will change and perhaps become too dynamic for extrapolations to be possible. Figure II helps to clarify the above and is included with a view to opening the way to macro-technological studies on this and similar subjects. The stages are the same in both cases; whether the increase is by arithmetical progression or by a geometrical progression with a ratio of 1.75.

/Figure I
It therefore seems preferable to take from figure I whatever approximations appear to be valid in all cases, or rather independent of the subjectivity with which the figure was constructed. The following ratings are given in the figure:

- Elementary K.H. 25
- Intermediate and consolidated K.H. 50
- Fairly advanced K.H. 75
- Advanced or up-to-date K.H. 100

The essential thing is to understand that when K.H. is taken as a whole, knowledge really does increase at a more rapid rate as it reaches one stage after another. From figure III it can be seen that the K.H. of the machine-tool sector took 110 years to reach the elementary stage, 50 years to reach the intermediate stage, and only 20 years to reach the fairly advanced stage. In basic terms, this means that:

1. The K.H. of the sector as a whole has advanced by geometrical progression and the initial process of its formation and definition was necessarily slow. When it became more consolidated, increasingly rapid advances were possible. When the pattern is repeated in newer countries, it would appear to be both natural and advisable to recognize that fact, even though the whole process of development does not take so long as in the past. This can be better understood by considering point 2 below.

2. The oldest branches of K.H. – the first six types for instance – required more time to pass from one stage of development to the next. On the other hand, as new types of K.H. were absorbed by the sector, the time required for their progression from the elementary to the fairly developed stage became shorter. This trend is shown clearly in figure III. It is based on the premise that, once the sector or enterprise has a thorough mastery of all the K.H. selected, if a new type of any importance arises, the time required for it to pass from the elementary stage to the stage when it is effective and fairly developed would certainly be shorter than the corresponding time required, on the average, for the types of K.H. that had been assimilated earlier.

/Figure III
3. As regards the slow progress, which stands out clearly from figure III, from the fairly developed stage of K.H. with a rating of 75 to the 1968 stage, this stagnation is more apparent than real, since the rather slow development of the internal K.H. is counterbalanced by the markedly dynamic influence of external K.H., as will be seen later. In other words, the sector embarks on a period of progress, with a marked inflow of external influence.

Even if comment is limited to these three points, an idea can be obtained of what general principles are advisable for promoting new activities in developing countries, what strategy should be followed and, to a certain extent, how much time would be required to produce results. This will be more clearly shown in the specific case of Brazil.

Turning now to the types of external K.H., particularly to columns (3) and (4) of table 2, the picture of the situation of the sector will be completed. Contrary to what was done in the case of internal K.H., there will be no outline of the background of each of the different types of external K.H. All that will be done is to illustrate, in the first place, the relationship that may exist, for various reasons, between external and internal K.H.; this is shown in table 4, which indicates in what fields they normally exist. In the second place, the influence of external K.H. overtime will be shown. Figure IV was constructed for that purpose. Curve 5, representing external K.H. with a rating of 75, cuts curve 4, which corresponds to internal K.H. with the same rating. Bearing in mind the proviso made above about the extent to which these ratings correspond to the real situation, it is possible to draw some interesting conclusions from this.

External K.H. can be subdivided into three different types according to the direction of the development they promote: traditional, semi-traditional and rapidly expanding, the latter having a very marked influence on the sector. The last type in particular currently constitutes an external influence that is having a strong impact on internal K.H. in general and on the structural modifications of products in particular.

/Table 4
<table>
<thead>
<tr>
<th></th>
<th>Castings</th>
<th>Forgings</th>
<th>Other semi-finished parts</th>
<th>Small metal parts</th>
<th>Electric motors</th>
<th>Components for electrical circuits</th>
<th>Components for hydraulics systems</th>
<th>Components for pneumatic systems</th>
<th>Components for lubricating systems</th>
<th>Components for refrigerating systems</th>
<th>Components for mechanical systems</th>
<th>Gearings, etc.</th>
<th>Measurement and control parts</th>
<th>Automatic control, numerical control, etc.</th>
<th>Accessories</th>
<th>Specialized servicing</th>
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<tr>
<td>1.</td>
<td>Selection of product</td>
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</table>
INTERFERENCIA DEL KNOW-HOW EXTERNO
INFLUENCE OF EXTERNAL KNOW-HOW

Cantidad de \( K_{H_s} \) internos
Amount of internal \( K_{H_s} \)


\( K_{H_s} \) en rápida expansión y de gran influencia que comienza en partes del área de la curva 4.
\( K_{H_s} \) rapidly expanding with a marked influence partly offsetting that of curve 4.

