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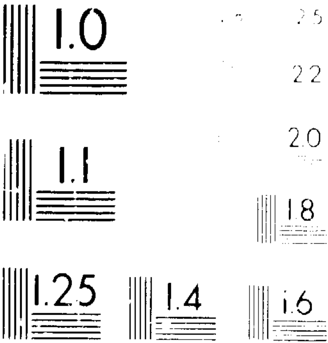
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ESSAY ON "THE MULTI-PURPOSE PRODUCTION UNITS".

Theoretical Considerations and Practical Applications

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Santiago, Chile, May 1984.

Contents

14 ANNEXES in a Separate Volume.

FOREWORD

In the course of North-South know-how transfer, with the subsequent diffusion of electro-mechanical industries, EMIs, in the Third World, during the last three decades it has often been recognized, on one side, the impossibility of imitating that process within the same operative structures of the industrial North, without suggesting on the other clear concepts, efficient alternate patterns or practical adaptations which could maximize the effects of industrialization in young countries.

In countries with an important binomial surface-population such as for example Brazil, India and Mexico, many of the solutions adopted came close to those of the industrialized world, due to local markets dimensions. However, for the great majority of the Third World countries, the fact of withdrawing from rather ideal or only sufficient local market conditions, has not met among the north manufacturers of final and intermediate capital goods - highly specialized - productive structures easy to imitate even only in some respects.

In order to attain the aims outlined in the "Lima Statement" it becomes imperative to make a serious and systematic effort toward understanding the difference of technological contents among the various capital goods. Such a difference may be objectively estimated and classified for example along a Scale of technological complexity, Ec, which is realized by means of the work indicated in 1/. At the same time it is essential to explore, experiment and apply every possible form of multi-purpose industrial production - a method opposed to the rigidity of highly specialized production - if one wishes to increase and accelerate the diffusion of the manufacture of electro-mechanical products in the Third World.

The purpose of this essay is to study the multi-purpose production patterns, individualizing the different cases which in practice may arise and which represent an authentically alternate behavior for developing EMIs.

It is not a question of dealing here with the subject from an academic angle nor to extend the considerations to the aspect of industrial costs. We think that more refined analyses are useful and necessary provided the field of action of multi-purpose concerns has been adequately defined. We also think that neither the exact function of the multi-purpose unit nor its multi-purpose field were conveniently explored, at least for the objectives pursued in this essay. That will therefore be the direction assumed here, emphasizing on the multi-purpose configuration especially adapted to the problematics of Third World medium and small-size countries.

The first chapter organizes the subject in a conceptual manner, since it is well known that different interpretations exist, some to our knowledge incorrect, which must be duly cleared up.

Chapter 2 develops the way of finding the most suitable multi-purpose composition on the basis of the enunciations made in the former chapter and of a set of industrial data computarized according to the Technological Complexity method created by the author of these notes. 1/

The purpose of the first two chapters will be to demonstrate that the term "multi-purpose", or if preferred, the condition of "multi-purpose productor" is not associated with the position of arbitrary composition, namely, that starting from a certain production unit, any or almost any type of product may be obtained.

1/ "How to Program the Electro-Mechanical Industry", F. Vidossich. Technological gathering composed of 9 volumes: 1 theoretical text explaining the theory of technological complexity of an electro-mechanical product; 1 of practical applications; 1 Engineering manual for calculating the Index of complexity; 5 vols. of industrial data corresponding to 500 products, and 1 vol. with the different computation programs (4) and respective diskettes.

In this first part then, the discipline according to which that type of production units must fit in will become evident, if one wishes that such unit, together with other more specialized or standard ones, may constitute an efficient and not-distorting contribution to the Third World electro-mechanical industries, HEMIs. At any rate, the idea is to avoid solving a problem - the productive one in this case - in detriment of others, thus incurring in deformations which could hinder the accumulation of technological knowledge, or adhering to excessively artificial production methods such as those avoiding to depend upon a local industrial weave, which are compensated with an excess of imports.

A chapter follows then with speculations at sectorial level, applying in practice the organization of new ideas derived from the original raisings of the first part. The sector selected here is AGRICULTURAL MACHINERY.

Once finished this chapter essay, the fourth one deals with final and intermediate capital goods as a whole, looking for some behavorial general rules of a practical type, to be added to the conceptual raisings of Chapter 1.

The subject coming next is the problem of human resources in connexion with multi-purpose units, an aspect which will be superficially developed since the subject of professional formation will be dealt with in a document shortly to be issued by UNIDO.

Finally, Chapter 6 will present a condensed summary on the technological complexity methodology of electro-mechanical products, thus enabling readers not yet familiarized with it to follow the text with greater interest. In such case it is advisable reading Chapter 6 before the rest. Whereas the persons who already have a notion about the last edition of the material indicated in foot-note 1/, are exempted from doing so.

The computation program used in order to find the most adequate composition of a multi-purpose production unit is enclosed as an annex at the end of this essay, together with the respective diskette.

The specific multi-purpose program is a natural extension of the four programs included in 1/. The same as those ones, it is presented in BASIC language, for the following equipment:

Apple III Computer 256 Kbytes.
Hard-disk Profile 5 Mbytes.
Thermal printer Silentype.
Dot-matrix printer 132 columns.

Programmer Engineer Leonardo Fuentes collaborated in the preparation of the above-mentioned program.

Chapter 1

SEARCH OF A DEFINITION FOR MULTI-PURPOSE CONCERNS

The denomination of multi-purpose unit itself assumes that we are dealing with an industrial behavior opposed to another one, obviously specialization. But this dichotomy is not clear enough in itself to appreciate the industrial fields of action of each one. In some aspects this has even led to confusion, since precisely by contrast to specialization, multi-purposeness is associated as the art of making everything or practically everything starting from a given structure and from specific and flexible productive machine-tools in use. The sight of the workshop with machines controlled by a central computer from where the most different work (cycles) orders are given to various production centers, contributes to a great extent to extrapolating to exaggerated limits the degree of freedom of the production unit.

If by the end of last World War on one side we have attended to the consacration of metal-cutting and metal-forming production equipment called "special", specifically dimensioned for one piece to be manufactured in continuous series, thus creating the generation of mass production equipment, on the other side we have also attended, after a temporary desertion, to the evolution of universal production equipment with automatic cycles. This way the first generation of that type of machinery* was originated, a fact more closely linked to certain production structures of industrialized countries themselves, since in the United States of America for example, "it is estimated that only a fourth of metals transforming work, including automobiles, deserves the qualification of mass production". 2/

2/ Bounine, Dalle, Lussato: "Le Taylcrisme à l'Envers". Institut de l'Entreprise, 1977.

* The author of this essay conceived and designed, if not the first, one of the first machining centers (University of S.Carlos, USP, Brazil, 1957).

The Third World must carefully observe this last trend, since it is not substantially opposed to its productive interests. However, the respective technological and conceptual filters must be adopted, due to the fact that the motivations and conditions of multi-purpose production - flexible, varied, etc. - are not coincident in both worlds. It is therefore interesting to know the second and third generations, in sum, the evolution of machine-tools and other universal production equipment, but without this implying or stimulating the absorption of the know-how, as may be seen at present in OCDE countries.

The main objective of this chapter is then to contribute to the formation of concepts on every industrial case fitting into multi-purpose production, establishing differences or pointing out at the same time the new or already existing compositions in which the Third World is more interested.

1.1 Considerations on the production series

As it has been noticed, multi-purposeness has continuous or mass production as a counterpart. Without this being a definition, it serves for determing the point of departure of a reasoning sequence. The next step is then to clarify the scenery of what it already exists in the international productive structure and to observe the relationship between the production series and multi-purposeness.

Table 1 outlines the relationship between the type-series, 6 in this case, and various other factors.

The 6 openings adopted for production series S are the same included in the technological gathering mentioned in op.cit. 1/. (See also Chapter 6.)

CUADRO 1

SERIES DE FABRICACION Y POLIVALENCIA a/

1	2	3	4	5					
Series de producción	Qué convivencia puede existir en término de serie	Cómo se distribuye la variedad V fabricada entre las series	Movimientos que indican necesidades o deseos de abarcar otras posiciones de series	Los Niveles de Complejidad N de los productos					
				N1	N2	N3	N4	N5	N6
1. SERIE CONTINUA O MUY ELEVADA	a	Baja, muy reducida	a						
2. SERIE ALTA	b	Limitada	b						
3. MEDIANA SERIE: 500-100 POR AÑO; REPETIDAS ALGUNAS VECES POR AÑO	c	De mediana	c						
4. PEQUEÑA SERIE: 1 A 3 POR MES	d	para	d						
5. FABRICACION UNITARIA REPETITIVA	e	alta	e						
6. FABRICACION UNITARIA ESPECIAL									

a/ Conceptos aplicados a una sola unidad de producción. Se descartan entonces los casos en que, bajo la misma denominación social, operan diferentes unidades de producción.

Naturally, the 6 cases considered represent rather the situations prevailing in final and intermediate capital goods manufacture, since position (4) shows the production of 1 to 3 equipment per month, position (5), repetitive unitary production, and position (6), special unitary production.

There are industrial situations in which each one of the 6 "series" points coincides with the real activities of the concern, an aspect in which no significative variations are evident.

But it also exists - the majority of cases - the fact of different series living together wi ..n the same concern, which constitutes an indication of a larger produ..tion variety starting from certain available machine-tools in use. The most frequent cases are indicated in block (2).

It may be appreciated how in fact continuous series live together with one or more high series, as it often occurs in the automotive industry; this case is indicated with (a); (b) shows instead that high series live together with medium and small cnes, as it sometimes occurs with the production of electric motors, and hydraulic and pneumatic components.

Type-(c) living - together is fairly characteristic of final capital goods of significative size and/or of high technological complexity, such as for example machine-tools production. Finally, we find the last two positions (d) and (e) related to specially complex material or to semi-heavy and heavy boilermaking, as well as the production of semi-heavy and heavy metallic structures.

Block (2) is therefore illustrative, since it would point out that the series living-together degree increases from (a) to (e), that is, as they decrease.

There is certainly nothing new about this; it hardly shows what in practice exists, putting it in an order which may be useful for the aims pursued.

In block (3) three hatched areas are clearly seen. The upper one represents rigid or scanty-flexible productions, completely conditioned to a definite production equipment, usually conceived for very specific works.

The intermediate area corresponds to high series which already accept some degree of flexibility although limited, and which at any rate constitutes a passing zone with the lower one, characterized instead by the living-together of different series of types and models of products, which in its turn is not only an expression of diversified manufacture but it well represents the stage of constructive multi-purposeness.

When indicating the variety of types of products manufactured (for example 2, 4-cylinder, centrifuge, axial, etc. air compressors) with Vt, and with Vm the existing variety of models for each Vt type (power variation for each compressor type), it will be possible to note that with Vt and Vm increase or with that of the products V variety, the concern withdraws from any rigid, inflexible productive scheme. Starting from a certain degree of living-together with V, the concerns become in some way multipurpose. They are so of course according to some rules that must be clarified.

Capital goods concerns are called to living together within an apparently curious contrast. On one hand market requirements and the consolidation of the concern's position make that from a comfortable position of continuous S(1) series, the action extends to S(2) or from S(2) to S(3), etc. This means that from a definite and high S position almost always exists the interest or the need of complementing the higher series with others of a lower rythm. On the other hand, the assertion that starting from any S position, excluding S(1), a permanent effort is made for increasing the series to their maximum values as indicated in block (4) of Table 1, is also realistic. The descending movements may then be identified with "market needs, industrial strategy, safety of the group and the like", while the ascending movements show rather "a wish for taking advantage of the higher production scale, of reducing fixed unitary costs, in sum, at equal work volumes, to reduce somewhat V variety". In industrial reality, both trends are inseparable and although changeable along a period within the same concern, they are not annulled nor stabilized due to technological changes or to the products innovation speed which in larger or smaller degree makes pressure for such type of changes or living-togethers.

The investigation on S series may be extended to the complexity of electromechanical products in general. With that purpose in mind, PROGRAM 2 of ANNEX C of op.cit.1/ for the Computer System is used.

Table 2 shows the distribution of cases among S series and the products N technological complexity levels regarding the sample of 500 products considered in op.cit.1/, allotted among the five different ISIC groups, namely, 381, 382, 383, 384 and 385.

In Table 2 the field of major representativity has been limited taking into account that the same is not quite illustrative for N5 and N6. Two singular areas are separated here, showing with cross hatching almost inexistent situations, and with simple hatching those less frequent ones, namely, areas A and B. They indicate that the higher the product complexity, the lower will be the series adopted. On the contrary, the more N complexity is reduced, the greater the interest will be for high and continuous series, with the exception of automobiles and trucks. This is synthetized in block 5 of Table 1.

Thus the sequence of considerations derived from S series, conveniently selected in order to prepare the development of the next paragraph, is completed.

CUADRO 2 [illegible]

Grupo : 38   Factor : 5 SERIE

	0	1	2	3	4	5	6	TOTAL
N6	0.0% 0	0.0% 0	0.0% 0	0.2% 2	0.2% 2	0.1% 1	0.1% 1	0.7% 6
N5	0.0% 0	0.2% 2	0.4% 4	0.9% 8	1.0% 9	1.1% 10	0.8% 7	4.4% 40
N4	0.0% 0	1.2% 11	1.2% 11	2.9% 27	3.7% 34	2.8% 26	2.2% 20	14.1% 129
N3	0.0% 0	4.2% 39	5.3% 49	10.2% 94	9.4% 86	6.3% 58	4.1% 38	39.7% 364
N2	0.0% 0	8.1% 74	8.0% 73	7.7% 71	4.0% 37	2.3% 21	2.2% 20	32.2% 296
N1	0.0% 0	3.2% 29	3.3% 30	1.9% 17	0.3% 3	0.2% 2	0.2% 2	9.0% 83
TOTAL	0.0% 0	16.9% 155	18.2% 167	23.9% 219	18.6% 171	12.9% 118	9.6% 88	100.0% 918

1.2 Basic criteria for defining the action of multi-purpose concerns

The tile is expressive by itself. It clearly suggests that multi-purposeness cannot be identified with one single type-situation or within a frame of inconditional operational freedom. This means that multi-purposeness must be accepted according to some discipline. It should then be defined which are the acceptable bonds and the limits which cannot be trespassed without damaging the essence of the producing unit.

In the first place a position related to the project know-how should be cleared up. In fact, it must be recognized that the vastly multi-purpose productive formula in opposition to that of high specialization, should give up the efficiency and advantages of the latter in relation to the first one. Actually, it would be unreasonable to think in suddently transferring all the project capacity and the knowledge accumulated by the highly specialized project bureaus to multi-purpose concerns. The latter cannot aspire to having over-dimensioned project bureaus as regards the rest of the concern, as the case would be for example, if they wished to design, calculate and experiment prototypes, as well as to participate in the technical evolution of every final or intermediate capital good produced, just as specialized concerns do. Therefore, to the highly multi-purpose issue of products corresponds a global decrease of project capacity in each speciality, product line, sector, etc. With the exception of very specific cases (see POL.10 farther on), this assertion has always proved valid.

This means an indisputable relinqueshment not only for Third World EMIs but also for the concerns of industrialized countries themselves which will be in favor of multi-purposeness.

Consequently, highly multi-purpose production must rely in principle, if not wholly at least partially, on the contribution of third parties' project know-how (manufacturing licenses) and on some form of technical assistance for the transfer of production, assembly and maintenance know-hows.

As a result, Hs technical bureaus (see Chapter 6, factor 009) shall have connotations differing from those of specialized concerns. The personnel occupied will be strictly limited to that necessary for understanding, absorbing and transferring to the workshop as well as to the utilizer, the know-hows of a highly varied range of products, without arriving however at a complete control over such know-hows but after quite some time. Depending on the nature of the product and on the speed of the annual evolution of the same, one should by no means think in greater autonomies before 10, 15 or even up to 20 years of activity.

Multi-purpose concerns cannot therefore be considered nor conceived as productive units capable of making products develop technically, especially from level N3 onward, maintaining themselves at the head of progress in each speciality, sector, subsector, etc. They must rather be considered as concerns following progress and at a certain distance from it, which will be more or less marked according to local circumstances and to the product nature. This is then the highest price to be paid when passing from a highly specialized production to multi-purpose production.

A second basic aspect is constituted by the degree of integration of the work attributed to multi-purpose concerns. In fact, if multi-purposeness were only interpreted as the assembly of different types of machines and equipment with insignificant aggregate value, then the degree of freedom for constituting multi-purpose concerns would be very high. That reasoning would lack however any industrial meaning.

In accordance with arguments presented in op. cit. 1/ (Vol. II, Chapter 8), the only valid reasoning for any type of production in the Third World must fit in the formula A+B = LOCAL/ REGIONAL, where A represents (see Chapter 6) the producing unit and B the infrastructure serving unit A, composed of B1, semi-finished products (cast, forged and similar ones), and B2, third parties' specialized services.

The analyses and reasonings appearing farther on in the text in relation to multi-purpose concerns will refer to the position A+B = LOCAL/REGIONAL, accepting besides that C, components, be depending on foreign countries without further restrictions and/or in adequate proportions, as it occurs in OCDE countries.

Actually, multi-purposeness would not have technical or economic meaning should it operate under very different manufacture and local aggregate value conditions from those usually found in the industrial world, and specifically in smaller OCDE countries and probably also in those of COMECON.

Desorganized and under any condition multi-purposeness has been accepted every time it has been intended to initiate through that artifice supposedly accelerated industrializations, injecting into such units products with N technological complexity levels too far away from local technological capacity. As a matter of fact, formula A+B = LOCAL/REGIONAL has a sense only and when referred to products with a technological complexity according to the EMIs global technological level. For example, should that one be at N2 or N3 levels, on pretending to manufacture N4 or N5 level capital goods, this would only be made at an assembly regime and even so not without difficulties as regards quality and especially maintenance. Whereas if multi-purposeness were carried out with N2 or N3 products, namely within the EMI real operational level, the previous formula should be applicable, thus maximizing local work.