\( K_{H_s} \), semi-tradicional
\( K_{H_s} \), semi-traditional

\( K_{H_s} \), tradicional
\( K_{H_s} \), traditional

Número de \( K_{H_s} \) externos
Number of types of external \( K_{H_s} \)

1 2 4 3 15 16 5 10 12 6 7 8 9 11 13 14

\( K_{H_s} \) tradicional
Traditional \( K_{H_s} \)

\( K_{H_s} \) semitradicional
Semi-traditional \( K_{H_s} \)

\( K_{H_s} \) en rápida expansión y de gran influencia,
\( K_{H_s} \) rapidly expanding with a marked influence

/The sluggishness
The sluggishness in the development of internal K.H. illustrated in Figure III, which shows it as occurring between the ratings of 75 and 100 in terms of time compared with the past, was described as more apparent than real. The growth capacity of the sector has been maintained under the now clearly discernible influence of some of the external K.H., particularly that of the third type. It may therefore be said that, in order to maintain dynamic development of the product, the machine-tool sector is currently taking more advantage of external factors than in the past. The final result is the same. It is essential to understand that:

1. Internal K.H. has developed up to highest point on curve 1. From now on the numerical increase will not be so great.

2. Internal K.H. has developed according to a definite mathematical progression, as is shown by curves 2, 3, and 4. But as the internal instruments and their corresponding types of K.H. improve, there is a rapid structural change in the sector, which is undoubtedly influenced by the more dynamic types of external K.H.

These conclusions, which are almost universally valid, are very important because they make it possible to see the cases of smaller nations clearly in perspective, as will be done in the case of Brazil. An attempt will be made therefore to pinpoint the exact technological position of the sector at the present time and the most logical route it can follow for its future development.

The scheme followed in the first three chapters with regard to internal and external K.H. obviously does not exhaust such a vast topic. However, apart from furthering the aims of this paper, it may pave the way for more detailed studies in this field in the future.

The method adopted involves a recognition of how difficult it is to establish an exact quantitative scale of knowledge extending overtime, starting from intrinsic concepts that are inseparable from the K.H. itself. This could possibly lead to an insuperable indeterminism. For this reason, a scale was finally adopted which relates to the practical effects of specific K.H. in the course of time; this constitutes not only a basis

/for reasoning,
for reasoning, but a means of grouping together and classifying general activities of recognized complexity. Otherwise, there would be a risk of getting bogged down in pure theory, of which it would be difficult to take advantage for the achievement of practical objectives in a field such as that of machine tools.
CHAPTER IV

PROSPECTS FOR THE FUTURE DEVELOPMENT OF KNOW-HOW

The content of the foregoing chapters provides a good enough basis for a clear-eyed and down-to-earth look into the future. The year 1990 – two decades hence – has been taken as the reference year. Here, too, it has been preferred to separate comments on the two types of K.H. – internal and external – leaving to the last a brief over-all interpretation of their effects.

In the field of internal K.H., there are no good reasons for thinking that the seventeen types already discussed will decrease; on the contrary, they have all come to stay. On the other hand, an important industrial development could be the widespread use of computers for various purposes. Business organization in the sector will then receive the impact of the advanced administrative techniques that are applied in mass production and, to some extent in other capital goods sectors.

In addition, a place may have to be found for another type of K.H., namely, scientific and technical information, which could be defined through a new system for the organization and dissemination of information not specially peculiar to the sector, but part of a general movement relating to the spread of specialized centres using electronic computers, which would enable factories to communicate easily. Consequently, by 1980 perhaps, the libraries and technical and/or other archives which are currently used will appear somewhat out-of-date. The implications that this might have for various types of K.H., in particular K.H. 1, 2 and 3, are worthy of note.

The forecasts for each type of internal K.H. are summarized below in a logical and orderly way:

K.H.1. Selection of the product
Rapid progress will be made towards standardizing the measurements and operations of several types and models of machine. The collection of statistics and information will become increasingly active and the coverage more complete which means that this type of K.H. will encroach on the field of K.H.2.

K.H.2. Design
K.H.2. **Design of the product**

As always, in practice conservative concepts will continue to exist side by side with more advanced ideas, because of the demand to be met, on the one hand, and of inherent capacity or incapacity to satisfy this demand, on the other. Even so, not all the machine types and models will be equally open to future refinements, owing to the very functions which they are built to perform or to the impossibility of incorporating in them certain very important types of external K.H. However, it is easy to foresee the introduction of more rational designs, with a view to achieving steady increases in productivity and precision from machines with the same weight and/or installed power, which means acceptance of the fact that there will be a greater proportion of machines that operate or are fed automatically compared with those that are semi-automatic or largely manual. It may be assumed that the growing influence of the rapidly increasing fund of external K.H. on K.H.2 will be a characteristic feature of the next twenty years. It is therefore towards the understanding and assimilation of these external types of K.H. and their subsequent use to produce a functional product that much of the additional effort to be made in the field of project K.H. must be directed; it is already fairly well organized in conventional terms.

K.H.3. **Laboratory**

Its development will largely depend on the activities of specific research institutes, as has already been mentioned. Since the number of such institutes is constantly growing, there will not be probably not any considerable increase, compared with the present, in the number of staff employed in the testing and experimental departments of enterprise. There is no doubt that there will be fundamental changes here too, that is, research will be carried out into other subjects which will be complementary to the work done by the institutes.

/K.H.4. **Internal**
K.H.4. Internal standards
This type of K.H. will continue to make significant headway in line with developments in the conception of the design of products, the materials used and the numerous components acquired from other enterprises that supply a large amount of external K.H.

K.H.5 Specifications for outside services
Given the importance of having available a certain amount of external K.H. to provide the main impetus for technological progress in the manufacture of many products, it is obvious that this type of internal K.H. will have to grow proportionally in volume and improve in technical quality.

K.H.6. Design of auxiliary tools and equipment
From the conceptual point of view there will be no significant changes, that is, the techniques already known will be applied to different jigs, frames, etc., and to other cases. However, in many cases, there may be less scope for it by virtue of the development of machine tools themselves: universal machines, for instance, that are programmed and have a high degree of precision will render supplementary manufacturing equipment traditionally used obsolete or make its use less common. The use of new machines, though it may come late by comparison with other sectors, will ultimately spread to the manufacturers themselves.

K.H.7. Instruction and time cards
This will necessarily accompany changes in production technology that will be introduced generally, among the most important of which, of course, are those relating to numerical checking and tools (form and attachment).

K.H.8. Production planning
It will continue to develop thanks to the progress achieved in other sectors. The practical effects are seen in the precision, flexibility and rapidity of programming. The chain of operations going from the issue of work orders, through their return, classification, comparison between order and execution, etc. will improve compared with the methods and means currently used.

/K.H.9. Purchases
K.H.9. Purchases
As progress is made in industry, communications and sales organization and as product specifications become more and more complex, the task to be carried out with the help of this type of K.H. will become somewhat easier, while at the same time it will continue to expand in terms of volume, diversification and origin. At the same time, the general improvement of programming will force the buying sector to operate within a very rigorous system of supply.

K.H.10. Selection of equipment
Progress will also be made as a large number of types and models of machines develop, although the sector as a whole has almost always shown itself to be somewhat conservative in the field of production equipment. One of the reasons for this may be that the manufacturers, strong in their knowledge of a technique of machine utilization of which by definition, they cannot be ignorant, have judged themselves to be sufficiently well equipped to deal with their own problems. However, a large number of large- and medium-sized enterprises will be faced with the necessity of renewing their equipment and constructing new factories. This will be forced on them by changes in the conception and design of many products and by the rationalization of production on scales which will probably not be much larger than at present. The constantly increasing precision that will be required in the performance of machine tools is another significant factor that will affect this type of K.H.; for on the average, the tolerances allowed for in the projects prepared by the K.H.2 section will be even smaller than at present.

K.H.11. Intermediate checks
This will continue to increase in importance and more equipment will be used, but this will not involve any great conceptual changes.
K.H.12. Assembly and finishing
The level of this type of K.H. will have to be raised and gradually changed to keep pace with the changes that will occur in the composition of products. For instance, electrical engineers, electronic engineers and experts in complex automatic programming will play a more important role. The final checks on products will also become more complex and comprehensive and there is no doubt that the Schlesinger recommendations, which were previously so useful to manufacturers and users alike, will become obsolete.

K.H.13. Industrial accounting
From a conceptual point of view, no changes are expected. However, those working in this branch of K.H. must prepare themselves to adopt unconventional means of operation, taking advantage of the computers that have already been mentioned.

K.H.14. Technical sales organization
The level of education required for the application of this type of K.H. will be constantly rising in direct ratio to the product changes that are introduced, so that there will be more university graduates in this field than in the past.

K.H.15. Propaganda
On the whole, the trend that has been observed in the last decade, which is already well defined and quite costly for manufacturers, will be maintained.

K.H.16. Technical assistance to customers
The marketing of increasingly complex machines in the most remote and varied parts of the work will make it necessary for the provision of this type of K.H. to be organized skilfully and efficiently, so that it can be supplied rapidly and effectively. The quality of the technical assistance will also have to improve. As regards the importance of technical assistance to purchasers, all that needs to be said is that, if the present trend continues, the products will become increasingly expensive, so that they cannot be allowed to break down.
K.H.17. Business management

It is unlikely that there will be any change during the next twenty years in the relationship between management capacity and the techniques available to keep administration up to date. This means that if there are changes in administrative techniques which make them more efficient, the cultural level of top management will have to be proportionally higher and it will have to have a very forward-looking approach, to which it might be said that the sky is the limit.

The forecasts regarding external K.H. have been grouped together, and subdivided as in figure IV. The trends of the different types of K.H. in each of the three groups will not be different enough from each other to make individual consideration worth while. On the other hand, the dynamic effect of each group will be quite different, as the following remarks will show.

K.H. 1, 2, 3, 4, 15 and 16. Castings, forgings, other semi-finished parts, small parts, accessories and special services

They will continue as before since it is impossible for them to disappear and because of the type of responsibility assigned to them in the final composition of machines.