As a result, that position inevitably implies another general conditioning. Multi-purpose concerns, just as specialized ones or any other, should not be conceived in the Third World, as it has sometimes occurred, for products exceeding in terms of N technological complexity levels, LOCAL/REGIONAL manufacture capacity, including the participation of B infrastructure, just as defined in op. cit. 1/. In other words, EMI maximum N operational level and its B1 and B2 infrastructure, and N level of products with which it is intended to assemble a multi-purpose intermediate as well as final capital goods concern, must be coincident.

These are the general basic rules from which other more specific considerations may be derived, which follow below.

1.3 The different types of multi-purpose concerns

In this respect, ideas should not be exclusively adapted to what it already exists of multi-purpose in the industrialized world.

The Third World, and specifically the Third World EMIs, are interested in finding out whether it is possible, on the basis of present multi-purpose positions or near them, to conceive other situations which although being uncommon or even non-existent in the industrial world, may achieve a real meaning in EMIs operational field. Furthermore, it should also be ascertained whether concerns systematically operating in an already stabilized manner in industrialized countries, within continuous or almost continuous S(1) and S(2) series, may in fact be "fractionated" or "reconditioned" into multi-purpose schemes and if so, under which rules and conditions.

Once rejected then the unreal position that with a complete productive machine-tool stock in use, together with a number of indirect technicians with varied formation, practically any product may be manufactured, in other words, starting from a production unit of colosal dimensions for the Third World, it must be assumed that the only realistic base upon which multi-purposeness may be founded is to have some characteristics in common among the different products manufactured. Total contingency is therefore rejected for the fact of being unreal.

Consequently, the various cases with common characteristics determine the types of production multi-purpose units which may exist. To each one of such cases multi-purpose actions correspond which are not necessarily equal among them but differ according to those characteristics accepted as common in the production unit.

Starting then from some common characteristic, especially conditioned to the aims pursued, it should be possible to act in a multi-purpose manner, that is, to obtain a fairly diversified production in Vt types and Vm models in order to fit into a situation of multiplicity of utilizers or sectors, or of use multiplicity when directed to a sector itself.

On multi-purposeness identifying itself with high Vt and Vm variety, in the end it is a question of substituting great specialization, usually seriate, by units opposing to that characteristic and by way of defense, a satisfactory operational critic mass, obviously variable according to cases. Therefore, low-series multi-purposeness and acceptable operational critic mass, against high specialization and/or high production series.

Let us now examine the so-called common or homogeneous characteristics, namely, let us determine the environment within which multi-purposeness is already operating or multi-purpose conditions would exist.

Eleven well-defined cases have been selected, extracted from practical observation, accompanied when necessary by theoretical notions. In a first stage these eleven cases are considered as independent, that is, without eventual interactions among them. which should facilitate forming the initial concepts about them.

Common characteristics are transcribed below.

POL.1	-	Metal-forming machine-tools in use (Factors E.01 to E.10 within subgroup A3 - See Chapter 6.)
POL.2	-	Metal-cutting machine-tools in use (Factors E.11 to E.34)
POL.3	-	Metal-cutting and metal-forming machine-tools in use (Every factor from E.01 to E.34.)
POL.4	-	Manufacturing processes.
POL.5	-	Precision and quality ranks (Factors E.44-E.45.)
POL.6	-	Hd rank (direct hours of manufacture per ton of final product).
POL.7	-	Hs homogeneity (hours of project bureau per each 1.000 US$ of final product (1976-77 US$).
POL.8	-	Homogeneous utilizer sector.
POL.9	-	Multi-use specialities.
POL.10	-	High values of Hs, L, Hd and industrial T.
POL.11	-	The special case of maintenance.

Every case is considered below, together with the main observations, the summary of which is presented in Table 4.

POL.1 - Metal-forming machine-tools in use

Concerns using practically only metal-forming machines for multi-purpose production already exist. Typical examples are boilermakings, the manufacture of metallic structures, metallic silos, etc. Generally the products designed by third parties prevail over those of own design which sometimes are even inexistent. That is the reason why POL.1 usually manufactures the most different products in shape, complexity, quality control, types of material and thickness of sheets and profiles, direct hours per

Hd ton, and of course, utilizer sectors. Production series are usually low; unitary production is frequent, either repetitive or not. More substantial series may be considered rather circumstantial.

As a general rule then, Hs personnel suffers from atrophy if compared to that of other industries. In compensation, production engineering indirects are numerous, including times and methods. With such production equipment, N products complexity is not high. N4 is considered a good maximum, which is obtained when P weight of the part or product is between P4 or P6. (See Chapter 6.)

According to this configuration, Third World EMIs cannot assume other attitute than imitating the great variety of already existing cases. Suffice it to point out that combinations lower than N1 with P2 or of N1 with P3 should always be present in any EMI being formed or at its first operational stage.

In multi-purpose terms, POL.1 is known above all according to the above-mentioned description. But one should not forget that POL.1 also operates at a lower level as supplier of minor parts and pieces for the assembling industry and in such case it is considered as multi-purpose offer of technical services for third parties.

POL.2 - Metal-cutting machine-tools in use

The existence of POL.2 in the EMIs is especially due to its role as technical service for third parties. Nevertheless, its behavior, as multi-purpose as POL.1, has been significantly reduced in the course of time, making way to rather specialized mechanized units, namely, furnished with a reduced variety of the machine-tools in use.

POL.2 may be the origin of POL.9 variant, Multi-use specialities, but in the end it is not recognized beforehand as a sufficient base for manufacturing different final capital goods within the same operational unit; this in the developed industrial world. However, although with some restrictions, this may be applied to the Third World producing units of multi-purpose type, striving for an adequate organization and accepting, as already pointed out, a certain passivity in terms of Hs.

POL.3 - Metal-cutting and metal-forming machine-tools in use

It basically refers to the addition of POL.1 plus POL.2. In the developed industrial environment this formula is not considered as a unique and sufficient criterion in order to produce a great quantity of capital goods types and models. The same as in POL.2, specialized production is preferred. On the other hand, based on a coinciding stock of machine-tools in use, it is always possible to operate in a multi-purpose manner (and more so than with POL.2), namely, to manufacture very diversified products, provided the restrictions pointed out in the previous paragraph are respected.

If all the variety of the productive stock of machine-tools in use is considered as a common element, naturally the possibilities of multi-purpose manufacture increase. Here it is pertinent to remember that while electro-mechanical products V variety, that means the universe, is of approximately 8-9 x 10^6 , measured in fundamental types and models, the machine-tools basic variety constituting the manufacturing machine-tools in use does not exceed 3 x 10^3. Adding now the machine-tools complementary productive equipment, a total basic variety of approximately 10^4 will be obtained. This shows that productive machine-tools in use are by themselves fairly flexible for generating highly larger variety effects than their own. But this in no case authorizes to think in desorganized multi-purposeness, alien to any discipline in connexion whether with their own productive stock of machine-tools in use or with the products to be manufactured.

The direct control of the machine-tools in use through a central computer does not constitute by itself a multi-purpose structure according to the terms applied to the eleven POLs here selected. In our opinion, this is only a very restricted side of the problem, at any rate of limited interest for the Third World now and in the near future. Because if such special state of multi-purposeness were accepted as a unique solution with the pretext that it would supplement insufficient manual labor technical formation - a factor almost constant in the Third World - the prospects of increasing national or local aggregate value of under-developed countries would diminish excessively. Since besides its product engineering, that of processes, of a part of components and sometimes even of maintenance, in such case the dependence on times, methods and the production equipment itself which due to its sophistication could not be reproduced in developed and under-developed countries, would also be added and without appeal.

The utilization coincidence of the productive machine-tools in use according to one of the three formulas considered: POL.1, POL.2 and POL.3 constitutes always the ideal and desirable point of departure for every multi-purpose combination which might be conceived. Utilization coincidence which must of course be associated with machine loads between 80% and 100% when referred to one work shift.

The search of coincidences or of the best desirable coincidence among various products is easily attainable through the Computer System program described in the following chapter, which is applicable to each one of the first three POLs considered.

Even when other basic criteria were selected in order to form multi-purpose units through the program indicated, it should always be possible to verify which degree of coincidence might be obtained with POL.1, POL.2 and POL.3 equipment, thus confirming or not the position adopted.

POL.4 - Manufacturing processes

Interesting variants exist for the Third World in connexion with the use currently made of POL.4 in industrialized countries.

We refer to the processes which usually are or can be considered as a technical service for third parties and which as such accept and execute quite a diversified range of works for highly varied utilizers. Classical examples of this are the processes of galvanoplastics, cold or hot metallic and non-metallic deposits in general, all the vast series of thermic treatments and others. In developed EMIs those technologies present themselves with specialization characteristics either in the case of being incorporated to the manufacturing process itself, or in that of services rendered to third parties, that is, of B2 infrastructure (see Chapter 6.) But as services rendered to third parties they may be included in Third World EMIs with fairly different characteristics.

In the first place, the variety of services rendered in terms of processes, materials and dimensions should be extended. Associate then to that activity other different commercial aspects such as the sale of equipment and materials related to the nature of the service rendered.

Some examples of such multi-purpose services will serve to clarify this concept:

- Concerns with facilities for current stripping, varied electrochemical deposits, deposits by thermic means in liquid bath, deposits by means of hot spraying with gun, and eventually others.

  Sale of equipment and chemical products to local industry including similar processes in its manufacturing line.

  Technical assistance and maintenance for third parties.

- Concerns for the service of tension relief, annealing and thermic treatments, and other similar ones.

Direct sale service to the common carbon steel, alloy and special steel industry.

- Technical assistance to the utilizer for the correct use of steel and its thermic treatments.

Sophisticated manufacturing processes which in one way or the other are specifically related to N5 and N6 level final products and with the manufacture of military equipment, would remain out of the context of this essay.

POL.5 - Precision and quality ranks

This is a peculiarity which may become so conditioning within productive world, that it should be closely observed and separated from other common aspects when striving for a multi-purpose formula. In fact, it is not convenient to gather product manufactures with excessively diverging characteristics as regards precision and quality. The homogeneity in the precision rank, for instance ISO 5, ISO 7, ISO 9-10, etc. and/or the static and dynamic qualities of its constituent parts, must be admitted as a solid criterion for choosing multi-purpose opportunities. This is a highly selective position; however it does not limit options to only a few cases. If the manufacture of a great V variety of cases with a certain stock of machine-tools in use is desired, they should be situated in the same or approximately the same precision and quality ranks. Otherwise the utilization of the machine-tools in use risks decreasing, thus making it too dispersive and expensive. In the field of metal-cutting machines itself, in hot and cold metal-forming machine-tools, in a vast series of alternate machines and motors, in boilermaking services (already mentioned in POL.1), in measuring and control devices, recorder instruments and laboratory apparatus as well as in various others, examples of homogeneity exist in this sense.

POL.5 initiates another series of common aspects and homogeneity criteria for constituting multi-purpose units, called RANKS (see Table 3). This indicates that whenever it becomes impossible, not clear or easy to look for a multi-purpose solution through the orientation of common factor EQUIPMENT, it is advisable to speculate according to RANKS.

Nevertheless, EQUIPMENT as well as RANKS and later on MISCELLANEOUS, do not present themselves as independent selections. With higher or lower intensity and according to actual cases, interactions exist between one group and the other and consequently between one POL and the other, as shown in Table 3.

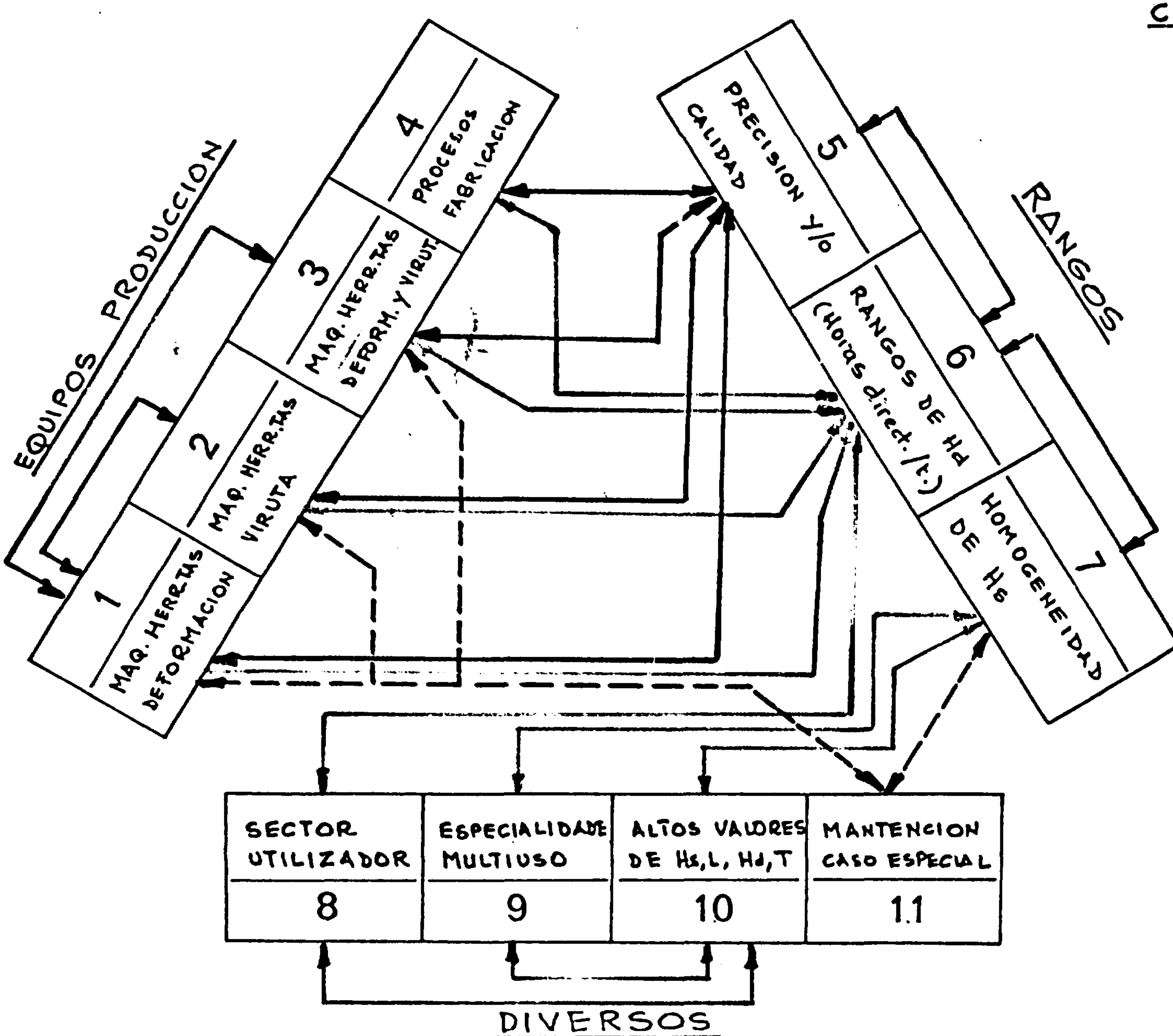
This table indicates only the main and easily recognizable directions of interaction. The real situation is much more complex. Here only a synthesis favoring a quick orientation for constituting POL concerns outside of what is contingent and absurd, was striven for.

POL.6 - Hd rank (direct hours per ton)

Hd rank is another interesting aspect for constituting multipurpose concerns. Although homogeneity does not guarantee in this sense an equally favorable performance of other sides of the problem, it should be considered as a first option when other solutions have taken multi-purposeness to gather excessively dispersive products in Hd or other ranks. Actually, it is a well-known fact how difficult it is to operate simultaneously products in small and medium series with Hd lower than 100 direct hours per ton and others with 800 or more. This lack of homogeneity may lead to further lacks, thus originating an excessively hybrid POL. When that occurs, the abnormal Hd strip should be restricted to a minimum percentage just as an exception in order that it may be acceptable.

INTERACCIONES ENTRE LOS ELEMENTOS COMUNES DE LAS EMPRESAS POLIVALENTES

CUADRO 3



At any rate this option implies exact notions on industrial production as well as occasionally rather confidential data. In that sense it is therefore less intuitive than the remainder.

An example will serve to clear out any doubts. Thus, while POL.5 condenses an idea of precision which may be applied to numerous metal-cutting machine-tools, Hd, for the same precision rank, may fluctuate from values of 400 up to 1.000-1.200 hours. Consequently, from the viewpoint of POL.6, at equal quality and/or precision ranks, two or three highly multi-purpose concerns may be conceived within the same sector. And should the final composition not result satisfactory, equally sophisticated machinery from other sectors could be added, which would be interpreted by **Hd** intensity.

POL.7 - Hs homogeneity (hours of project technical bureau per each 1.000 US$ of product)

While POL.5 and POL.6 showed ranks having direct implications on productive machine-tools in use or on some peculiarity of them, POL.7 emphasizes a fundamental characteristic for the development of multi-purpose units in the Third World. Considering that the multi-purpose solution annuls specialization and consequently the respective professional formation, it becomes essential to substitute it with what has here been summarily called **Hs homogeneity**. This consists in assuming that the element common to every product is an intelectual quality existing in the project bureau under the form of Hs and which is consequently extended to other qualifications in assembly, maintenance, technical assistance and sales.

In that case are included for example equipment having in common heat, cold, vibrations, vacuum, kinematics, electricity, optics and other physics general definitions. Therefore, should multi-purposeness relinquish strict speciality within the same physics discipline, as in the case of **refrigerating display counters in the discipline of "cold"**, it would not deviate from the search of other products having in **cold** their common denominator.

In fact, we think it inconceivable to accept multi-purposeness covering different physics disciplines with the excuse for instance, that an acceptable coincidence was found in the utilization of machine-tools in use.

In POL.7 it is clearly evident that it is not only a question of passively manufacturing products and launching them to the local or regional market. The work and responsibility of POLs are in practice wider and must cover technical assistance, know-how diffusion to the buyer for the equipment adequate utilization, as well as an efficient maintenance. It is therefore necessary that POLs show some industrial temperament, which may be attained through Hs homogeneity. In such case the aspect of speciality is maintained but at a rather macro-disciplinary level.

As a result, POL.7 will represents a well-succeeded interpretation of reality for under-developed EMIs, provided this is carried out according to the general disciplines already enunciated, and of course, provided the products technological level does not exceed N4.

With POL.7 the group of multi-purpose units composed from the concept RANKS is finished. Table 3 clearly shows its interactive bonds with groups EQUIPMENT and MISCELLANEOUS.