New developments may take place in K.H.3 and K.H.16, in respect of the use of non-metallic parts, certain finishing processes, and heat and/or other treatment. In brief, this group of types of K.H. develops slowly compared with the groups mentioned below, from which it may be assumed that the advances achieved in the sector will not depend on these types of K.H. to the same extent as in the past.

K.H. 5, 10 and 12. Electric motors, cooling systems, bearings

In this group, although any possible improvements are not likely to be radical, the needs of the manufacturers will probably force them to develop technically in new directions. Thus, the performance of small components of machines may be improved, with a resulting improvement in operation. The research departments will have something to do with these advances, but the industrial
importance, the financial resources and the capacity of the firms providing these types of K.H. will always be a guarantee for the manufacturer, as has been shown. In general, these types of K.H. will continue to be semi-traditional in the future, which means that they will occupy an intermediate position on the scale of development, between the previous group and the very important group that follows.

K.H. 6, 7, 8, 9, 11, 13 and 14. Electric circuits, hydraulic systems, pneumatic systems, lubrication systems, mechanical systems, measurement and automation

As has been pointed out, this is a dynamic group in full expansion, which can be applied in this field and in many others connected with capital and durable goods. The impact of these types of K.H. as a group, taking as a starting point the K.H. on electronics (K.H.14), is tremendous, greater even than the impact of each one individually. Consequently, the influence that this group will have on the sector as a whole from the beginning of the next decade may be said to be unique in the history of machine-making.

There will be many examples, ranging from a single central control point capable of programming different cycles of operations for several machines to equipment permitting individual numerical checks and other controls involving recording and direct reading of the number of units completed at any time during an operation or at the end of it, that will show the shape of things to come. There will be a further reduction in idle capacity of the more simple and older machines, and marked technological advances in the field of partial automation - i.e., the provision of all the automatic means that can help the operator, but the presence of the operator at the machine is essential. The types of external K.H. considered here will be an indispensable part and a characteristic feature of the whole period.

The move towards regular replacements will be helped along by the many sectors that use machine tools and have interests similar to those of the machine-tool sector, thus ensuring the existence of a growing and really attractive global market for the producers
of intermediate capital goods. Thanks to these features of consumption, there will be an even greater increase in manufacturing, more research, a greater variety of solutions and, lastly, the economic capacity of the supply will be much larger.

If the machine-tool sector takes account of what has been said above, and realizes that it is only one of the various fields in which this over-all trend will make itself felt, it will be in a better position to accept and understand the new approach, which it will be able to adopt and adapt to its own special patterns. If this happens, as may logically be expected, it will gain time, or rather, the whole sector will keep abreast of technical innovations, as is already happening in those enterprises that have been selected to form the universe of manufacturers which is the basis for the observations made in this paper.

Figure V summarizes the above remarks. Part A gives ratings showing the probable progress of the different types of internal K.H., thus providing a view of the rate of expansion of each. Part B analyses the stage of growth that could be reached by internal and external K.H., represented by lines 2 and 3, at a rating of 125 for both. According to the arguments already put forward, external K.H. is likely to maintain its lead over internal K.H., as has been the case since the stage to which the rating of 75 has been given. Among the types of external K.H., however, there is an important group which is described in figure IV as "rapidly expanding and with a marked influence". In order to give a rough idea of the most recent trends, 1985 has been taken as the year when the rating of 125 is reached.

The considerations set forth do not go beyond a subjective analysis that is perhaps somewhat conservative in over-all terms; but they show, nevertheless, that much of the sector will be obliged to undertake far-reaching programmes of modernization in respect of certain types of K.H. and that, similarly, the manufacturers will have to make a considerable effort in order to be sure of assimilating the dynamic types of external K.H.

Although reservations.
Although reservations may be made in respect of the individual qualitative assessments given, i.e., the comparisons between different types or different groups of K.H., it is not difficult to see what the main recommendations regarding the machine-tool sectors that are being formed in the developing countries ought to be.
Gráfico V
Figura V
EXPANSION DE LOS KNOW-HOWS INTERNOS Y EXTERNOS
-PREVISON PARA 1990-
EXPANSION OF INTERNAL AND EXTERNAL KNOW-HOW
-FORECAST FOR 1990-

Probable posición de los K.H.s internos puntajes en 1990
Probable position of internal K.H.s ratings in 1990

En 22 años
25 puntos
25 points in
22 years
En 22 años 17 puntos
(Excluyendo externo)
17 points in 22 years
(Excluding external)

K.H.s, internos
Internal K.H.
K.H.s, externos
External K.H.
K.H., externes
External K.H.
K.H.s, externes
External K.H.
K.H.s, externes
External K.H.
K.H.s, externes
External K.H.
Chapter V

TRANSFER OF KNOW-HOW

Now that the different types of internal and external know-how have been defined and a study made of their movement through time and into the near future, all that remains to be done is to analyse one last feature before considering the subcase of Brazil, i.e., the transfer of K.H. from enterprises which form part of the universe already specified to others which, for reasons of location - far from developed areas, for instance - or for lack of opportunity, bad administration or poor development strategy, are lagging behind and wish to meet the needs of their market in a more efficient way. In order to simplify, this analysis will be made on the basis of the points detailed below.