POL.8 - Homogeneous utilizer sector

POL.8 initiates a series of fairly varied criteria yet to be considered in order to form multi-purpose units. The common element in this case is the UTILIZER SECTOR. This constitutes an interesting POL structure for the Third World, slightly used by developed countries industries, which prefer to operate with more specialized units. Classical examples are bakery, confectioneries and other products, as well as those for service stations, agricultural tools (a subject considered separately in Chapter 3), food and drink machinery, and other cases of great variety of types and models of machines and equipment dedicated to a unique class of utilizers.

This reasoning implies concentrating into only one producing unit the manufacture of a number of specialities which in practice are usually fractionated among different concerns. In the case of bakery products for example, industrialized countries generally dispose of one concern specialized in electric ovens for bread, another in steam ovens with tubes, cyclo-thermic ovens, etc. There are also those specialized in kneaders, rollers, dryers, in biscuit production and so on, until attaining 20, 30 or more specialities. Now then, all such specialities have something in common: the raw material treated, namely flour, in addition to the utilizer. Gathering in well-projected unique producing units all that manufacture has demonstrated to be not only technically feasible but also income-producing in medium-size concerns. Argentina's and Brazil's experiences in that respect since the 1950's so prove it.

POL.8 thus constitutes another disciplined example of substitution of the **binomial series-speciality** for the **variety of types and models of small-series equipment.**

As always, this multi-purpose formula also loses something with regard to specialized structures. On one hand it follows technological progress at a certain distance, and on the other, it is hardly applied to products above N4. Obviously the first case is not alarming for the Third World or it becomes practically indifferent when the products have a very low innovation speed per year or per century, as it occurs with equipment for bakeries, biscuits, etc. The second one is less frequent due to the fact that N5 and N6 levels are technologically too advanced for underdeveloped world EMIs and for every collateral problematic therein involved.

<u>POL.9 - Multi-use specialities</u>

This definition identifies a fairly common situation existing in the industrial structure of industrially developed countries.

As a matter of fact, this formula is normally in operation for the manufacture of some components for which the production unit usually manufactures an extraordinarily large variety of types and models, in an effort to covering a major part of the speciality field. The purpose is to attain through it strategic industrial safety as well as to dilute R & D expenses among the largest number of possible applications.

Concerns manufacturing components for hydraulic, pneumatic, lubricating, control electric circuits, electric power circuits, kinematic components, etc., are typical examples of the above. In connexion with Third World solutions, one should not abandone the concept enunciated but should certainly find production compositions different from the usual ones. For instance, to reduce the variety for hydraulic circuits maintaining the manufacture of agricultural tractors and machinery (pumps, distributors, etc.) and general applications up to pressures of 70 kg/sq. cm.; to add dump truck, shock absorber productions - a speciality always separated from the rest - and eventually other frequently replaced parts.

In some respects, POL.9 complements and/or improves, depending on cases, the opportunities arising from POL.7 (Hs homogeneity), operating however in its own fields and with solutions of its own.

These POLs are directed toward a number of sectors and subsectors in developed EMIs, which implies manufacturing a great variety of types and models of products. Nevertheless this is necessarily reduced when POL.9 operates within a local or regional under-developed market. In other words, when EMIs do not exceed the 500,000 persons occupied or their machine-tools in use are of less than 300,000 units. In such cases the idea is redynamized when the variety composition of products manufactured in relation to what is customary in OCDE, is modified.

Under those circumstances, the above-mentioned POLs may hardly achieve the maximum technological levels recorded in industrialized countries even when working under licence. Their field of action, just as it occurs with POLs already considered in terms of N complexity, will undoubtedly remain below the maximum known for each speciality.

POL.10 - High values of Hs, L, Hd and industrial T

On maximizing the four factors included among those constituting Ic Index of complexity (see Chapter 6) as a common element, or if preferred, when considering them at very high levels, a based is obtained for approaching and solving numberless quite different problems due to the high technicality available. We are obviously referring to the conception and manufacture of complex and bulky capital goods.

This reasoning is possible and real in industrially developed world but it does not coincide with the possibilities and structures of yet under-developed EMIs, with the exception of a few countries having a especially privileged binomial surface-population.

Thus the present case is only mentioned by way of simple knowledge regarding the variety of cases which may exist in relation to multi-purpose productions. No further comments are therefore necessary.

POL.11 - The special case of maintenance

Leaving aside the small repetitive maintenance services for third parties as well as that of a craftmanship type, once structured as an authentic production unit, maintenance assumes characteristics proper of POL concerns.

In fact POL.11 presents itself under different aspects. It may either reveal itself as part of a POL already considered, or it may also stimulate the production of final capital goods once a certain maintenance line has been successful or has attained a significative volume. In the latter connexion it is often recognized as an industrialization alternative. To that effect POLs should even be constituted bearing in mind the subsequent passing from MAINTENANCE POL to another FINAL PRODUCT POL which might be situated among the first nine POLs. From medium and long-term viewpoints and as a previous step, in our opinion no important or systematic investments have been made. We think that when the ideas regarding the different technologically possible and economically feasible or only acceptable structures for constituting multi-purpose concerns have been cleared up, as it is partly the intention of this essay, the reasoning referring to **multi-purpose maintenance concerns** capable of originating at a second stage a final goods POL of N technological level above that of maintenance will automatically be favored.

Consequently, POL.11 is a special case. In order that it be wholly usable in Third World EMIs and in order that the maximum possible technological utilization be made out of it, it should then be considered not as a POL with aims in itself, but rather as an organized step for achieving its inclusion into the rank of a well-defined capital goods POL, without relinquishing on that account the multi-purpose maintenance services already attained.

One immediately recognizes some bond with POL.7, **Hs homogeneity**, as well as with not disorderly production machine-tools in use, which is related to POLs 1, 2 and 3. Maintenance should not undiscriminately consider the multi-purposeness of electric, together with mechanical, hydraulic, etc. materials, in addition to static and dynamic positions or those of standard size and very heavy ones. At any rate, some orientation is required, namely, the existence of some **common factors** already mentioned in previous POLs must also repeat itself here.

1.4 Considerations as a whole

Table 4 sums up the observations made in paragraph 2.2. Here the field of action of the eleven POLs in terms of S series is added, which is valid for final and intermediate capital goods and for action in the Third World.

A comparison follows - column 4 - among POLs positions in industrialized countries when they exist according to the above-mentioned specifications, and the positions extended or explorable especially for the Third World. (For A, B, C, see Chapter 6.)

This comparative synthesis will lead to finding out which is the adequate direction industrialization efforts must adopt in under-developed and developed countries when local and/or regional markets are insufficient. In other words, which are the real options presented against high specialization when - we repeat - complexity is limited to N4 level and the impossibility is recognized, at least for sometime, of being highly creative in terms of project and of not being able to dispose of the contribution of efficient laboratories.

Described in such more disciplined terms and separating POL solutions for the Third World from the sophisticated although restricted concept which would be surging in industrialized countries as a result of CNC evolution and of controlling a group of machine-tools directly through a computer, we think that POLs represent a really useful and advantageous field for the Third World. However, in order that this is materialized, conscience should be created at the most varied levels of industrial programmers, in the sense that economic and technological solutions exist, which differ from the "modus operandi" of industrialized countries. This action is extended to the manner of selling and buying know-how as well as to that of programming or guiding industrialization and financing it.

CARACTERISTICAS PRINCIPALES DE LAS UNIDADES POLIVALENTES PARA BIENES DE CAPITAL a/

CUADRO 4

POL Nº	1 Elemento común u homogéneo elegido para formar una POL	2 La POL se dirige hacia o consiste en:	3 b/ Las series S más comunes de las POL	4 c/ CAMPO ACTUACION DE LAS POL EN LOS: PAISES INDUSTR.	 PVD - PSD	5 d/ Los niveles de complejidad N PVD-PSD N1	 N2	 N3	 N4	 PI N5	 N6	6 Ejemplos de POL
1	Parque de máquinas-herramientas de deformación	los sectores diversos	b c d e	A - Poco → B - Poco → C - Regular	A - Bastante B - Regular C - Regular	x	x	x	x			Calderería - Estructuras metálicas
2	Parque de máquinas-herramientas con producción de viruta	los sectores diversos	b c d e	A - Poco → B - Poco → C - Regular	A - Mucho B - Regular C - Regular	x	x	x	x	x		Máquinas y componentes en general
3	Parque de máquinas-herramientas con producción de viruta y deformación	los sectores diversos	a b c d e	A - Poco → B - Poco → C - Regular	A - Mucho B - Regular C - Regular	x	x	x	x	x	x	Maquinaria y componentes electromecánicos en general
4	Proceso de fabricación	los utilizadores más diversos	b c d	A - B - Regular → C -	A - B - Bastante-Mucho C -	x	x	x				Galvanoplastia. Protecciones superficiales. Tratamientos térmicos
5	Rangos de precisión y/o calidad	los sectores más diversos	b c d	A - Muy poco → B - Muy poco → C - Regular →	A - Bastante B - Bastante C - Bastante		x	x	x			Instrumentos de medida y control. Elementos padronizados para estampar y para prensas de plástico
6	Rangos de Hd. horas directas de fabricación por tonelada de producto final	un sector con productos variados o para diversos sectores	a b c d	A - Poco → B - → C - Muy poco →	A - Bastante B - Poco C - Poco	x	x	x	x			Maquinaria
7	Homogeneidad de Hs. horas de oficina de proyecto por 1000 US$ de producto	utilizadores muy variados	c d	A - Muy poco y especializado → B - → C - →	A - Bastante B - Poco C - Bastante	x	x	x	x			Hornos. Equipos para tratamiento alimentos. Equipos para conservación de alimentos
8	Sector utilizador homogeneo	Equipos de producción muy variados	c d	A - Muy poco → B - C - Poco	A - Bastante B - C -		x	x	x			Maquinaria para panaderías y similares. Equipos para estaciones de servicio. Equipos para hospitales
9	Especialidades multiuso	los más diversos sectores	b c d	A - Poco B - C-Regular →	A - B - C - Bastante		x	x	x			Elementos p. circuitos hidráulicos, neumáticos, lubricación, vacío, eléctricos, electrónicos, ópticos, etc.
10	Altos valores de Hs, L, Hd y T	Sectores de tecnología de punta	d e	A - Regular B - Poco C - Regular	A - B - C -					x	x	Productos aeroespaciales
11	Mantención, caso especial	la mayoría de los sectores	c d e	A - Poco → B - C -	A - Bastante B - C -	x	x	x				

a/ Se refieren a una unidad de producción única. Se descartan entonces los casos donde diversas unidades de producción opere operen bajo una misma denominación social.
b/ Para el significado de a, b, c, d, e, ver col.(2) del Cuadro 1.
c/ A = Bien de capital final; B = referente a los servicios técnicos prestados por terceros; C = componentes (ver también Cap. 6). La flecha indica los casos donde puede incrementarse la polivalencia en los PSD y PVD.
d/ Hasta N4 son soluciones para PSD y PVD.

We should feel highly gratified if this essay would succeed in contributing to thinking on POLs in an orderly way, at the same time stimulating its operating conditions in the Third World.

The former reasonings will certainly be criticized by the technologists on one hand, and on the other by economists in relation to the production unitary cost, obviously increased as compared for example with the usual OCDE ones.

With reference to the first point, it should immediately be observed that the suggested POL formulas have a sound, non-artificial base, since in the end they derive from detailed practical observation of the Third World and OCDE industries in the last 35 years.

Practice will indicate that when a POL unit is saturated in its natural growth by T size or by V variety, it will always be able to separate from the group a part of its V variety in order to originate a less multi-purpose producing unit with some degree of specialization, thus attaining more operational agility. This has occurred with Brazilian and Argentine experiences. Thoroughly interpreted and studied, POLs should be able to repeat and diffuse themselves with equal success. It is therefore in this sense that efficient and industrially logic in time evolutions must be recognized to POLs, which would not be the case using disorderly and anarchic reasonings since the beginning.

In connexion with the products manufacturing costs, it is undeniable that they will not be able to match those existing in the industrially developed world. On summing up the effects of unit A with local and/or regional costs of semi-finished B1 and technical services B2, the final costs obtained will be higher. Although some curve of apprenticeship must be accepted, fluctuating from case to case, it must be recognized that POLs adequately fitted into the types mentioned also offer cost reduction advantages. Indirect services, technical as well as administrative, just as Hs and L reduction in relation to normal, constitute good reasons for reducing costs. To them the advantages of a lower manual labor cost may be added, obviously when not annulled by the larger number of direct hours of manufacture Hd used, as well as other advantages of a financial nature or of applied industrial policy. Considering that advantages as well as disadvantages are substantial, one should not assert beforehand that the proposed multi-purpose formulas would not at any rate be feasible without a high tariff protection, for instance of more than 50% over CIF prices. With the exception of very specific cases, generally speaking, the POL formula, adequately studied and composed as will be showed in the following chapter, must be acceptable starting from protections of 20%, maximum 25% over CIF prices. This on condition that it refers to capital goods with up to N4 technological complexity level, and also leaving aside in this connexion the production of uncommonly large-dimension concerns at present operating in the industrialized world, or any other dumping-type distortion which may be applied.

On the basis of the positions assumed here, a method for constituting POLs starting from vast industrial data may now be developed; such is the purpose of the following chapter.

Chapter 2

MULTI-PURPOSE UNITS COMPOSITION THROUGH THE VIDOSSICH SCALE OF TECHNOLOGICAL COMPLEXITY AND A SPECIAL PROGRAM FOR P.C.

For the above-mentioned objective the available material of the technological gathering indicated in op.cit.1/ is used, namely the programs in BASIC language of the Computer System of ANNEX C, together with the stock of industrial data composed of 500 Index of technological complexity forms, corresponding to as many electro-mechanical products which are also included in ANNEX C.

The Computer System indicated here is the same one used in op.cit. 1/:

APPLE III Computer, 256 Kbytes.
Hard-disk Profile 5 Mbytes.
Thermal printer Silentype.
APPLE Plotter, Model 410.
Dot-matrix printer 132 columns.

At a succeeding stage to be developed in the following 2-3 years, the data stock will be extended to 4,000-5,000 products, thus originating a program at present under way at UNIDO. Once the information basis is extended, the Computer System should also be correspondingly strengthened.

With the aim of favoring and accelerating the search of the best solutions for POLs according to the objectives established in Chapter 1, an specific program was created which was added to this essay, entitled: **PROGRAM 5 - SELECTION OF MULTI-PURPOSE INDUSTRIES.** This program is already adapted for operating from a data file including 4,000-5,000 products.

The program structure is described below.

The main MENU is composed of 6 points, namely:

1. PRIMARY SELECTION.
2. FINAL SELECTION/DEGREE OF COINCIDENCE
3. RETURN TO SELECTING.
4. LIST SELECTION.
5. END.

The basic goal of this MENU is to select concerns from a vast data stock in order to compose the best possible multi-purpose production unit among the most different options. The group of cases being analyzed may be extracted from PROGRAM 3 of op.cit. 1/, ANNEX C, or directly from PROGRAM 5, specifically prepared for this essay.

The aim of PROGRAM 5 is to compose in the first place the group of concerns being considered, carrying out then two composition - selection stages, (1) and (2), each one with different characteristics. The first one examines definite factors such as **N** products level, **Hs**, **Hd**, **P** and others, while the second one analyzes the coincidence of A3 production factors and of B1 and B2 infrastructure as well as semi-finished products and third parties' specialized technical services, that is to say, the majority of the industrial weave.

This is followed by the usual options RETURN TO SELECTING (3), LIST SELECTION (4) and END (5).

Let us now develop the most characteristics points of the MENU. **PRIMARY SELECTION** (1) is composed in its turn of the following MENU:

1. Select by code and Ic level.
2. Eliminate by A1, A2 and other characteristics.
3. Annul last modification.
4. Return to main MENU.

Once the listing of study (1) is composed, extracted from the file according to ISIC code and to **N** complexity level - a level which may only be equal or exceed the EMI local capacity within certain rules (op.cit. 1/, Vol.II, Chapter 8) - the elimination of concerns (forms) is undertaken, according to **A1**, **A2**, E.44, E.45 (quality controls) and **B** factors, which cannot and must not as expressed in Chapter 1, live together in the same project. That way products are homogenized according to **P**, weight of the same, to **Fp** and/or **Fm**, that is, looking for situations with lower evolution speed for example, etc. However, other filters may also be applied, precisely some of those pointed out as **common characteristics** in Tables 3 and 4, attempting compositions within the concepts of **POL.5 - Precision**, of **POL.6 - Hd**, **POL.7 - Hs**, or of **POL. 10.** Thus multi-purpose compositions may be configurated, approached in accordance with the general rules explained in Chapter 1. It may occur that such results be already satisfactory through this PRIMARY SELECTION. Nevertheless, it is also essential to know the degree of use coincidence of the productive machine-tools in use and of **B** infrastructure. With that objective point (2) of the main MENU is applied, namely, the **FINAL SELECTION/DEGREE OF COINCIDENCE.**

The previous step consists in eliminating every form using opening (6) in **A3** factors, which corresponds to **special machinery or equipment**, in more than two cases. For one or two cases instead, they are kept among multi-purpose listing, besides the answers with **Mx**, which in some way may admit productive alternatives. (See op.cit. 1/, Table 4.) The reason is obvious. Multi-purposeness is only achieved through a reasonable productive flexibility. Now then, **special machinery** is exactly the antithesis of flexibility; it should therefore be elimin·ted from the best composition foı multi-purpcseness, admitting the use of up to two cases.

Once overcome this filter, point (2) MENU appears with the following options:

1. **A3** - Metal-forming machine-tools.
2. **A3** -- Metal-cutting machine-tools.
3. **A3** - Other production equipment.
4. Every production equipment.
5. **B2** - Semi-finished products.
6. **B2** - Third parties' specialized technical services.
7. **B** - infrastructure (industrial weave).
8. Return to main MENU.

The group of **A3** production factors is subdivided into three more specialized fields, namely, metal-forming machine-tools from factor 14 up to 23, metal-cutting machine-tools from factor 24 up to 47, and finally other miscellaneous equipment from factor 48 up to 56, the latter corresponding to painting.