(a) Types of K.H. that are normally transferred in the sector

It is assumed at the outset that the firm interested in receiving the K.H. should produce nothing else but machine tools or, at the very least, if it produces other items as well, the machine-tool production should constitute an important share of its total activities. In these circumstances, the buyer will be interested in only some of the seventeen types of internal K.H. selected.

The industrial position of the firms receiving the K.H. cannot be uniform, which leads to the conclusion that there are several types of real and possible transfer transactions. Table 5 relates the seventeen types of internal K.H. to three typical cases of buyers, which will now be described in detail.

I. A factory planned along sound lines in all sections, using complete and developed K.H., which is interested in adding a new line of products without abandoning traditional activities. The difference between the technological level of the buyer and that of seller is not very great, and both are assumed to be high. The reason for the transaction is that the buyer does not have available enough man-hours at
the project stage to cover a very wide programme in a short time, or that his K.H. would not be rapidly adapted to a new line of products, or simply, that the new product or machine is immediately sellable on a certain market.

II. The buying enterprise is medium-sized with an average level of technology, being inferior to the supplier in both respects. Consequently, the K.H. of the enterprise is not sufficient to enable it to design new products of the same quality as those of the supplier. The goods are purchased in order to modernize various sections of the enterprise and to update some branches of its K.H. The goods concerned are either new products that will gradually replace existing lines, or more advanced products to be added to existing lines.

III. The buyer does not have much experience owing to the fact that his K.H. is not complete and his products are on the traditional and unsophisticated side. Measured in technical and economic terms, the gap between buyer and seller is considerable. The buyer is interested in making long-term agreements to enable him to achieve a position of some authority in the sector, backed by a large enough market, and encouraged by specific institutional and other industrial promotion measures.

These three typical cases of course exclude cases at either end of the scale, that is, the supplier being a small share-holder in the buying firm, or establishing an affiliate or taking over a factory already in operation. As these are special cases, they have been disregarded, but it is recognized that the transfer of K.H. involves the same technical problems for them as for the three standard cases described above.

Table 5 is fairly explicit, although it shows for the moment only part of the problem, which will be filled out in the paragraphs below. In fact, the situation is as follows:

/Table 5
Table 5

TYPE OF TRANSFERABLE KNOW-HOW AND COMPARISON OF ITS TRANSFER TO ENTERPRISES IN THREE TYPICAL CASES

<table>
<thead>
<tr>
<th>Type of internal know-how</th>
<th>Class I: Between large-scale enterprises</th>
<th>Class II: Receiving enterprise of medium size</th>
<th>Class III: Small-scale receiving enterprise</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>Total</td>
<td>Total</td>
<td>Total</td>
</tr>
<tr>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>Partial</td>
<td>Partial</td>
<td>Partial</td>
</tr>
<tr>
<td>5</td>
<td>Partial</td>
<td>Partial</td>
<td>Partial</td>
</tr>
<tr>
<td>6</td>
<td>None</td>
<td>Partial</td>
<td>Partial</td>
</tr>
<tr>
<td>7</td>
<td>None</td>
<td>Partial</td>
<td>Total</td>
</tr>
<tr>
<td>8</td>
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<td>None</td>
<td>None</td>
</tr>
<tr>
<td>9</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>10</td>
<td>None</td>
<td>None</td>
<td>Partial</td>
</tr>
<tr>
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<td>None</td>
<td>None</td>
<td>Partial</td>
</tr>
<tr>
<td>12</td>
<td>None</td>
<td>Partial</td>
<td>None</td>
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<tr>
<td>13</td>
<td>None</td>
<td>None</td>
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<td>16</td>
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<td>None</td>
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</tr>
<tr>
<td>17</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

/Interest in
The term *total* has been applied to a type of K.H. that is wholly transferable, that is, entirely exploitable, in theory; but not all types of K.H. are fully transferable, both on account of their nature and because a smaller quantity is sufficient to achieve success. Where the circumstances require, time could be added to this last condition as a *partial* factor, that is, it would not be necessary for certain transfers of K.H. to be prolonged for as long as it takes to manufacture a purchased product.

Table 5 and the summary of it clearly show how the situation may change, depending on the structure of the buying company. It also makes clear that there are eight types of K.H. which are theoretically transferable but in which there is no practical interest as far as receiving or buying is concerned since the only interest in them would come from the cases at either end of the scale mentioned above. Disregarding these extreme cases, therefore, we are in reality concerned with the transfer of two, five or seven types of K.H.; these types would clearly have a far-reaching impact on type II and III enterprises, especially on their structure.

To sum up, it may be said that:

K.H. 1, 3, 8, 9, 13, 14, 15 and 17 are not transferable according to the conditions laid down.

K.H. 2, 4, 5, 6 and 7 are transferable in written form, i.e., designs and drawings, tables, figures, recommendations, standards, etc.
K.H. 10, 11, 12 and 16 are transferable only with the presence on the spot of persons who possess adequate K.H. at a high enough level, in variable proportions.

Once the above has been made clear, other features of transfer may be dealt with.

(b) Cost of the transfer

This item does not admit of many alternatives, since the above summary has already shown the ways that have been followed in practice up to the present. The two ways of transferring K.H. - in writing or through persons - are merely the result of the form of the K.H. and how it is organized within the enterprise. A blueprint embodies the obvious abstract and intellectual aspect, but at the same time it contains the essence of all the theoretical and practical knowledge that has been accumulated, which is intimately bound up with the progress of ideas and the development of technology. The provision of direct technical assistance by persons away from their usual place of work is, however, a complementary aspect for which designs and blueprints are not a substitute, since this is knowledge that is acquired through daily and prolonged contact with its possessor.

The pattern of transfer costs in this field does not vary greatly. Looking at the past, or rather, at what is considered normal in the machine-tool sector, the following should be borne in mind, however:

K.H. in drawn or written form. Its transfer value is between 4 and 7 per cent, calculated generally on the basis of the cost of manufacturing the product; there are slight differences in costs between factories, which can of course be ironed out in the contract clauses.

The lowest costs are generally for K.H. relating to the simpler products, without much documentation on K.H. 4, 5, 6 and 7. The highest costs are normally for K.H. relating to complex products, accompanied by substantial documentation on K.H. 4, 5, 6 and 7.

Between the two, there are all kinds of intermediate arrangements, depending, among other things, on the philosophy of the supplier enterprise, the volume of production planned by the buyer, etc. /The agreement
The agreement under which the license to manufacture is granted is nearly always finalized by the on-the-spot payment of a fixed sum which may vary between 5,000 and 20,000 dollars, according to the number of products covered by the agreement (one type of machine or a complete line of machines, for instance). These payments normally symbolize ownership of the designs and drawings to which the agreement refers. Royalties are normally paid half-yearly or yearly, accompanied by the relevant documentation and the annual technical and economic report.

K.H. transferred through technical advisers. The rules governing K.H. transferred in this way are somewhat different from the above. When the company granting the licence agrees to provide a few technical advisers, either at its own suggestion or at the request of the buyer, the advisers do not leave their original posts, except in very special cases. Therefore, the personnel thus lent keep their positions in the parent firm. Travel, accommodation, fees or salaries are usually paid by the receiving firm, which may also have to pay a part of the salary and social security contributions in the currency of the country of origin of the staff, depositing the necessary amount through the concessionary firm.

Such transfers may be for a longer or a shorter period, depending on the technological capacity of the receiving firm and the nature of the services to be rendered; it is normally between six months and two years. On some occasions the position may be reversed: that is, the buyer may suggest and/or prefer that some of his staff should have special on-the-spot training with the seller's organization, at the buyer's own cost, of course. However, the two solutions are not mutually exclusive, and a combination of the two is both viable and realistic.
(c) **Time**

The amount of time involved in the transfer of knowledge through persons may vary under different agreements according to the individual cases and the persons involved and thus calls for no comment; but something must be said about the payment of royalties under the license. The most common typical cases in this field are summarized below.

(i) The contract provides that royalties shall be paid on a fixed number - hundreds or thousands - of machines. Once that figure has been reached, the contract becomes null and void or is reviewed.

(ii) The same applies to time limits - five, eight or ten years, for instance - that is, the royalties are not related to the quantity produced.

In both cases the buyer has the recognized right to receive documentation on any modifications that the seller may introduce into the product or line of products referred to in the contract; the buyer may adopt such modifications or not as he sees fit.

Looked at from any point of view, any agreement leasing the payment of royalties on numbers or time is restrictive. Technology never stands still, so that with even marginal changes, some products may become obsolete or nearly so in the course of one decade. Nevertheless, the renewal or the extension of the original agreement indefinitely is considered to be feasible under the following conditions:

(i) When the enterprise granting the license is technologically go-ahead in the sector, and the buyer is interested in keeping abreast of its ideas;

(ii) When the buying enterprise does not consider it advisable, for market reasons, to stop selling certain products with their original trademark, despite the fact that its own technical and technological levels have risen with time and it has developed structurally to a point where it can introduce some changes of its own in the products; in this case, however, the parties agree to reduce the quantum of the royalties originally agreed upon;

/(iii) When
(iii) When the receiving company is averse to depending exclusively on third parties for certain machines or lines of machines and concentrates its resources on other lines of production or other types of K.H.

(d) Remarks on the acquisition of K.H.