For each subgroup it is possible to know immediately:

a) The number of unused factors.

b) Total factors with **Mx**, **MD**, **MR**, **MW** (see op.cit. 1/, Chapter 5, Table 7).

c) Total theoretical observations including unused factors. It corresponds to factors Nr. x forms Nr.

d) Total theoretical observations related only to factors being used. It corresponds to Nr. of used factors x Nr. of forms.

e) Total of real observations.

f) DEGREE OF COINCIDENCE OF USED FACTORS related to (c).

f) DEGREE OF COINCIDENCE relative to (d).

PROGRAM 5 was not conceived with the aim of giving automatic answers to multi-purpose composition. It was preferred to show the links with an eventual preliminary project obtained through a possible and constant dialogue between the Computer System and the technologist.

The right-hand side of the data tabulation gathers under two additions, S1 and S2 (quantity and percentage), the use frequency of the machinery and equipment. S1 summarizes the use of universal manually-operated machinery and equipment (columns I1 and I2) and semi-automatics, represented by column I3. With such procedure it is recognized that certain passing flexibility exists between the universal and the semi-automatic, with a favorable result for one or the other producing method, according to the proper frequency or characteristic of each column or to other characteristics not revealed by Ic matrix.

S2 instead, refers to every automatic-cycle producing method, that is, with automatic rigidly-programmed machinery (I4), CN and CNC machinery (I5), and finally special machinery or equipment for mass production (I6). As it has already been noted, the latter appear in the tabulation only when used once or twice as a maximum in the group being examined.

Through the comparison between S1 and S2 the degree of productivity of each one of the three subgroups of A3 factors will be appreciated, whereas the horizontal observations will indicate the DEGREE OF USE COINCIDENCE of each factor in particular and therefore in which points or zones interest is largely concentrated.

Tables 5, 6 and 7 illustrate by way of example, the behavior of the three groups of factors constituting A3 when applied to the 23 cases (products forms) regarding **Machinery for civil construction** (Code 382.43) included in the 500 products stock of op.cit. 1/.

In that example, complexity was restricted to N3 and weight to opening (3), namely to P3, the rest of the openings being therefore eliminated.

Table 8 shows the summary of the three previous tables, that is, of every production means now considered as a whole.

The difference among the DEGREES OF COINCIDENCE of the three groups will thus be appreciated, comparing them with the total, in order to finally decide in favor of accepting the multipurpose listing or subsequent improvement attempts for attaining better coincidence results whether within a group or globally. The products deriving from successive selections and analyses should be easily listed.

The tabulation of data referring to B infrastructure or industrial weave differs somewhat from the former one.

In this case the results are subdivided into only the two groups already mentioned: B1 semi-finished products and B2 third parties' specialized technical services. Here we are especially interested in knowing the DEGREE OF CONCENTRATION by column, since each numbering (opening) from (1) to (6) precisely specifies the technological use level of the factors participating in the productive process.

In that manner the use frequencies of the different infrastructure technological levels are known thus making it possible to consider whether the offer is technologically adequate or not to the POL requirements. In the right-hand side of Tables 9, 10 and 11 the results are shown in percentages.

CONSTUCTION MACHINERY

SAMPLE DISTRIBUTION ACCORDING TO FACTORS INTENSITY metal forming machine tools

FAC	I0	I1	I2	I3	I4	I5	I6	FREQ	S1	S2	%S1	%S2
14	4		2	8	3			13	10	3	67	20
15	2	1	6	7				14	14		93	
16	2		7	7				14	14		93	
17	4		11					11	11		73	
18	12		3					3	3		20	
19	3		6	10	1	3		20	16	4	107	27
20	3		12	2				14	14		93	
21	8		2	5				7	7		47	
22	15											
23	7		2	6			1	9	8	1	53	7
tot	60	1	51	45	4	3	1	105	97	8	65%	5%

total coinciding no use factors :1
total factors with Mx,MD,MR, or MW :14
Total theoretical observations :150 DEGREE OF COINCIDENCE : 70 %
Total effective observations :135 DEGREE OF COINCIDENCE ON USE : 78 %

SAMPLE DISTRIBUTION ACCORDING TO FACTORS INTENSITY metal cutting machine tools

FAC	I0	I1	I2	I3	I4	I5	I6	FREQ	S1	S2	%S1	%S2
24			13	13	2		1	29	26	3	173	20
25	15											
26	10			5		1		6	5	1	33	7
27	13			2				2	2		13	
28	4		10	1				11	11		73	
29	12		1	2		1		4	3	1	20	7
30	2		10	7		1		18	17	1	113	7
31		1	11	10		2		24	22	2	147	13
32	1		9	8				17	17		113	
33	1		1	14		4		19	15	4	100	27
34	15											
35	2		11	3				14	14		93	
36	11			4				4	4		27	
37	11		2	2				4	4		27	
38	14			1				1	1		7	
39	4		9	3				12	12		80	
40	15											
41	15											
42	15											
43	15											
44	15											
45	15											
46	1		12	9				21	21		140	
47	11		3	1				4	4		27	
tot	217	1	92	85	2	9	1	190	173	12	62%	4%

total coinciding no use factors :8
total factors with Mx,MD,MR, or MW :45
Total theoretical observations :360 DEGREE OF COINCIDENCE : 53 %
Total effective observations :240 DEGREE OF COINCIDENCE ON USE : 79 %

CONSTRUCTION MACHINERY

TABLE 7

SAMPLE DISTRIBUTION ACCORDING TO FACTORS INTENSITY other production equipment

FAC	I0	I1	I2	I3	I4	I5	I6	FREQ	S1	S2	%S1	%S2
48			15	6				21	21		140	
49	15											
50	15											
51	15											
52	12			2	1			3	2	1	13	7
53	15											
54	15											
55	15											
56		10	4	2				16	16		107	
tot	102	10	19	10	1	0	0	40	39	1	75%	2%

total coinciding no use factors :6
total factors with Mx,MD,MR, or MW :7
Total theoretical observations :135 DEGREE OF COINCIDENCE : 30 %
Total effective observations : 45 DEGREE OF COINCIDENCE ON USE : 89 %

SAMPLE DISTRIBUTION ACCORDING TO FACTORS INTENSITY all production equipment

FAC	I0	I1	I2	I3	I4	I5	I6	FREQ	S1	S2	%S1	%S2
14	4		2	8	3			13	10	3	67	20
15	2	1	6	7				14	14		93	
16	2		7	7				14	14		93	
17	4		11					11	11		73	
18	12		3					3	3		20	
19	3		6	10	1	3		20	16	4	107	27
20	3		12	2				14	14		93	
21	8		2	5				7	7		47	
22	15											
23	7		2	6			1	9	8	1	53	7
24			13	13	2		1	29	26	3	173	20
25	15											
26	10			5		1		6	5	1	33	7
27	13			2				2	2		13	
28	4		10	1				11	11		73	
29	12		1	2		1		4	3	1	20	7
30	2		10	7		1		18	17	1	113	7
31		1	11	10		2		24	22	2	147	13
32	1		9	8				17	17		113	
33	1		1	14		4		19	15	4	100	27
34	15											
35	2		11	3				14	14		93	
36	11			4				4	4		27	
37	11		2	2				4	4		27	
38	14			1				1	1		7	
39	4		9	3				12	12		80	
40	15											
41	15											
42	15											
43	15											
44	15											
45	15											
46	1		12	9				21	21		140	
47	11		3	1				4	4		27	
48			15	6				21	21		140	
49	15											
50	15											
51	15											
52	12			2	1			3	2	1	13	7
53	15											
54	15											
55	15											
56		10	4	2				16	16		107	
tot	379	12	!!	!!'	7	12	2	335	314	21	64%	4%

total coincid'ng no use factors : 15
total factors with Mx,MD,MR, or MW : 66
Total theoretical observations : 645   DEGREE OF COINCIDENCE : 52 %
Total effective observations : 420   DEGREE OF COINCIDENCE ON USE : 80 %

CONSTRUCTION MACHINERY

TABLE 9

SAMPLE DISTRIBUTION ACCORDING TO FACTORS INTENSITY B1 : semifinished products

FAC	I0	I1	I2	I3	I4	I5	I6	FREQ	%I1	%I2	%I3	%I4	%I5	%I6
59	3		7	5	1			13		46	33	6		
60	5		7	3				10		46	20			
61	13			2				2			13			
62	15													
63	15													
64	15													
65	11		3	1				4		20	6			
66	11		3	2				5		20	13			
67	15													
68	15													
		0	20	13	1	0	0	34	0%	59%	38%	3%	0%	0%

total coinciding no use factors : 5
total factors with Mx, MD, MR, or MW : 2
Total theoretical observations : 150 DEGREE OF COINCIDENCE : 23 %
Total effective observations : 75 DEGREE OF COINCIDENCE ON USE : 45 %

CONSTRUCTION MACHINERY

TABLE 10

SAMPLE DISTRIBUTION ACCORDING TO FACTORS INTENSITY B2 :specialist's services

FAC	I0	I1	I2	I3	I4	I5	I6	FREQ	%I1	%I2	%I3	%I4	%I5	%I6
69	8		4	3				7		26	20			
70	4		7	4				11		46	26			
71	13	1	1					2	6	6				
72	3	3	9					12	20	60				
73	8		6	1				7		40	6			
74	12		2	1				3		13	6			
75	15													
76	10		4	1				5		26	6			
77	15													
78	15													
79	11		1	2	1			4		6	13	6		
80	11		4					4		26				
81	15													
82	14		1					1		6				
83	3	9	3					12	60	20				
		13	42	12	1	0	0	68	19%	62%	18%	1%	0%	0%

total coinciding no use factors :4

total factors with Mx,MD,MR, or MW :0

Total theoretical observations :225 DEGREE OF COINCIDENCE : 30 %

Total effective observations :165 DEGREE OF COINCIDENCE ON USE : 41 %

CONSTRUCTION MACHINERY

TABLE 11

SAMPLE DISTRIBUTION ACCORDING TO FACTORS INTENSITY B :infrastructure

FAC	I0	I1	I2	I3	I4	I5	I6	FREQ	%I1	%I2	%I3	%I4	%I5	%I6
59	3		7	5	1			13		46	33	6		
60	5		7	3				10		46	20			
61	13			2				2			13			
62	15													
63	15													
64	15													
65	11		3	1				4		20	6			
66	11		3	2				5		20	13			
67	15													
68	15													
69	8		4	3				7		26	20			
70	4		7	4				11		46	26			
71	13	1	1					2	6	6				
72	3	3	9					12	20	60				
73	8		6	1				7		40	6			
74	12		2	1				3		13	6			
75	15													
76	10		4	1				5		26	6			
77	15													
78	15													
79	11		1	2	1			4		6	13	6		
80	11		4					4		26				
81	15													
82	14		1					1		6				
83	3	9	3					12	60	20				
		13	62	25	2	0	0	102	13%	61%	25%	2%	0%	0%

total coinciding no use factors :9
total factors with Mx,MD,MR, or MW :2
Total theoretical observations :375 DEGREE OF COINCIDENCE : 27 %
Total effective observations :240 DEGREE OF COINCIDENCE ON USE : 43 %

In the lower part of the tables indicated the main reference data appear, together with both DEGREES OF COINCIDENCE, one theoretical regarding every possible observations, and another practical related only to the factors used.

The knowledge of the infrastructure of industrial weave degree of dependence is extremely important either for accepting or not the products composition selected, or for learning what happens with a group of projects, whether or not multi-purpose.

At the end of speculations on A3 and B, including the various attempts for obtaining better results, it is advisable to make the list of products subject to multi-purposeness. Therefrom, according to cases, other practical incompatibility considerations may be derived in connexion with Hs, with the purchase of designs, the living-together of licenses or other aspects.

Once the data stock duly extended from the present insufficient 500 products-cases, PROGRAM 5 will become a powerful instrument which will first prove useful as a guide for selecting among hundreds of thousands of definite data, and then as a decision-making instrument for the preparation of preliminary projects or industrial profiles.

Undoubtedly the DEGREES OF COINCIDENCE in A3 and B are desirable in their maximum expression but it would in no way be convenient that they represented a unique or prevailing position in order to compose multi-purpose units, as one usually thinks.

We insist on recommending that before accepting any result, various ways should searched, respecting the eleven POL cases here identified. The wider the adequate participation of different common elements, the better such results. PROGRAM 5 should not be considered as an automatic selector but rather as an instrument for more vast and refined analyses, thus favoring an important feedback between the latter and the interested party. This one's profile is preferably identified with the technologist's or the industrial engineer's who experiments a first composition of the producing unit. Later on other professionals should follow who usually participate in the preparation of preliminary projects and projects of economic feasibility.

The example included in this chapter is extracted from Code 382.43, **machinery and equipment related to civil construction.** They are 24 forms, from 382.43.01 to 382.43.24, of which a first elimination in terms of N levels is made, excluding those above N4, and another related to the weight of products which should not be higher than opening (3). From such 23 product-forms, A3 cases with opening (6), special machines, are eliminated, remaining 15 products, as indicated in Table 12. The example is not conclusive; it only served to show the calculus mechanics, leaving for Chapter 3 more practical speculations of PROGRAM 5.

At any rate, the example is useful for indicating the first step of POLs composition which is, we think, the most complex and the one implying a greater degree of indecision. It will always be difficult to find a perfect composition dividing among others a uniform occupation of the productive machine-tools in use during one work shift. The work posts resulting with a load of more than one shift generally do not present major problems. Those with a lower load instead, should be saturated with work for third parties, that is, other specialized or multi-purpose industries, especially for maintenance, should this side of the problem not have been considered previously in a separate way.

CONSTRUCTION MACHINERY - ONLY AN EXAMPLE FOR CALCULUS MECHANICS

TABLE 12

	CODE	DENOMINATION
1.-	382.43.02	Plantas moviles de trituracion primaria, secundaria y clasificacion, hasta 40 t, de peso propio
2.-	382.43.03	Trituradora conica hasta 300 m3/h
3.-	382.43.04	Plantas asfalticas gravimetricas hasta 150 t/h.
4.-	382.43.05	Planta de suelos hasta 100 t/h.
5.-	382.43.06	Plantas hormigoneras, tipo fijo
6.-	382.43.07	Camiones-betoneras
7.-	382.43.08	Silos de espera para hormigon con agitacion, mesas vibratorias, transportadores de aire comprimido y tuberia para hormigon.
8.-	382.43.09	Bombas de hormigon, bombas de arena.
9.-	382.43.10	Gruas sobre rieles y fijas para la construccion civil.
10.-	382.43.12	Carrocerias corrientes para camiones y especiales tipo " bottom dump "
11.	382.43.13	Algunos equipos mecanicos para plantas de ladrillos: mezcladores secadores, prensas conformadoras, hornos.
12.-	382.43.16	Distribuidor de asfalto sobre chassis, capacidad hasta 10.000 litros.
13.	382.43.20	Vibroterminadora de asfalto.
14.-	382.43.23	Carrito de mano para obra.
15.-	382.43.24	Montacargas para obras, sencillo

	CODIGO	DENOMINACION - EXAMPLE
1.	382.43.01	Plantas de trituracion completa, tipos fijos y desmontables.
2.-	382.43.02	Plantas moviles de trituracion primaria, secundaria y clasificacion, hasta 40 t. de peso propio
3.-	382.43.03	Trituradora conica hasta 300 m3/h
4.-	382.43.04	Plantas asfalticas gravimetricas hasta 150 t/h.
5.-	382.43.05	Planta de suelos hasta 100 t/h.
6.-	382.43.06	Plantas hormigoneras, tipo fijo
7.-	382.43.07	Camiones-betoneras
8.-	382.43.08	Silos de espera para hormigon con agitacion, mesas vibratorias, transportadores de aire comprimido y tuberia para hormigon.
9.-	382.43.09	Bombas de hormigon, bombas de arena.
10.-	382.43.10	Gruas sobre rieles y fijas para la construccion civil.
11.-	382.43.11	Gruas hidraulicas para camiones. Dispositivos hidraulicos para volteo de tolvas.
12.-	382.43.12	Carrocerias corrientes para camiones y especiales tipo " bottom dump "
13.-	382.43.13	Algunos equipos mecanicos para plantas de ladrillos: mezcladores secadores, prensas conformadoras, hornos.
14.-	382.43.14	Rodillos compactadores vibratorios, traccionados.
15.-	382.43.15	Ascensores para personal de obra
16.-	382.43.16	Distribuidor de asfalto sobre chassis, capacidad hasta 10.000 litros.
17.	382.43.17	Motoniveladoras hasta 15 ton de peso propio
18.-	382.43.18	Trailas en tandem, rebocadas.
19.-	382.43.19	Cargadora - retroexcavadora, peso propio hasta 10 t.
20.-	382.43.20	Vibroterminadora de asfalto.
21.-	382.43.21	Distribuidores, cilindros y afines para circuitos hidraulicos de maquinas viales.
22.-	382.43.22	Horno para cemento - sin equipo de acompanamiento.
23.-	382.43.23	Carrito de mano para obra.
24.-	382.43.24	Montacargas para obr s, sencillo

Chapter 3

MULTI-PURPOSE PRODUCTION APPLIED TO A SPECIFIC INDUSTRIAL SECTOR: AGRICULTURAL MACHINERY

3.1 The structure of ideas

Suffice it to know what ONUDI itself has published by means of various experts on agricultural material, beginning with the first consultation of STRESA on October 1979, to realize the effective contribution the Ic methodology may provide when a practical solution is being searched for multi-purpose production of equipment referred to a specific sector.

The work more directly connected with it and which in some way contains an embryo of Ic, is the "Etude mondiale sur l'industrie du machinisme agricole", 3/ precisely in Chapter III, parts A and B. The four types of complexity which have served for classifying agricultural equipment reasonably coincide with levels N1, N2, N3 and N4 of the Ic methodology. However, the fact of Ic including 103 factors with 6 progressive use intensities in order to constitute the Ic matrix of a product, makes it obviously possible to carry out more refined analyses and speculations in the search of adequate productive solutions for the Third World in the field of local production of agricultural machinery.

But before doing so, the technical context to which we adhere for formulating the work hypotheses and practical recommendations farther on presented, should be determined. This is based upon concepts such as **"the rupture of the exclusive dominating force of the heavy-traction model"** according to **"combined mechanization policies",3/** the **"existence of promotion conditions for the machines and of the techniques corresponding to such new methods of mechanization".3/** The concept of restudy and redesign of a number of agricultural equipment manufactured in OCDE with a view to increasing the possibilities of its production by Third World countries

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3/ UNIDO/ICIS.119. 29th June 1979.

with more problematics in this respect is also added, reducing its technological complexity to that effect. In this last case we refer to the excellent approach of Maurice Ogier undertaken for ONUDI, 4/ without accepting nevertheless that excessive simplifications be completely transferred to redesigning new products conceptions, capable of absorbing each and everyone of the operational deficiencies found in some countries with further relative backwardness, including aspects which fall outside the proper technique.

Thus, if on one side it is useful and essential to maintain the use of highly traditional agricultural equipment or to redesign, simplifying it, more advanced equipment, one should not forget to liberate a series of parallel actions for improving within a period of 10-15 years for example, the distribution and maintenance of products, the administration of spare parts and pieces, the organization of stocks of adequate raw materials, adapting manual labor formation and that of technicians, to productive schemes, modest but correctly dimensioned.

In other words, the development of this chapter cannot make abstraction of one of the main conclusions of the Second Consultation, 5/ which recognises that "the agricultural machinery industry cannot be considered isolatedly, that is, independently and outside of development and therefore outside of the problems affecting EMIs as a whole". We agree without hesitation with that approach since it is global at the same time as realistic; the ideas developed in 1/ provide a solid and vast support to this way of thinking.

Once the fundamental positions have been determined, upon which we are based, let us now deal with other complementary

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4/ "Problématique de la conception des matériels agricoles et ruraux fabriqués localement en Afrique". CINAM, Sept. 1982, and also "Le développement des capacités africaines de conception et de fabrication des équipements agricoles prioritaires". Une approche basée sur les réalités africaines.

5/ "Deuxième Consultation sur l'Industrie des Machines Agricoles". Vienne, 17-26 octobre 1983.

aspects before considering local production of agricultural machinery in a multi-purpose manner.

Upon specifically assigning to this problem the convenience of "ad hoc" conceptions, that is, of simplification of projects for the Third World, we are implicitly recognising an "ad hoc" conception for producing such capital goods.

The multi-purpose production way is being considered in this sector for adapting to market and redesign conditions of the products, while in industrial productivity terms, manufacturing overtimes should be accepted as regards OCDE production, whenever products be comparable.

An adequate customs protection, obviously variable according to the incidence of the transport cost, may be applicable, in our opinion starting from a 15% of CIF values, without any need of arriving to protections above the 50%. With the exception of manual tools, in the majority of the remaining equipment, either by weight or by volume, the increase between manufacturer FOB to CIF is such, that it favors by itself its manufacture in Third World countries.

Therefore, the multi-purpose production way results particularly attractive to a great majority of products.

Practically many sector products fit in technological levels N2-N3, this in numerical terms. As regards value terms instead, the equipment offered by OCDE is distributed rather between N3 and N4. Here it is worthwhile remembering that tractors level is N4.

Now then, quite a number of the sector products may be effectively redesigned and redirected to lower complexity levels, such as for instance from N4 to N3, from N3 to N2, and from N2 to N1.

Leaping two levels at a time seems rather forced, hardly advisable and occasional, at least when it occurs according to the concepts adopted in op.cit.1/, as explained below.

Therein the idea is developed that capital goods production in the Third World has only a sense if the formula A+B = LOCAL/REGIONAL (see Chapter 1) is accepted, namely, when B1 and B2 structure results LOCAL/REGIONAL, if not wholly at least in a high degree. When already known products with a high operative efficiency are redesigned or adapted, the contribution of B must be considered with the utmost seriousness. In fact, it would be unconceivable to divulge the industrialization of machinery according to national/regional aggregate values extremely reduced due to B, all the more when in general raw material imports (sheets, plates, profiles, bars, tubes, etc.) and those of specialized components, must be assumed to be normal. On the other hand, when redesigning or adapting known products, one must not forget the sound principle that to each structural simplification or that of the locally manufacturable part the same simplification must correspond when selecting the components added to the product. As a matter of fact, it would lead to nothing if the latter remained at a high sophistication level because that would involve high maintenance expenditures, a sustained paralization in the product use in case of slight damage, initial, unacceptable pressures on manual labor formation, and lastly, a significative reduction of local Va due to components.

When mentioning components, a crucial problem is raised if among them are included as such, alternate, gasoline and diesel motors. In various cases the driving source represents an important fraction of the equipment value, rather too important. It becomes then necessary to reconsider this problem first under a more global aspect, and then specifically for the local reproduction of such goods, which besides have usually other applications. From this viewpoint, the idea of motors conceived in a modular way (diameter, cylinder, liner, piston, rings, etc.) undoubtedly stands out.

In other words, starting from one cylinder, other compositions may be obtained, up to 6 cylinders in line, for instance.

Modulation in terms of cylinders and the corresponding standardization (more easily attainable) of energies, applied to programs common to large consuming regions, would lower down a lot of the sector products from their present N4 and N3 levels, to N3 and N2 levels respectively. Under this formula redesigned motors for tractors might also be included.

Through such a reasoning the best thermo-mechanic efficiency achieved by means of more compact and traditional motors would certainly not be obtained. The differences could however be acceptable, especially due to the fact that other advantages arise as regards maintenance, stocks of spare parts, costs, etc., together with a fairly increased local Va.

Some attemps are already underway in this respect. It would be advisable to add one or two more in order to settle in this manner a large mass of simplifying ideas, as necessary as the urgency of increasing capital goods production in the Third World.

This subject shows that to raise the production of agricultural machinery in under-developed countries without dealing with and solving this drive aspect, has no sense. Even when over-powered and sophisticated agricultural productive models which are not applicable in the areas of the countries here included were demystifyed, one cannot make abstraction however of a minimum use of alternate motors, be them stationary (in fixed facilities) or applied to movable machinery. In this manner, regardless of their higher or lower use intensity, such a reasoning should be enough to interest a large number of countries in order to hold regional meetings for establishing mutual support or complementary programs toward the industrialization of final goods and of assemblies of

B1 and B2 infrastructures. Agricultural machinery, its basic and elemental power source, as well as B1 and B2 basic industrial weave by it required, might be one of the three initial driving forces of the diffusion or the improvement of EMIs in the southern hemisphere. The other two sectors might be constituted by ordinary machinery used in civil construction and by metallic goods for housing and unsophisticated durable consumer goods. Once more then, the need is recognized of fitting this sector development, although incipient, within the EMI considered as a whole.

As a result of this extended premise, the question arises: how to insert then multi-purpose concerns and in which way? This is the subject of the following paragraph.

3.2 The production of agricultural equipment and multi-purpose concerns

PROGRAM 5 would be in a position to give conclusive and precise answers if the Ic forms of various hundreds of products were available; in other words, if the Ic, Index of complexity of a vast sample of the universe of the world offer of equipment and facilities were known. We think that sample should fluctuate between 400 and 500 forms.

With the objective of guiding this selection, we think it advisable to take as a basis the work prepared for ONUDI by the author of this essay, entitled "Agricultural Machinery".[6/]

The material herein referred to implicitly corresponds to the one considered in the work above-mentioned, composed of three large groups, namely:

A) Equipment for preparing, sowing and harvesting (field equipment).

B) Equipment for farms.

C) Miscellaneous equipment.

6/ "Universo determinado en base al material presentado al Salón Internacional de la Maquinaria Agrícola". SIMA, Paris, March 1981.

Each of those groups is divided in its turn into the following subgroups:

A) Equipment for preparing, sowing and harvesting:

A1 - Tractors.

A2 - Equipment for tilling the soil.

A3 - Equipment for sowing, planting, fertilizing.

A4 - Pesticide equipment.

A5 - Harvest machinery.

A6 - Transport equipment and maintenance movable machines.

A7 - Accessories for miscellaneous machines.

B) Equipment for farms:

B1 - Miscellaneous equipment for farms and workshops.

B2 - Motors and motor blocks.

B3 - Viticultural equipment.

B4 - Machines for milking and for milk products.

B5 - Animal production equipment.

B6 - Equipment for preparing fodder.

B7 - Fixed maintenance equipment.

B8 - Stocking, drying and dehydration equipment.

B9 - Machines for harvesting, selecting and conditioning (seed, fruits, vegetables).

C) Miscellaneous equipment:

C1 - Rural and breeding structures.

C2 - Hydraulic equipment (irrigation and pumps).

C3 - Greenhouses and plastic in agriculture.

C4 - Forestry and nature conservation material.

C5 - Equipment for exploitation and conservation of agricultural soil.

Each group gathers different specialities of which 319 had been selected for ONUDI work 6/. A new subdivision should be carried out with the participation of experts on the field, in order to select 400-500 highly representative products for the aims pursued in this essay; it is worthwhile remembering here that such aims are not strictly limited to the needs of countries with lower relative development.

It should be possible to adapt the methodology to inferior cases as well as to those countries with a large binomial surface-population, at present being developed. Simultaneously, it would be advisable that experts could manage to distribute the 400-500 products included in the sample of the world offer in accordance with the degree of agricultural development of the countries. In other words, it is a question of establishing a pattern-list or type-pattern representing two, three, even four stages of agricultural development, better defined by specialists, imitating N technological levels related to electro-mechanical products.

Now then, once the technological Ic of every one of the products connected with each agricultural development stage is known, the profiles could be analyzed which could be proposed with great precision, of the multi-purpose workshops best adapted to each development case, using for that purpose either the recommendations at EMI level of op.cit.1/, or this essay methodology for the composition of multi-purpose concerns.

As a matter of fact, each development stage may be perfectly associated to the use of machinery and tools of an specific technological level. On separating the corresponding Ic forms, that is, once rejected the products with N complexity above local possibilities, a listing of products would be obtained from which the most adequate multi-purpose solution or solutions would be analyzed.

The variety of products used in each agricultural development stage will increase together with such development, simultaneously with their technological level (higher capitalization per hectare tilled). Multi-purpose manufacture solutions will therefore be different, according to each case.

Thus it remains clearly established that in **multi-purposeness** one should not look for miraculous solutions. This will have a real sense only and when coherent and technologically feasible multi-purposeness is composed within the context of local EMI, which means linking the level of action of multi-purposeness in terms of N to the maximum N level in which EMI may operate, always respecting the formula A+B = LOCAL/REGIONAL.

Trying to go around such rule, which is a bond, accepting only assembly **multi-purposeness**, or with excess of assembly, would escape any sound objective of industrializing Third World countries.

With this extensive premise as a basis, let us now take by way of specific sectorial example, agricultural equipment and machinery included among the 500 Ic forms (products) composing ANNEX B of op.cit.1/.

33 products or Ic forms were considered for group A
11 products or Ic forms were considered for group B
13 products were considered for group C,
making a total of
57 products.

This is a group which is not representative enough of the variety of machines and equipment used by the sector, nor of the distribution within the N levels of the world offer. Also the products which once redesigned would pass from N3 to N2 or from N4 to N3 or even up to N2, are not represented here either.

The distribution of the 57 products according to N is shown in Graph 1, while ANNEX 1 contains the listing of such products.

In this way the 57 cases of gathering 1/ will be used only for indicating the production technological variety affecting quite a number of agricultural equipment and machinery, as well as for serving as an exercise in the application of PROGRAM 5.

In the upper part of Table 13 the **pattern-profiles** of the more feasible POL combinations are shown. Following is indicated how

Graph 1

DISTRIBUTION BY COMPLEXITY LEVELS

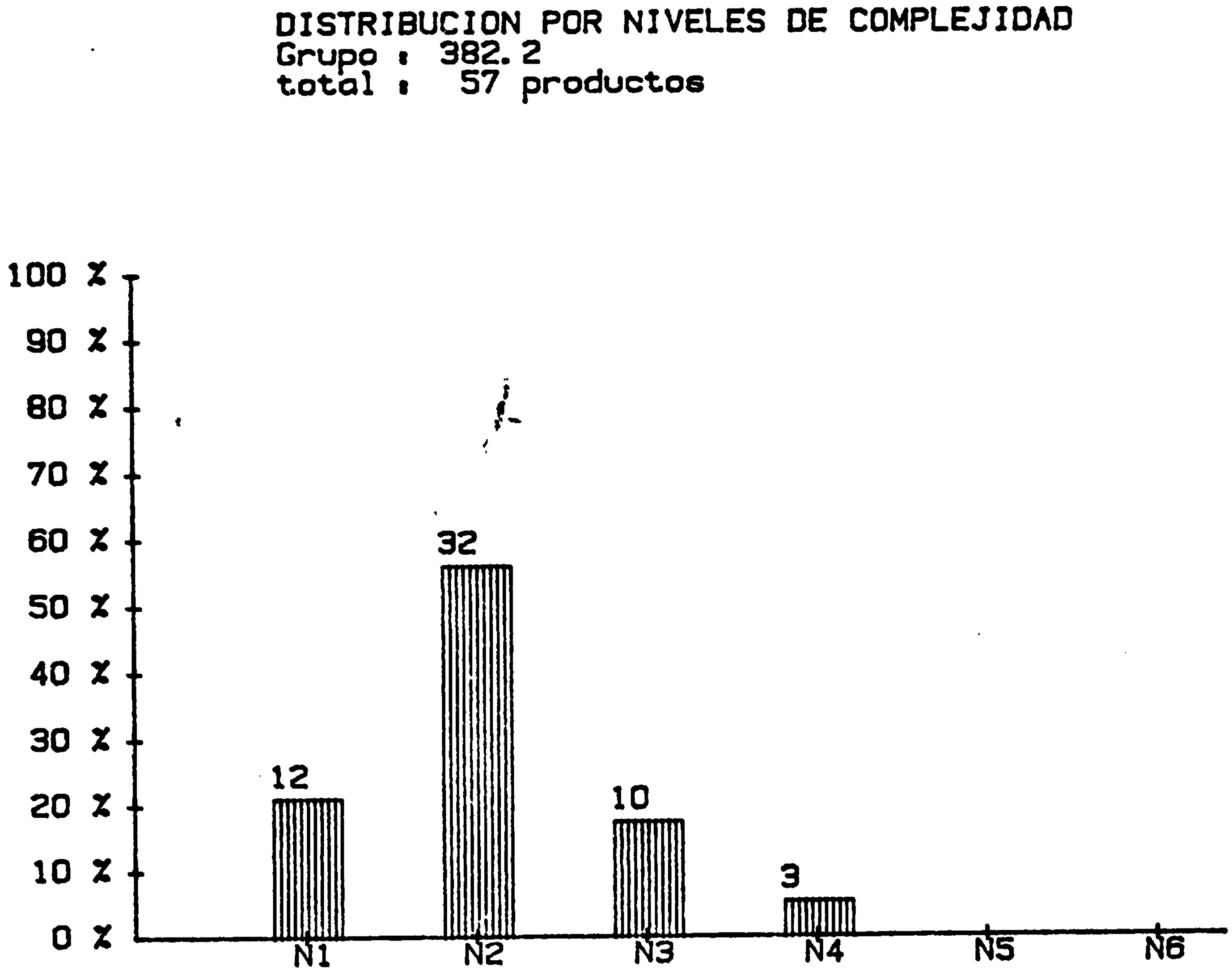

Table 13

AGRICULTURAL MACHINERY

The possible ways for constituting multi-purpose concerns from POL.8 type

Denomination	N1	N2	N3	N4	N5	N6
Nr. of products selected and available in Ic forms: 400-500 Distribution according to levels	?	?	?	?	2/3 cases	—
Multi-purposeness based on POL.1, by level	Little	Little				
Multi-purposeness based on POL.2, by level		Regular	x			
Multi-purposeness based on POL.3, by level		x	x	x		
(N1+N2) multi-purposeness and POLs 1, 2, 3	←——	——→				
(N2+N3) multi-purposeness and POLs 1, or 2 or 3		←——	——→			
(N3+N4) multi-purposeness and POLs 2 or 3			←——	——→		
THE BEST SOLUTIONS:						
a) When EMI is embryonic						
b) When EMI operates at N2 level						
c) When EMI operates or starts at N3						
d) When EMI operates or starts at N4						
e) When EMI normally operates at N4						
EXAMPLES OF THE 57-PRODUCT SAMPLE:						
382.2 without opening (6) in A3 - ANNEXES 2, 3, 4.						
382.2 for (N1+N2) and POL.3 - ANNEX 5.						
382.2 for (N2+N3) and POL.3 - ANNEX 6.						
382.2 for (N3+N4) and POL.3 - ANNEX 7.						

the best solutions vary in function of the degree of EMI development expressed in N levels.

The pattern-profiles for the sector are practically six. The first three are variants related to the productive machine-tools in use and are homogeneous as regards N complexity level. These latter though are rather theoretical since for being effective they require a vast and varied market, conditions essential for feeding a really multi-purpose concern at a unique N level.

When the market is very restricted as in the majority of cases instead, it is advisable to look for other solutions.

The most efficient is then to operate POL.8 covering two neighboring N complexity levels, for instance (N1+N2), (N2+N3) or (N3+N4), thus constituting other three solutions, as indicated in Table 13. These combinations are obviously more easily divulged and more multi-purpose than the former ones because they cover two N levels instead of only one. For practical operational reasons and for a minimum industrial realism, multi-purposeness at three N levels within the same concern would in no way be defensible. The lack of any type of homogeneity from manual labor, processes, values per ton, Hd, Hs and others, does not justify the manufacture under the same roof of products of such different structure. In such case multi-purposeness would get out of touch with some discipline (Chapter 1) to become rather anarchic. And should the sector serve as an incentive for others, it would constitute an extremely bad productive example.

Since the effort of passing from an N level to the successive is exponential (see cp.cit. 1/, Chapter 8), it is not advisable to force toward other solutions than the three last mentioned. It is on the basis of them that the best solutions will be suggested for the sector - always starting from the POL.8 basis - according to the EMI development, the inseparable context of reference of any reasoning to be put forward. Such solutions are schematized in Table 13, in five compositions from (a) to (e), which accompany in its progression the development of EM1 and of the local/regional market of agricultural machinery, and consequently, the degree of development of the agricultural sector.