The first simple calculation that must be made is a comparison of the cost of the design or model that the buying enterprise is thinking of acquiring, manufactured in its own workshops, with the accumulative value of the royalties paid over five or more years. This cost cannot be taken a priori as uniform for each of the three typical cases considered above. If account is taken, for instance, of the positions adopted in "Criterios y antecedentes para la programación de la industria de máquinas-herramientas" (E/CN.12/L.15), op. cit., it is fair to say that the typical cases in table 5 would correspond roughly to the following:

I. Enterprises employing 500 or more persons.
II. Enterprises employing about 250 persons.
III. Enterprises employing about 100 persons.

Stated in those terms, there is no avoiding the conclusion that the three typical enterprises have an unequal capacity to produce complex and precision goods. Thus, the average cost per hour of the drawing and design office staff in the different fields of K.H. will also differ, as will the number of hours of K.H. needed for the study of each of the products manufactured by these enterprises. In short, this means that each of the enterprises will tackle the question of acquiring design K.H. from different angles, which means that the amount of money that they are willing to spend on design will be very different in each case.

It is not difficult, therefore, to make some speculations. If enterprise I has an average cost of, say, 3 dollars per hour for K.H.2 (design K.H.), a project taking 30,000 hours will signify an expenditure of 90,000 dollars. Adding to that the cost of the other types of K.H. needed to develop the prototype, that of the drawings and blueprints needed for mass production, and certain general expenses, it can easily be seen that this cost may even be doubled. This figure, although

/inexact, provides
inexact, provides a first basis for comparison with the accumulative value of the royalties paid over the period covered by a contract.

It remains to consider some other very important aspects that do not come out in that calculation. One concerns the technical K.H. capacity of the receiving enterprise. If it lacks experience in some area or other, for instance, many more hours will be needed to achieve the same result, which means more time and a higher final cost. Furthermore, given the complexity of the subject, it may not be certain of achieving an equally satisfactory result from the functional and cost-of-production points of view.

It is obvious that other factors may play a part: market and brand, technical and psychological factors, either separately or in conjunction, and these factors are sometimes only partly quantifiable. But, be that as it may, it is always important from the point of view of technical and economic viability, to compare the estimated internal cost of what is purchased with the amount that the firm is prepared to pay for it.

In the case of enterprises of type II and particularly of type III, it has been admitted a priori that the level of the K.H. of the buying enterprise is much farther below that of the seller than in the case of type II. However, the bases of calculation are not fundamentally different from those just mentioned. But in the cases of type II and III enterprises the cost per hour of the relevant design K.H. is less, since the products manufactured are generally less complex. Therefore, such enterprises are interested in acquiring design K.H. which is less expensive in absolute terms, both in intrinsic cost and in terms of range of technology applying to the product.

In view of the difference in inventive and productive capacity between cases I, II, and III, and the consequent differences in their ability to absorb complex K.H., it is easy to understand that, of the royalty rates mentioned in (a), the highest — for instance, 6 or 7 per cent — will be paid mainly on transactions likely to be carried out by type I enterprises, while for type II the upper limit should be 5 per cent, and 4 per cent for type III. This is a rough yardstick.

/The wider
The wider the gap between suppliers and buyers in respect of their design K.H. capacity, the more value are the buyers likely to attach to this type of K.H. indeed they may even go so far as to consider the price they pay for it a matter of somewhat secondary importance. However, this attitude is far too easy-going and not nearly hard-headed enough; in most cases it is untenable in the long term from the economic point of view. For the buyer, this means that he cannot determine whether a given transaction is advisable without taking a hard look at the structure of his own enterprise and seeing how backward it is compared with the seller's. In other words, a transaction will be advisable only if the difference in level between the interested parties is not too great. This difference can be accurately measured in the case of type I enterprises, but the very structure of type II and type III enterprises is sometimes an obstacle to the exact evaluation of how advisable a transaction may be, as has been shown in practice.

When the specific case of Brazil is studied in Part Two of this paper, the problems facing type II and III enterprises in connexion with the acquisition of design K.H. will be clearly shown.

As regards the K.H. transferred by persons, the ability of the typical enterprises to utilize and to pay for it is in inverse ratio to their needs, and it could not be otherwise, given the types of K.H. transferred in this way and the size of the firms. Those of type I, which are better organized, have ample resources at their disposal which enable them to make all sorts of different arrangements, while those of type III, for instance, which have a greater need of such assistance, cannot afford to pay for it. The cost of such transfers of technical staff, which are usually temporary, must be related both to immediate short-term goals and to the over-all technical development policy of the firm, and it is therefore natural to debit it to general expenses. In this way, for the purposes of calculation, the expenditure on K.H. acquired through transfers of staff can be divided between the cost of the product for which the license has been acquired and the other costs of the enterprise or of manufacturing, thus spreading this expenditure over a wider area. The ratio of costs for technical assistance to both of the latter can be evaluated in each case, and this will determine what are the financially acceptable limits.