The most elemental solution (a), is related only to products N1. If even with multi-purposeness it is not possible to feed a small concern, multi-purposeness should be increased outside POL.8, adding other sectors (represented in Table 13 by an arrow).

Solution (b) instead, has already more possibilities of remaining in POL.8 and of forming a well-structured production unit.

Configuration (c) is situated on what we have already commented when limiting multi-purposeness exclusively to two N levels, leaving aside N1 in this case, since POL (N2+N3) is undoubtedly more attractive than (N1+N2).

Solution (d) is a natural consequence of the possible structures analyzed; it should however be observed that behind POL (N3+N4) there may be an interest in further degrees of specialization in N1 and N2, capable of compromising POL (N1+N2) solution due for example to higher production series.

As a variant, structure (e) is illustrated. This maintains POL in central complexities N2 and N3, while N1 and N4 extremes would be fed rather by specialized units.

To sum up one might say in general that (a), (b) and (c) represent by far the three schemes worthwhile being diffused in the majority of the Third World, while the two following would be reserved to a very limited number of countries which would withdraw besides from POL solutions as time passes.

Should POLs (a), (b) and (c) not result feasible according to sectorial approach POL.8, other products with the same N level proceeding from other sectors should be searched through PROGRAM 5. In that case POL.8 loss of homogeneity should be compensated with good coincidence results in POLs 1, 2 and 3, and an acceptable homogeneity in ranks POL.5 and 6, avoiding distorsions and artificiality in Hs (POL.7).

ANNEXES 2, 3 and 4 are added rather as an exercise than as a practical example, in order to illustrate multi-purposeness derived from the data stock of 500 products of op.cit.1/ (ANNEXES B), corresponding to level N1, N2 and N3 products respectively. To them ANNEXES 5, 6 and 7 regarding multi-level POLs, are also added.

From the ANNEXES above-mentioned multiple numerical speculations, comparisons, etc. may be extracted. As this is only an exercise, it is not advisable to fall into the temptation of making definite comments, which will only be possible when the sample of 400-500 products representing a very wide range be available, as already indicated; one of real interest for countries of relative development, under-developed and developing ones.

When observing the different degrees of coincidence of the exercise it will be appreciated that it should not be difficult to find combinations for metal-forming and metal-cutting machine-tools with coverings between 80% and 90%, while for "other equipment" lower values will be found, which would not greatly affect adequate solutions.

The degree of coincidence in B1 indicates the pressure existing over semi-finished products. This result must be analyzed vertically, column by column, in order to know the degree of coincidence within a technological level itself, that is, whether this is (1), (2), (3) or more. For instance, in case the product is an N2 level but requires openings (3) or (4) in one or more factors of B1 as well as of B2, this will simply mean that it cannot be manufactured by local infrastructure which, when properly dimensioned and supplied, will only attain the technologies foreseen for opening (2) of every factor. Under such circumstances, either finished parts are imported, or they are imported in the rough and are mechanized locally, or finally, the product is abandoned. Nevertheless, before rejecting a product or before importing parts which are an attribute of the production unit, it is worthwhile finding out, at equal functions, whether the possibility exists of simplifying the dependence of B1 and B2.

This argument must also guide, "mutatis mutandi", the technologist in his search toward constituting a productive machine-tool stock in use, on the basis of synthesis data obtained by means of PROGRAM 5. (In this respect see also Table 14.) The proportion of S1 compared to S2 indicates greater or smaller production flexibility and degree of capitalization of POL. The technical possibility of passing from S2 to S1 by reducing the complexity of the production equipment, and the heavy manufacturing infrastructure which always goes along with S2, should be permanently looked for. PROGRAM 5 will catch the magnitude of the problem at each POI attempt, indicating which are the most flexible factors.

Column (5) is situated in S2 and it represents production goods with CN, CNC and the like, for A3 factors. Contrary to various experts' opinion, who are favorable to a systematic application of CN or CNC or at any rate an application wholly imitative of the productive trends of industrialized countries, we prefer more cautious positions, maintaining the same approach expressed at the Moscow Symposium on machine-tools organized by United Nations. 7/ In other terms, one should bear in mind not only the productivity differential between OCDE and under-developed or developing countries, but also its relationship with the technological complexity of the product. Generally speaking, CN is not economically justified in N1 and N2 products manufactured in units or in low-productivity EMIs, for example between US$ 8,000 and 15,000 per person occupied per year. And to these, numerous N3 capital goods might

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7/ "Simposio Interregional sobre el Desarrollo de las Industrias del Metal (Máquinas-Herramientas) en los Países en Desarrollo". Moscow, 7 Sept.-6 Oct., 1966. Organized by United Nations.

Table 14

AGRICULTURAL MACHINERY
Exercise with PROGRAM 5 a/

Nr. cases	Products	MF MTb/	MC MTc/	O MTd/	A P Ee/	B1	B2	B	S1f/	S2g/
8	N1 level	67	44	38	51	22	45	36	46	4
27	N2 level	65	58	34	55	25	45	38	45	6
7	N3 level	87	77	60	77	31	60	51	58	9
35	(N1+N2) level	63	50	26	48	20	38	31	40	5
34	(N2+N3) level	64	58	28	53	22	45	37	43	6
8	(N3+N4) level	90	71	63	75	38	65	56	55	11

a/ Degree of use coincidence.

b/ Metal-Forming Machine-Tools.

c/ Metal-cutting Machine-Tools.

d/ Other Machine-Tools.

e/ All Production Equipment.

f/ Universal or semi-autcmatic Production Equipment.

g/ Automatic Production Equipment (continued or discontinuous cycle).

be added. Every yet young EMI operating within the first work generation (25-30 years) hardly disposes of producing units with important or sufficient critic mass. Under such condi ns, the introduction of highly productive or sophisticated technologies should be postponed, at least until attaining sufficient indirect structures in order to guarantee the adequate operation and use of CN and the like, without this constituting in itself a position of abandonement or one retrogressive in respect of development. Suffice it to remember which were the user's industrial dimension and the products N level to which CN was applied in its first years of diffusion in industrialized countries.

Thus, just as a fundamental interest exists for redesigning products in order to reduce their technological complexity, the ability must also exist and in a parallel way, for redirecting S2 technology toward S1, emphasizing as much as possible semi-automatic production technologies, within which it is worthwhile remembering, is included the read-out with its variants (S1, column 3).

Anyway, although it is true that each sector includes specific technological problems, it's not in vain to remember that the production of agricultural machinery is a part of the context of EMI and as such it influences and is influenced on its turn. The lower the level of EMI, the lower will be N level of manufactured products, at the same time that the greater will result the influence on the manner of producing other simple but basic capital goods. On the contrary, the higher the level of EMI, the better the sector will profit technologically by the improvement of the others.

The first aspect is fundamental for quite a number of countries with lower relative development and assigns a great responsibility on how to take advantage of PROGRAM 5 to compose N1 and N2 multi-purpose units.

On the other hand, the same care should be attributed to the selection of products which will constitute the Ic 400-500 forms from which more definite speculations will be made through PROGRAM 5.

Another crucial point should now be raised in connexion with multi-purpose units, namely, which is the adequate industrial T dimension for each combination.

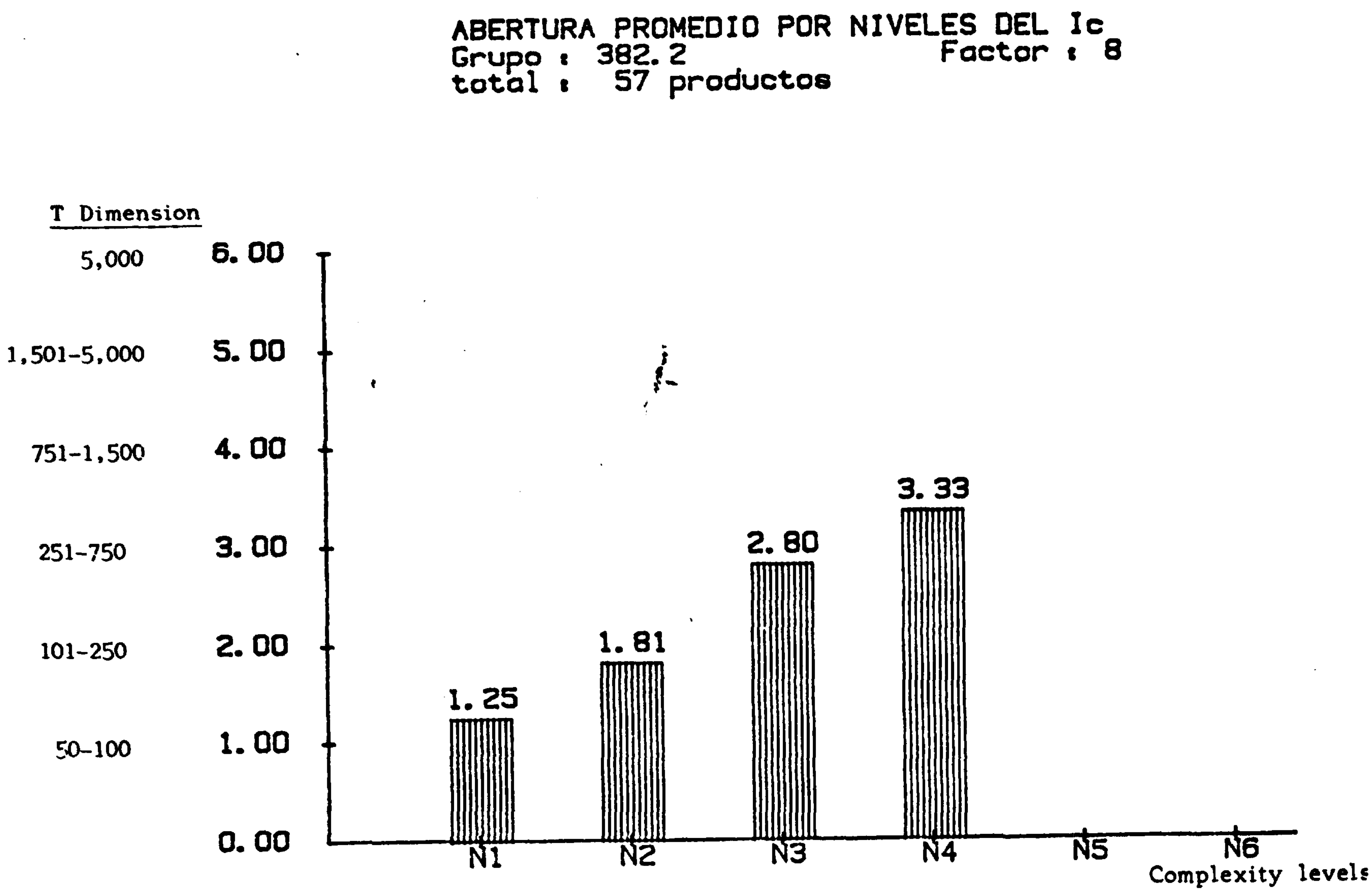
In the first place, let us observe Graph 2 or its tabulated form in Table 15. The same trend recorded in other capital goods exists in the sector. Industrial dimension T is defined in the Ic matrix as the minimum dimension required for producing a specific capital good, that is, it corresponds to the critic mass below which the product cannot be manufactured within normal Va, guarantying the users quality, rules, adequate technical assistance, etc.

The values of Graph 2 indicate T average for each N and for the 57 products of the sample. They are applied to a single product or according to fairly modest or controlled Vt varieties such as those illustrated in Graph 3.

For selecting the correct critic mass of the multi-purpose unit, the T corresponding to each form must not be added since it would be senseless, nor the average T be taken. One should find the maximum T of the forms participating in multi-purposeness by adjusting it according to the average productivity of EMI, thus obtaining the order of magnitude of production. This latter may be above or below the needs. In the first case the POL should be adapted to other compositions or multi-purposeness be extended to other sectors; in the second case, the T dimension should simply be increased.

The EMI average productivity must include the learning curve when new products are injected and especially when products are

AVERAGE OPENING BY Ic LEVELS



Grupo : 382.2
Group

	0	1	2
N6	0.0% 0	0.0% 0	0.0% 0
N5	0.0% 0	0.0% 0	0.0% 0
N4	0.0% 0	0.0% 0	0.0% 0
N3	0.0% 0	0.0% 0	5.3% 3
N2	0.0% 0	15.8% 9	36.8% 21
N1	0.0% 0	15.8% 9	5.3% 3
TOTAL	0.0% 0	31.6% 18	47.4% 27

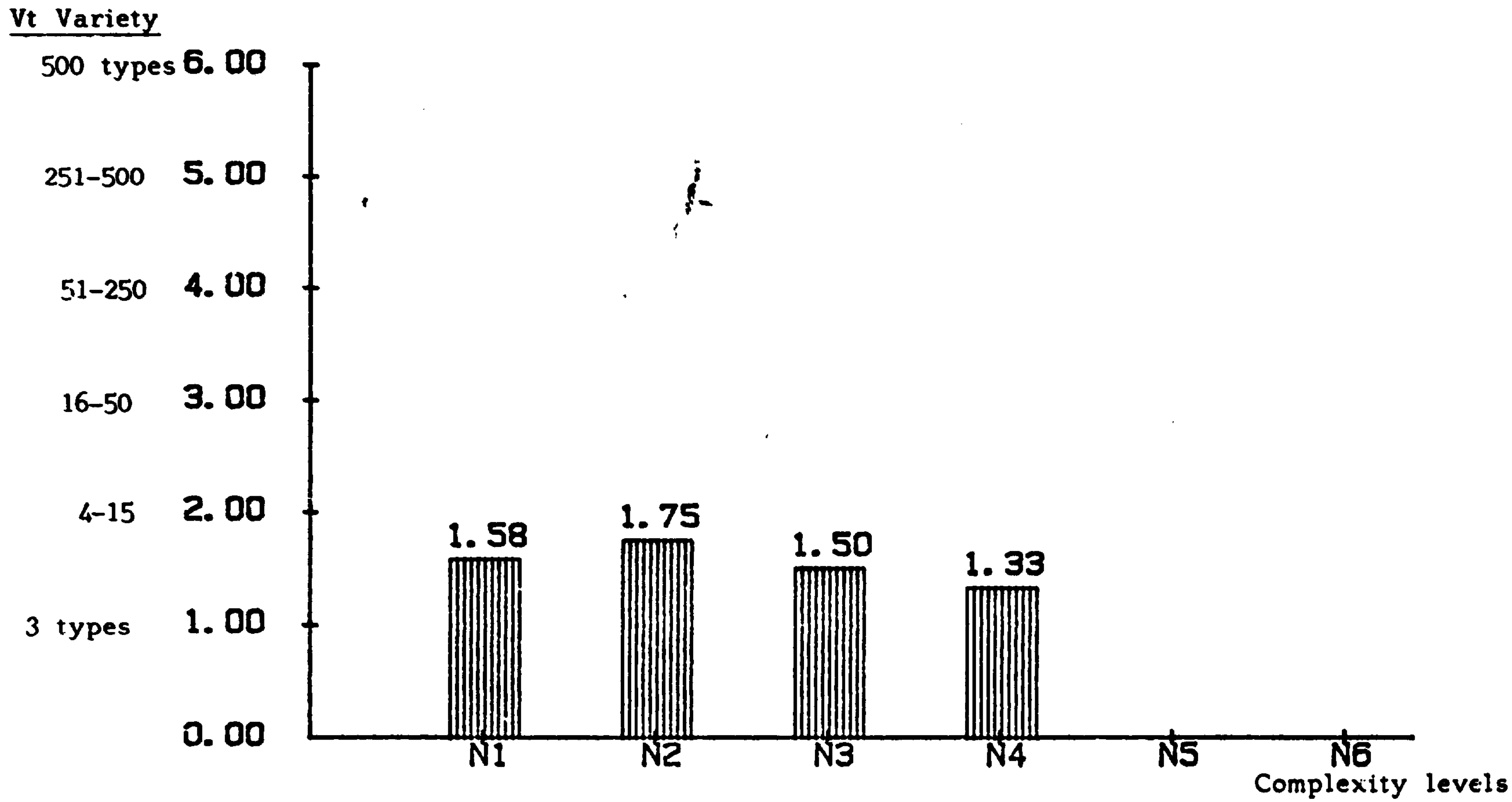
Table 15

Factor : 8

	Factor 3	Factor 4	5	6	TOTAL
	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
	3.5% 2	1.8% 1	0.0% 0	0.0% 0	5.3% 3
	10.5% 6	1.8% 1	0.0% 0	0.0% 0	17.5% 10
	1.8% 1	1.8% 1	0.0% 0	0.0% 0	56.1% 32
	0.0% 0	0.0% 0	0.0% 0	0.0% 0	21.1% 12
	15.8% 9	5.3% 3	0.0% 0	0.0% 0	100.0% 57

AVERAGE OPENING BY Ic LEVELS

ABERTURA PROMEDIO POR NIVELES DEL Ic
Grupo : 382.2 Factor : 3
total : 57 productos



incorporated, the N level of which constitutes the first leap toward a higher N level (of only one step) to which other capital goods will be later on associated. This situation may be frequent for various under-developed countries and for those of lower relative development. It refers specifically to the first N2 levels injected in quite elementary situations represented by N1, and to the first N3 levels starting from yet young EMIs, operating at N2 level.

It is utterly inconvenient to deal with the T aspect through rigid and dogmatic criteria, even when inspired in the Ic methodology. It is convenient instead, to adjust them to the above-mentioned approach and to constantly accept two supplementary controls on its reasoning. One consists of simulating how the expansion of the unit at medium and long-term would occur, and in which time limit more attention would eventually be justified toward the speciality. The other control should compare the performance and structure of POL as regards the alternative of other two minor POLs with smaller T dimension, an aspect to be always observed when the first attempts lead to constituting POLs of more than 200-300 persons occupied.

At any rate, whenever possible, it would be recommended to try defining no less than 3 POL types: one for field equipment excluding tractors (group A), another for equipment for farms (group B), and a third one for miscellaneous equipment. This in a preliminary way and from N2 level, of course including N3, while N1 level would be excluded from this approach.