\( (e) \) Imported
(e) Imported K.H. and the general level of development of the local engineering industry

Although the responsibility for the choice of the product and the transfer of the K.H. that goes with it lies with the buyer enterprise, it will not be out of place to situate the problem within a more general or national framework. In view of the fact that in the most common cases K.H. is acquired in order to achieve a technological advance in manufacturing, and consequently at the national level, compared with the past, there must be, before the decision to acquire more is taken, a body of effective modern K.H. which can be turned to good account. If the K.H. selected is to be of the right quality - a point to which enterprises of types II and III have paid so little attention - the buying firm must have an exhaustive knowledge of the statistics, policies, development, techniques and economic situation of the user sector, complemented by a market research section in the enterprise which makes regular surveys of the existing and potential clientele in the firm's area. Import statistics alone are not a sufficient basis for a judicious decision. What short- and medium-term strategy should be adopted to fit the technological development of the user sector will emerge from an analysis of the user sector as a whole, its problems of mass production, the opening up or development of new subsectors, sectoral development policies and its specific and general economic problems. The main preoccupation of the buyer of K.H. must primarily be, therefore, the technological content of the K.H. he is buying, judged from the widest possible angle.

Anyone who is thinking of acquiring different types of K.H., knows in advance that there is a fixed, albeit modest, sum to be paid, a percentage for the design K.H. which has already been discussed, and quite often expenses for technical assistance from experts. All this involves amortization and, as a result, a strengthening of the technical development of the enterprise within a specific period; but this takes some time, that is to say that the return cannot be measured except over a period varying between five and ten years. For that very reason, improvisation is ruled out in principle. It is therefore obviously /important for
important for the buyer to possess a K.H. that will enable him to cope with the problem. What this should really be is a happy mixture of the two types of internal K.H., 1 and 17, described above, and this should not be an exclusive prerogative of large firms.

An exhaustive knowledge of the user environment, which in fact corresponds to the metal-transforming sector, is now provided partly by statistics and practical studies that are normally published by the various national associations of manufacturers, the technical journals of the sector, the specialized research institutes, the ministries of industry, planning, and others. If they are exporters, the manufacturers of capital goods can no longer be passive and ignore the wider context of the national, regional or international market, as they have in the past. In figure III, the speed with which the various types of internal and external K.H. are expanding jumps to the eye, and the figure gives an idea of how the time between one stage of development and the next is shrinking. Although the figure reflects the world situation identified in this paper as the universe, it is clear that, in the long run, national trends will approximate more and more closely to those of that universe, though at different stages according to the country concerned. Thus, when considering the question of the acquisition of K.H., the national picture cannot be left out of account. It is necessary to proceed with caution, for it may be much less advisable, from the point of view of its probable over-all effects on the technology of the user sector, to acquire a type of design K.H. on which the royalties are low - 3 per cent, for instance - but which has only a modest technical content, instead of some other type of K.H. which may be more expensive in terms of royalties - 5 per cent, for instance - but which is likely to produce better technological and economic results over a fairly long period.

Another feature that is worth pointing out and which has often confused the inexperienced buyer, is that of machines that have been automated with few basic changes in structure, their complexity being increased not so much through the application of internal K.H. as by the assimilation of numerous types of external K.H. that are easily available on
available on the market. The acquisition of these types of design K.H., which are graphically presented, must be studied from a different angle, since the external K.H. to be acquired, although co-ordinated to a certain extent, is obtainable from a multiplicity of diverse sources. In the simplest cases - of which there are not a few - it would be better for the receiver not to purchase the design K.H. from third parties but to look for an expert or experts who would be able to tell him what types of K.H. could successfully be combined in the structure of his product. The free and independent recruitment of experts, even international experts, is therefore justified and is an attractive and valid solution in many cases.

To sum up, given that the assimilation of internal K.H. is always a fairly slow process, particularly in under-developed areas, it is necessary to consider the cost of the transaction in relation to how much it will do to narrow the technological gap between the user and the supplier; and it is particularly necessary to evaluate the extent to which the technical aims that may be adopted as a result of such a transaction are forward-looking. No matter how advantageous it may be from the point of view of price, any agreement which does not have wider objectives is not good strategy in the capital goods sector, and particularly in the specific field dealt with here. The figures showing the future development of the sector which have been included in the text should provide fairly good guidance in this respect.

This chapter should doubtless have covered more ground than it has done. Its scope has been deliberately curtailed, however, so as to avoid repetitions in the analysis of the particular case of Brazil. Thus, in Part Two, some more remarks of a general nature will be found, but they will be more comprehensible when related to a particular case. In fact, the recommendations made in respect of a particular situation should not merely derive from a comparison with the universe already described. Although the latter constitutes a point of reference that is valid in all respects, hypotheses must be tested in each case before the most suitable strategy for acquiring K.H. can be found, a strategy that will ensure that the speed of technological expansion in a given area goes hand in hand with a progressive narrowing of any technological gap which may be having an adverse effect on the area concerned.

/Part Two