The manufacture of tractors must be considered as a special case. Its simplification PANGOLIN or YETI-type 8/ is fairly partial since the motor and gear-box as well as the wheels would be

8/ "Séminaire sur la conception et le développement des équipements agricoles pour l'Afrique". Le Caire, Egypte, 17-28 octobre 1982. Document ONUDI.

imported due to the fact that their complexity would be higher than their manufacturing possibilities with EMI operating at N1 or N2 levels in the majority of Third World countries.

Considering from every angle the importance of the problem, beginning with the technological up to the social one, we are in favor of making a bigger effort starting from the idea of modular motors in order to reduce tractors of up to 50 CV for instance, from N4 up to N3, with the participation of B1 and B2 not higher than technological intensity (2) or (3) as a maximum, in slight proportions.

Once this position has been conquered, it will be possible not only to find adequate technical solutions for producing in lower series than those customary at present, but also to greatly facilitate the possibility of associating that manufacture to other capital goods, an aspect which today is fairly entangled in view of the conception of the tractor itself, of the magnitude of its manufacturing series, and in short, of the N4 level, still too far away from the possibilities of the great majority of the Third World EMIs.

The main speculations deducible from the sample of 57 products are thus finished.

Other aspects common to any capital good which may be useful for the sector under analysis, will be dealt with in the following chapter.

Chapter 4

MULTI-PURPOSE PRODUCTION OF CAPITAL GOODS

4.1 Prolegomena

When the whole range of capital goods is covered, for instance up to N4 level included, and adding intermediate capital goods (components as regards the final capital good), the interest in observing again Table 3, that is, the types of multi-purpose concerns analyzed in this essay, will easily be understood.

Although the POL.8 basic approach on the subject of agricultural machinery was the point of departure, it is recognized that it will not always be possible to do so in other sectors, since not all of them contain enough variety of N2 and N3 products as those of Chapter 3. Thence the convenience of searching for new combinations among the eleven POLs indicated.

Whenever the sectoral solution be impracticable or result in low-performance POLs, it will be advisable to insist on forming POLs on the basis of POLs 5, 6 and 7. It is implicitly understood that POL.9 represents already known cases in front of which only adjustments of greater or minor importance are striven for, and that POLs 10 and 11 do not present further problems.

In principle, this approach should not get out of three large production axis: one connected with products of ISIC Groups 381 and 382, another with the electric material included in 383, and a third one regarding transport material in 384. This orientation must at least be accepted during the EMI first generation, taking it automatically as surpassed when EMIs operate with a critical mass of over 40,000-50,000 persons occupied, due to the fact that better opportunities arise then for constituting POL concerns.

When dealing with the subject of the interest the agricultural machinery sector would have in redesigning a wide range of products in order to reduce their technological complexity, the idea was not to suggest that this might be applicable indiscriminately to every final capital good and its components. Although in theory or academically it is always possible to imagine a much less complex design than the maximum existing for many products, this would in no way be applicable to sectors such as aerospace, special heavy and superheavy trucks, gas, steam turbines, and others.

Consequently this means that in many sectors and subsectors the **natural trend of evolution in terms of technological complexity** should simply be accepted. Naturally the products affected are especially N5 and N6 ones. For N4 products instead, various situations will occur; on one side those which cannot reduce their complexity without getting out of minimum quality, security, efficiency, etc. norms, and on the other, those which do admit to be redesigned either for reducing the level of technological dependence of B1 and B2, for decreasing the intrinsic complexity of the product, or finally, for reducing the degree of automatism of the same. N3 and N2 products are already less problematic in that sense becuase in a good proportion they come within the reproduction possibilities of the EMIs of a number of Third World countries. They can also be easily led to still lower Ic complexity indices.

In view of this structural reason, it will be advisable to differentiate POLs independently of their type, by degree of responsibility or by N level. POLs including also or only N4 products (those with N5 are excluded here) constitute a separate class not only due to the operational critic mass they may achieve, but also due to the high complexity and resulting **managerial** quality by them required in order to be efficient. Therefore, such solutions may only be used in already prepared surroundings (EMI) with a certain experience, that is, in the course of the second industrial generation. Whereas every POL falling into N1, N2 and N3 levels will be able to operate already from the first industrial generation. (Compare with op.cit.1/, Vol.II, Chapter 7.)

This differentiation is based on the assumption already mentioned in the sense that work develops according to formula A+B = LOCAL/REGIONAL, which would deteriorate until annulled whether other production commitments or only painting and assembly activities were accepted as LOCAL.

In order to consider POLs as solutions capable of developing to a maximum the activities of Third World EMIs, it is not enough to accept the rules of Chapter 1 and apply PROGRAM 5. The constitution of POLs can in no way be carried to a play of abstract combination in an attempt to give work to an specific machine in-use stock. Consequently, the steps herein suggested will be the more realistic the better they are known by the technologist and later on by the economist, the global rules governing the electro-mechanical industry, its historic evolution, its evolution speed, and finally, clear notions are held regarding which are the limits of the recovery speed of the SOUTH technologic gap in relation to the NORTH one.

We are convinced that the whole gathering of op.cit.1/ constitutes a first original step, capable of organizing such a vast and complex subject. Its reading and meditation will therefore be essential requirements in order to forming not one but several POLs injected into an aggressive industrialization program.

On the contrary, should interest on multi-purposeness be restricted or isolated, the application of PROGRAM 5 and the fulfillment of the rules contained in this essay would be enough.

4.2 An exercize within Group 382, Mechanical capital goods

From the assumption that it is not possible to equate correctly a group of POLs so that they constitute an industrialization program of an specific N technological level without first knowing the EMIs basic industrial rules and/or of its large groups, the data stock of Group 382 has been selected, which attains 324 forms over a total de 500 of op.cit.1/, in order to obtain a guide line on the subject. The following exercize is related to the group of mechanical capital goods; available data covers a wide range of the variety of cases classified under 382.

As it has already been mentioned, information on N5 and N6 is limited, in view of the fact that emphasize was given to the former 4 Ns, as indicated in Graph 4.

It is worthwhile knowing then some of the characteristic trends of this large sector, which show the structure that may differentiate it from other large groups, as well as from the operational limits to which the 382 product POLs must adjust themselves.

Of course, some relation exists between N levels and the industry type or P weight of the products. This notion must be clearly understood once the POL programming should not include inconvenient variations of the first P factor among the 103 participants in the complexity index. The 324 Ic forms of the sample are distributed as shown on Graph 5.

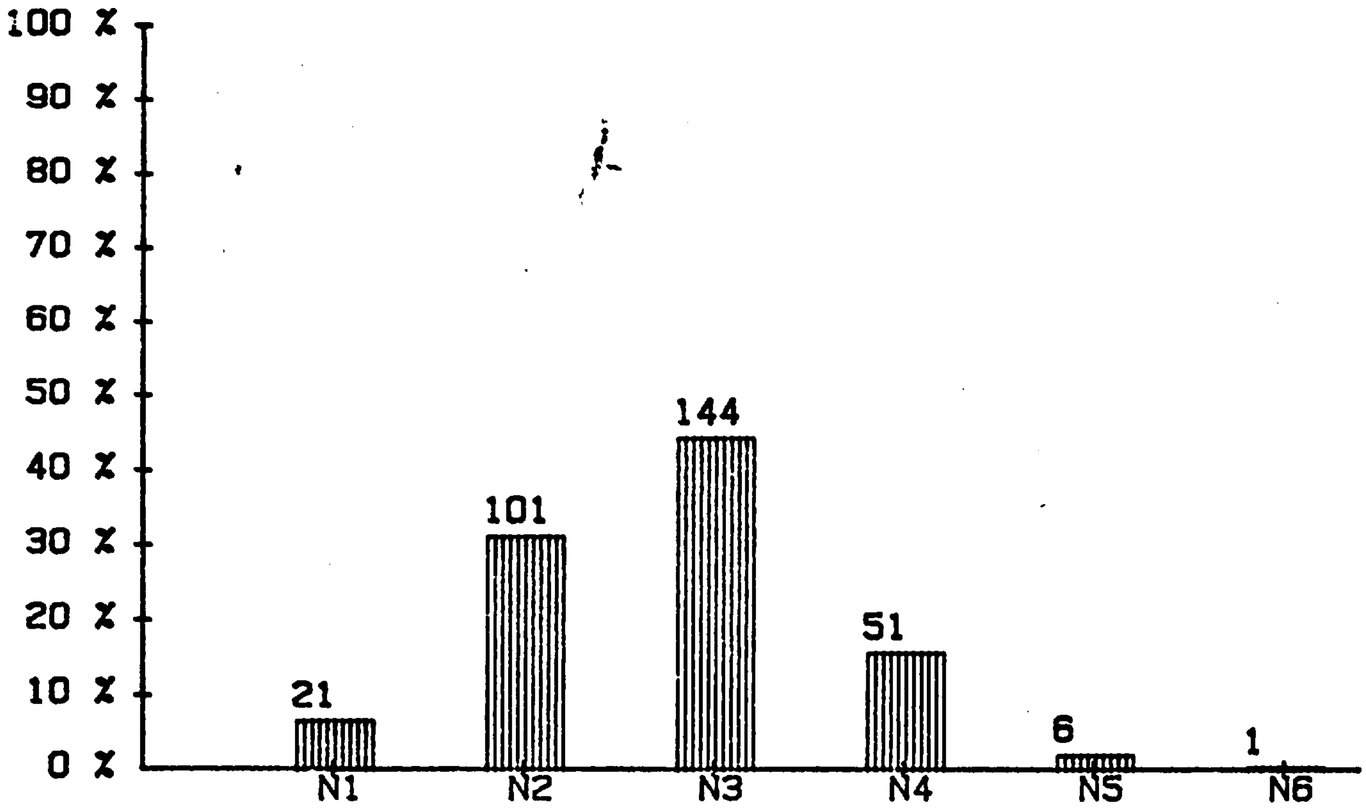
Likewise it should be clearly known how industrial responsibility varies in Q qualitative terms, the second factor, in function of N. The average progression is illustrated in Graph 6, noting however that fluctuations around average values are usually high up to N3, obviously decreasing in higher N levels.

It is also important to have an exact idea on how Hd behavior (factor 7), number of direct hours of manufacture by ton of final product, varies in relation to N. This is observed in

Graph 4

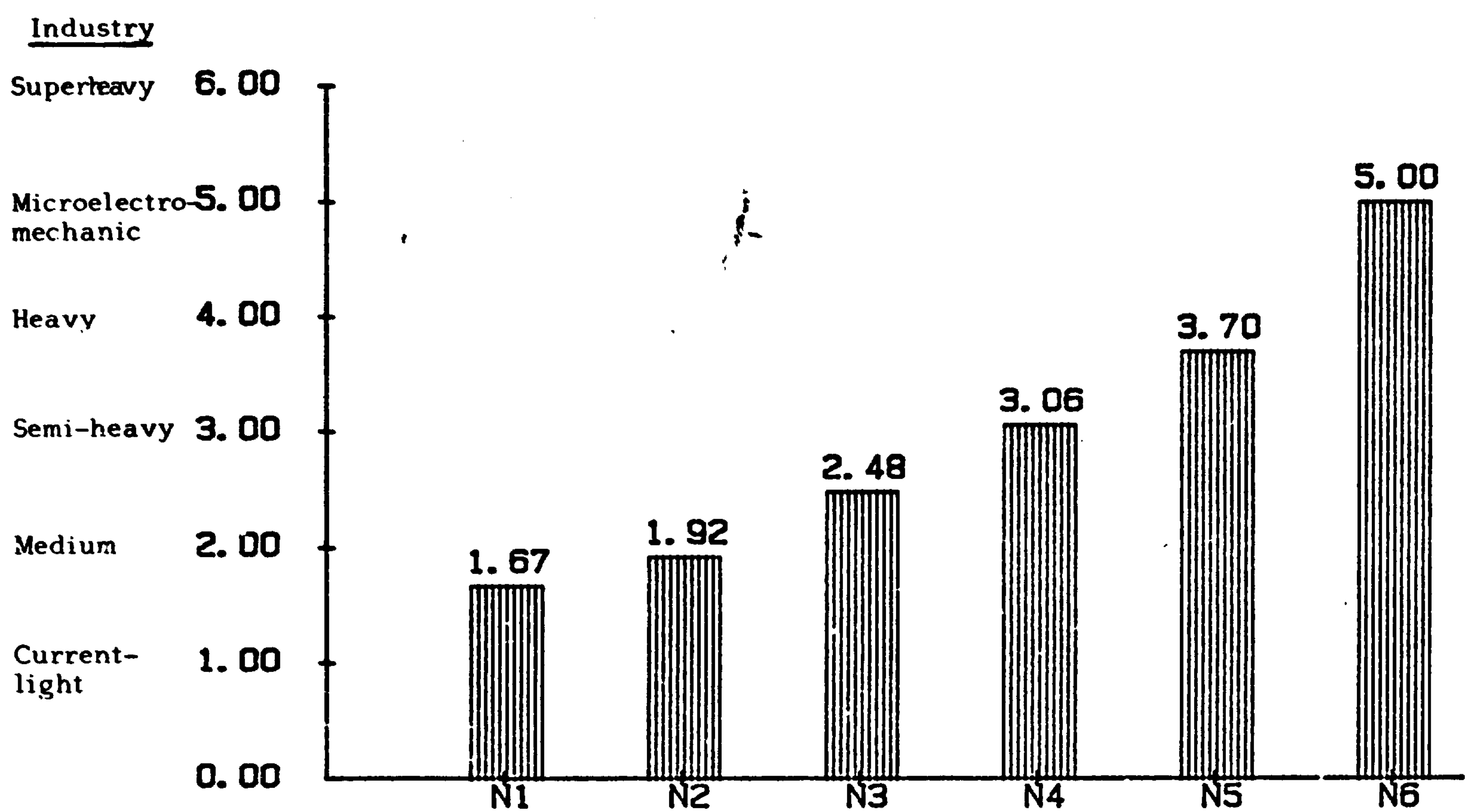
DISTRIBUTION BY COMPLEXITY LEVELS

DISTRIBUCION POR NIVELES DE COMPLEJIDAD
Grupo : 382
total : 324 productos



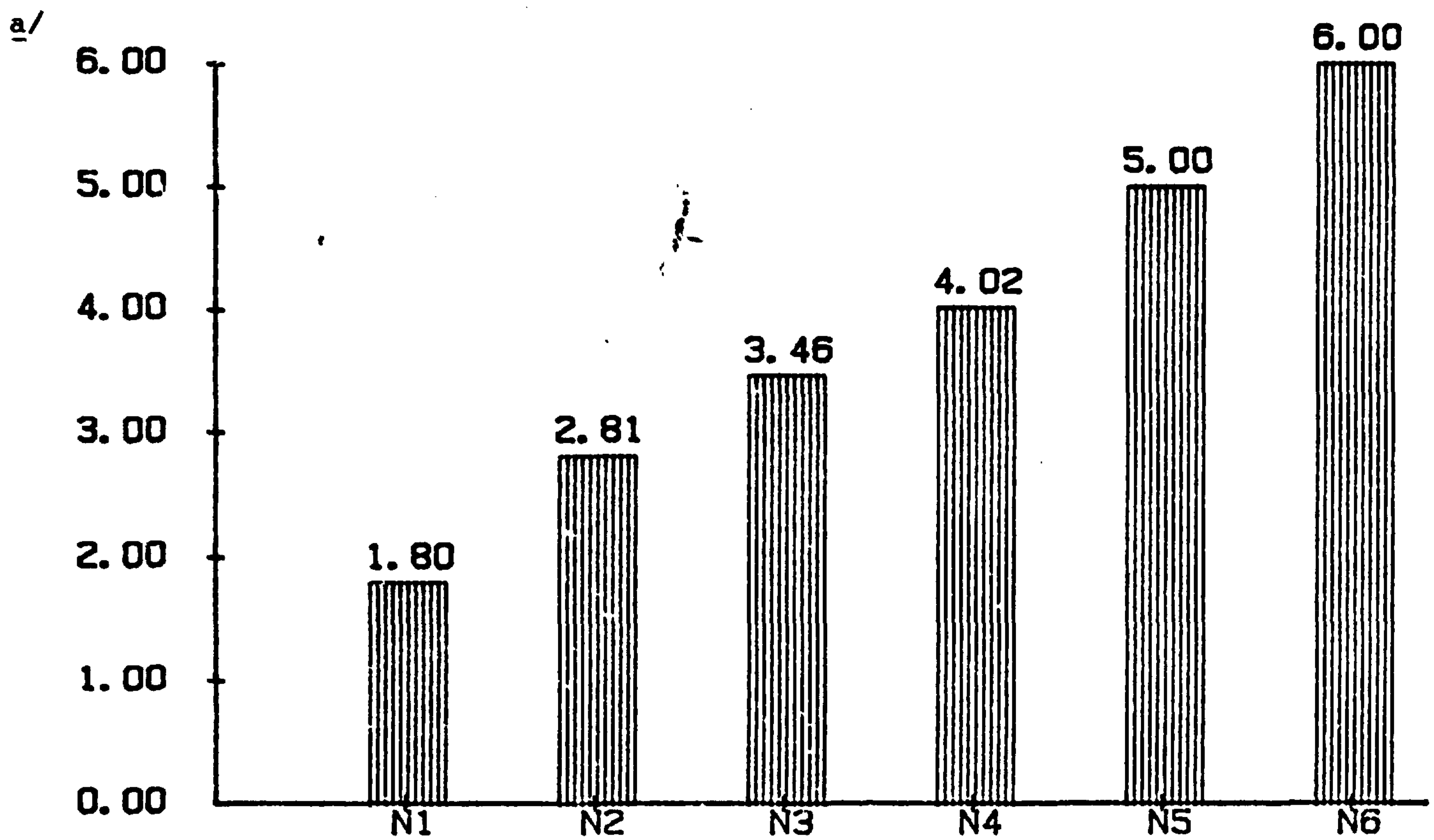
AVERAGE OPENING BY Ic LEVELS

ABERTURA PROMEDIO POR NIVELES DEL Ic
Grupo : 382 Factor : 1
total : 324 productos



AVERAGE OPENING BY Ic LEVEL

ABERTURA PROMEDIO POR NIVELES DEL Ic
Grupo : 382 Factor : 2
total : 224 productos



a/ See Chapter 6.

Graph 7 and it shows once more the inconvenience, not to say the utopia, not only of associating three N types under the same POL but also of pretending to manufacture N4 products when the EMI technological structure is only adequate for N2 or N1 levels. The difference for instance, between N4-N2 products, in low manufacturing series, may result in 300, 400, 500 and even more direct hours per ton of final product, leaving in evidence the intensity of the effort to be developed toward the capitalization and of course toward manual labor training.

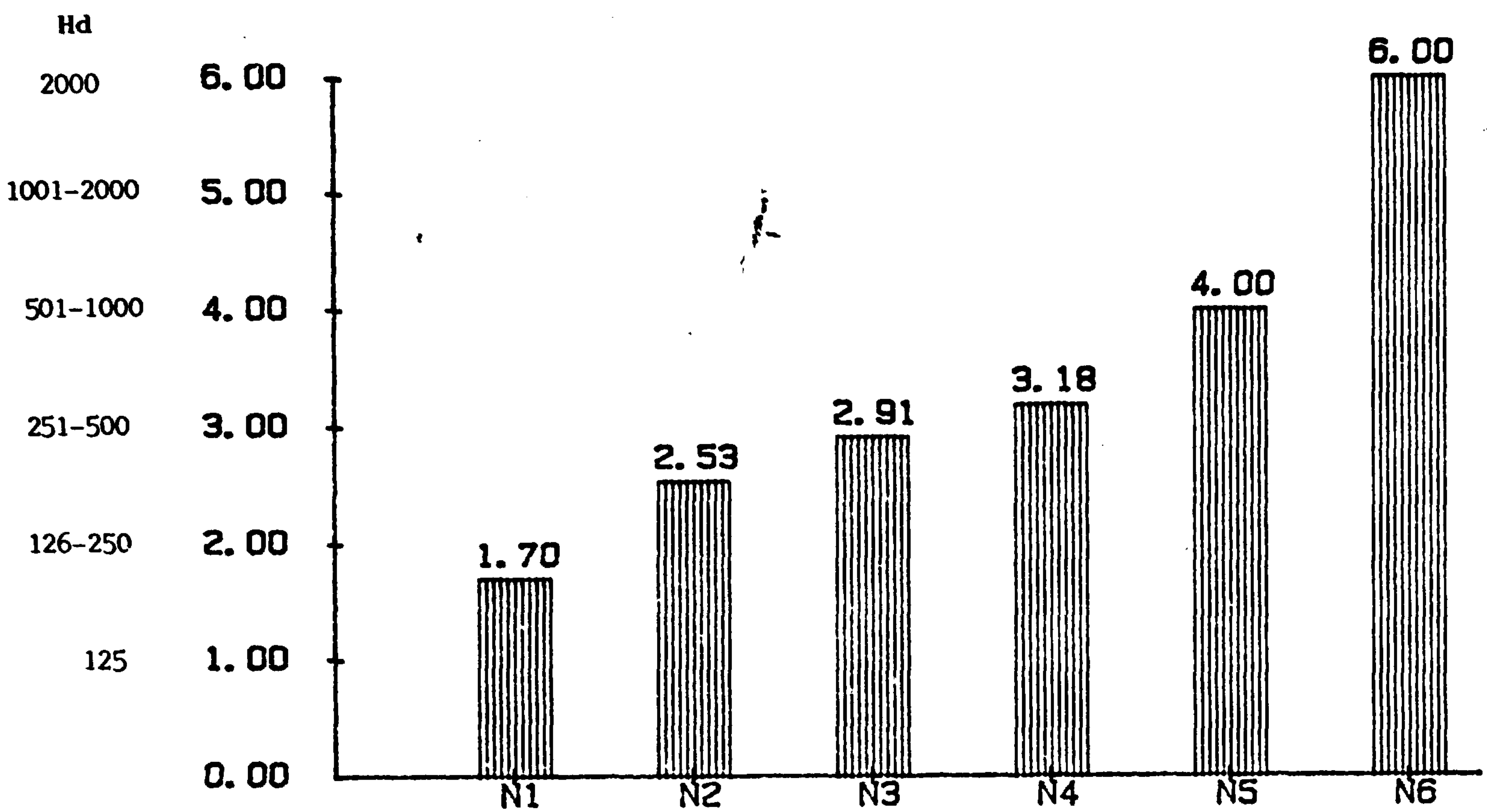
Following with the synthesis panorama, Graph 8 related to factor 8, namely the already commented T industrial dimension, is presented below. Thence the principle may be extrapolated according to which on increasing the average technological level of the products, POLs must accompany that progression since production should be realized outside the concept of the adequate critic mass.

Although it is true that in case of an accelerated industrialization, POLs, just besides as any other more specialized industry, depend on third parties' product know-how (Hs) (manufacture licences or other variants) and that in this way the size of engineering offices and of L laboratories is reduced, this does not exempt POLs from a certain responsibility. The intensity of technicality contained by the products increases according to N, as factor 9, Hs, progression proves it in Graph 9. This must be carefully considered since quite a number of Hs effects at its origin are transferred to Third World industries and with greater reason to the POLs which on their turn should control them in order to be able to assume their technical responsibilities in front of the utilizers. Hs intensity is a good indicator in this respect.

Graph 7

AVERAGE OPENING BY Ic LEVELS

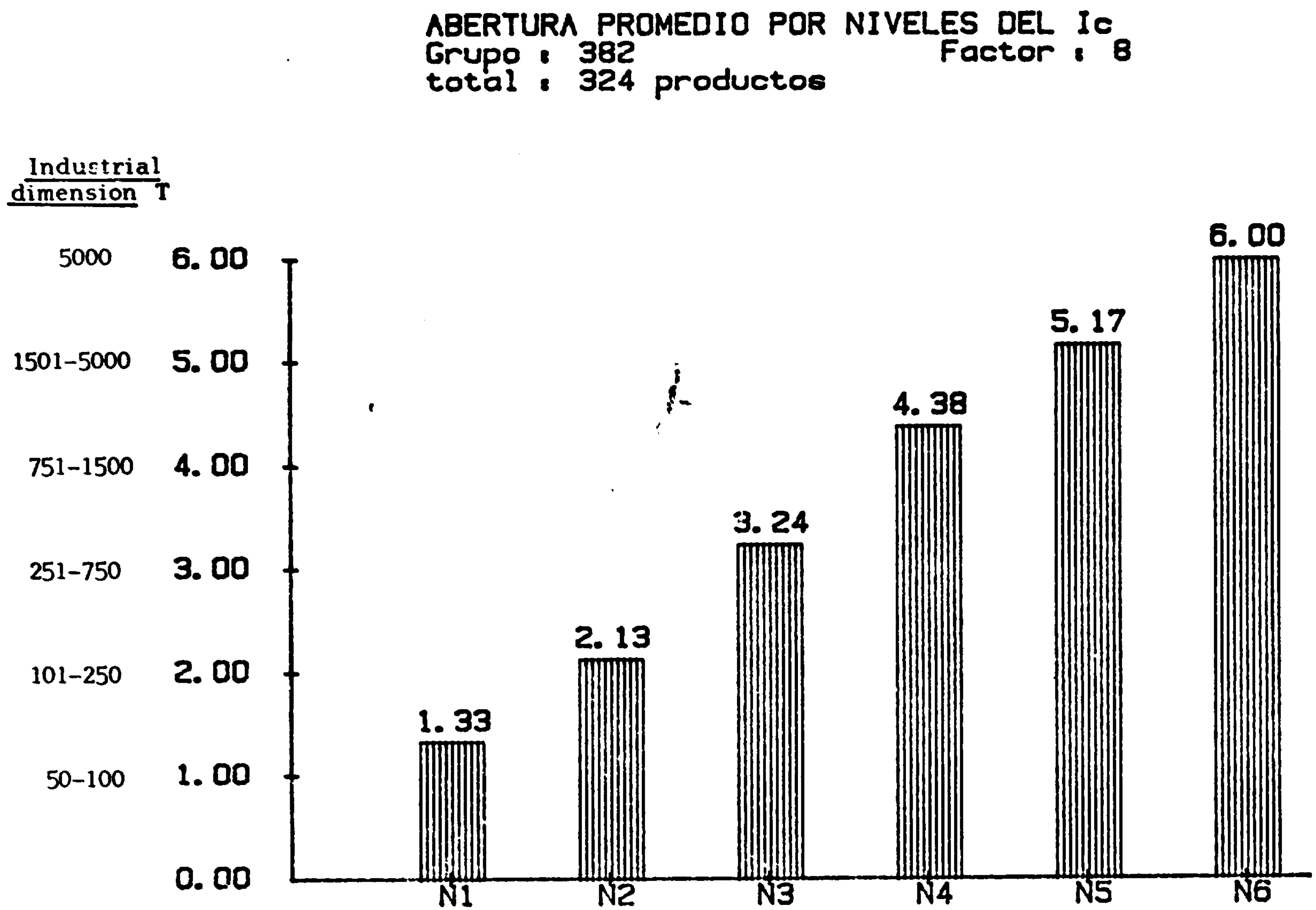
ABERTURA PROMEDIO POR NIVELES DEL Ic
Grupo : 382 Factor : 7[a/]
total : 324 productos



a/ Factor 7: Hd = Nr. of direct hours of manufacture per ton of final product.

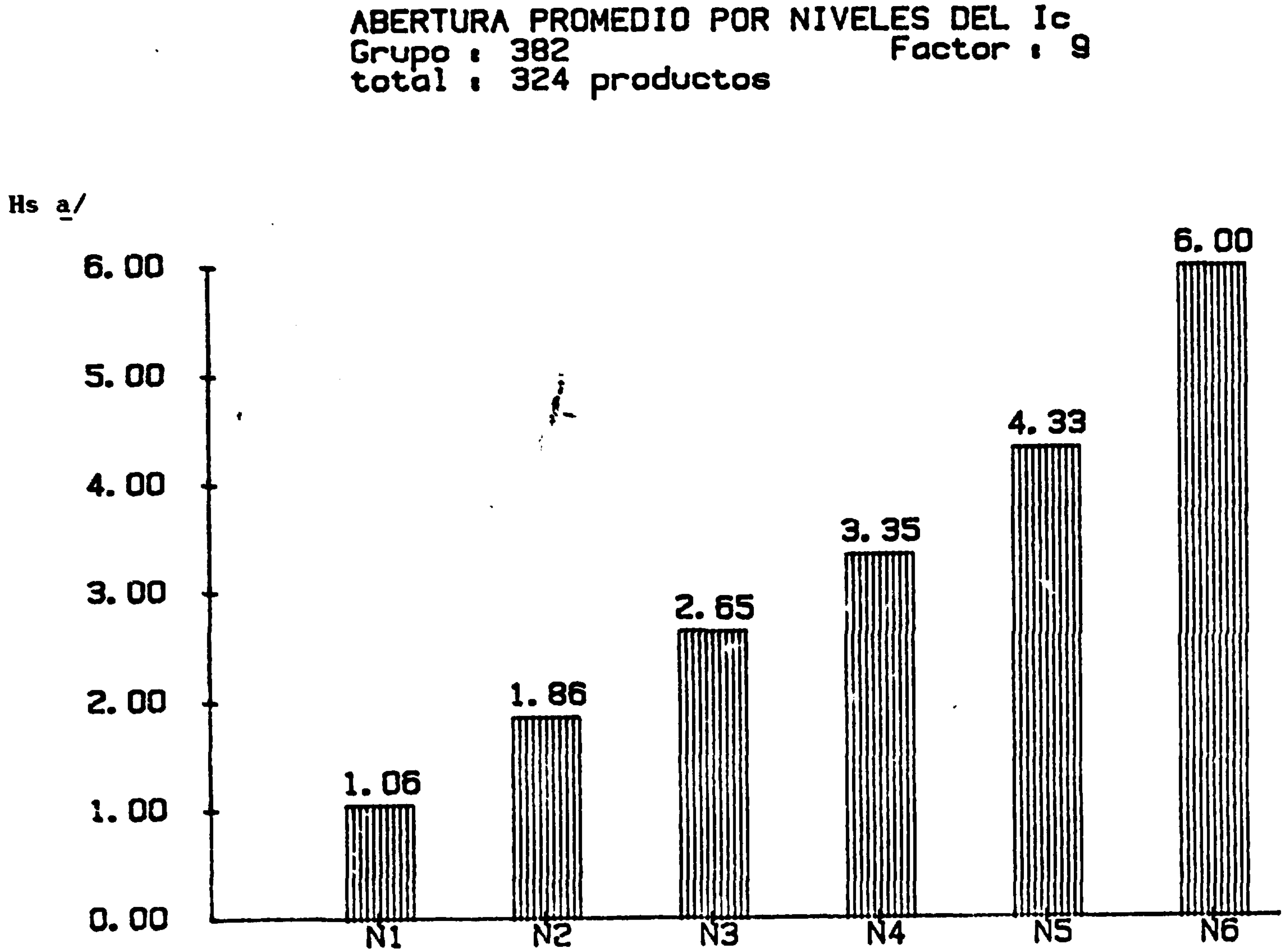
Graph 8

AVERAGE OPENING BY Ic LEVELS



Graph 9

AVERAGE OPENING BY Ic LEVELS



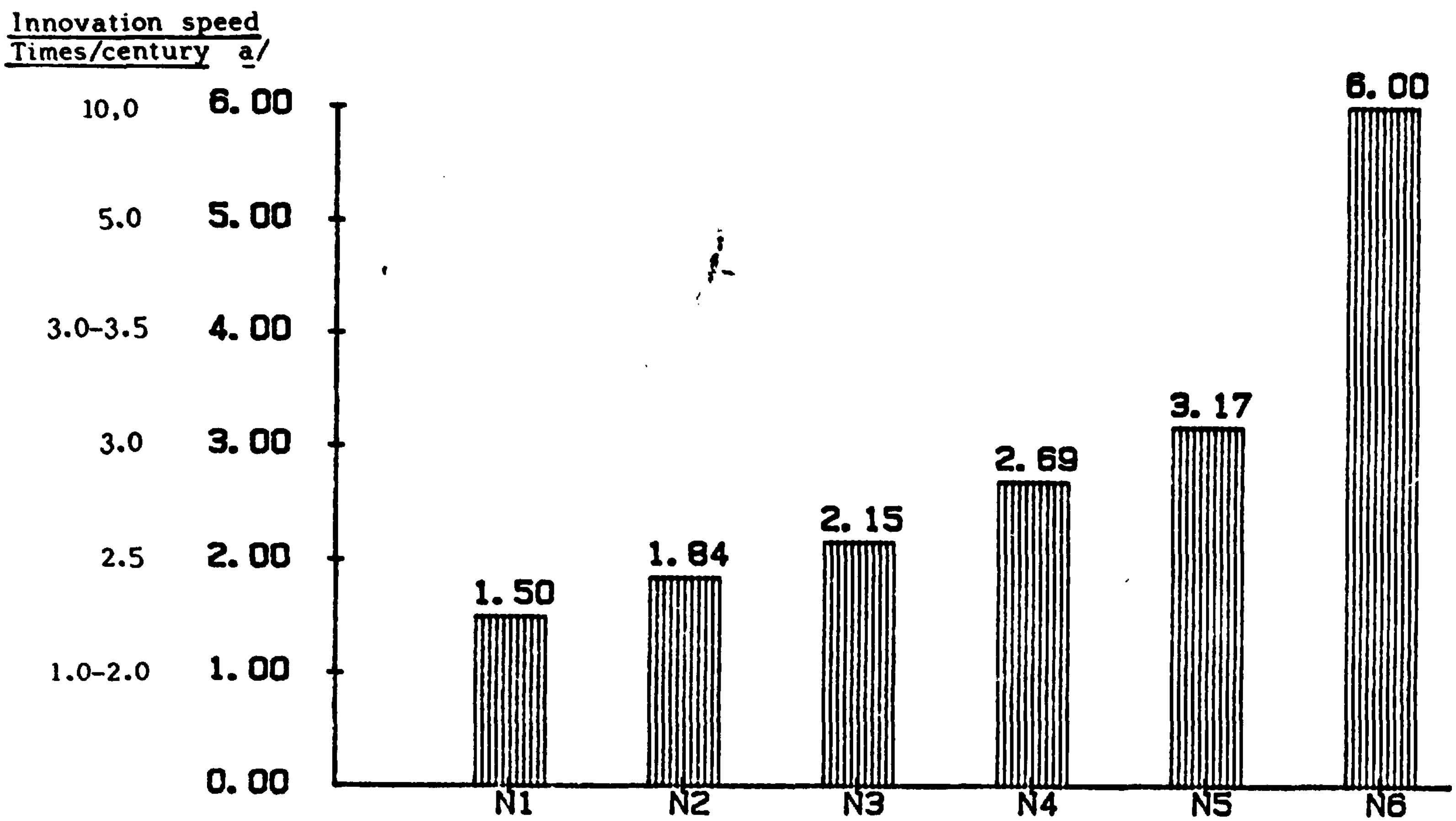
a/ See Chapter 6.

Finally, two other factors, Fp and Fc, the first interpreting the product innovation in relation to materials and production means, and the second, the conception of the project itself, should be pointed out. Graphs 10 and 11 clearly illustrate how the change of products in connexion with Fp and Fc is accelerating in average terms, as long as N complexity level is increased. (It should be remembered that N5 and N6 are not expressive of reality.) The fluctuations of both factors as regards average values occur especially in central N, namely N3 and N4, decreasing in the extremities toward high innovation speeds when products are very complex and inversely, toward stability - low innovation per century - when products are N1 and N2. This last fact makes it particularly interesting to organize the beginning of EMIs precisely from the manufacture of more stable products, the great majority situated in the inferior complexity scale. This is also valid for POLs. With reference to factors Fp and Fc, it will always be advisable to verify that the products participation in one POL be not only homogeneous but also that it be situated within the first three steps. More dynamic POLs operating with products of steps (4) and (5) must be considered rather as special cases, at any rate as the result of industrial maturity, that is, of an specific managerial evolution. It is not advisable to constitute POLs with such characteristics from the beginning, at least in Group 382. That bond, the same as others already commented, may be established or realized through PROGRAM 4 (op.cit.1/), the equations of which will facilitate decision taking in more doubtful cases.

Now then, once settled the subject within these and other similar concepts not explored here, the task of composing a group of POLs participating in an industrialization program, will become more expedite and precise.

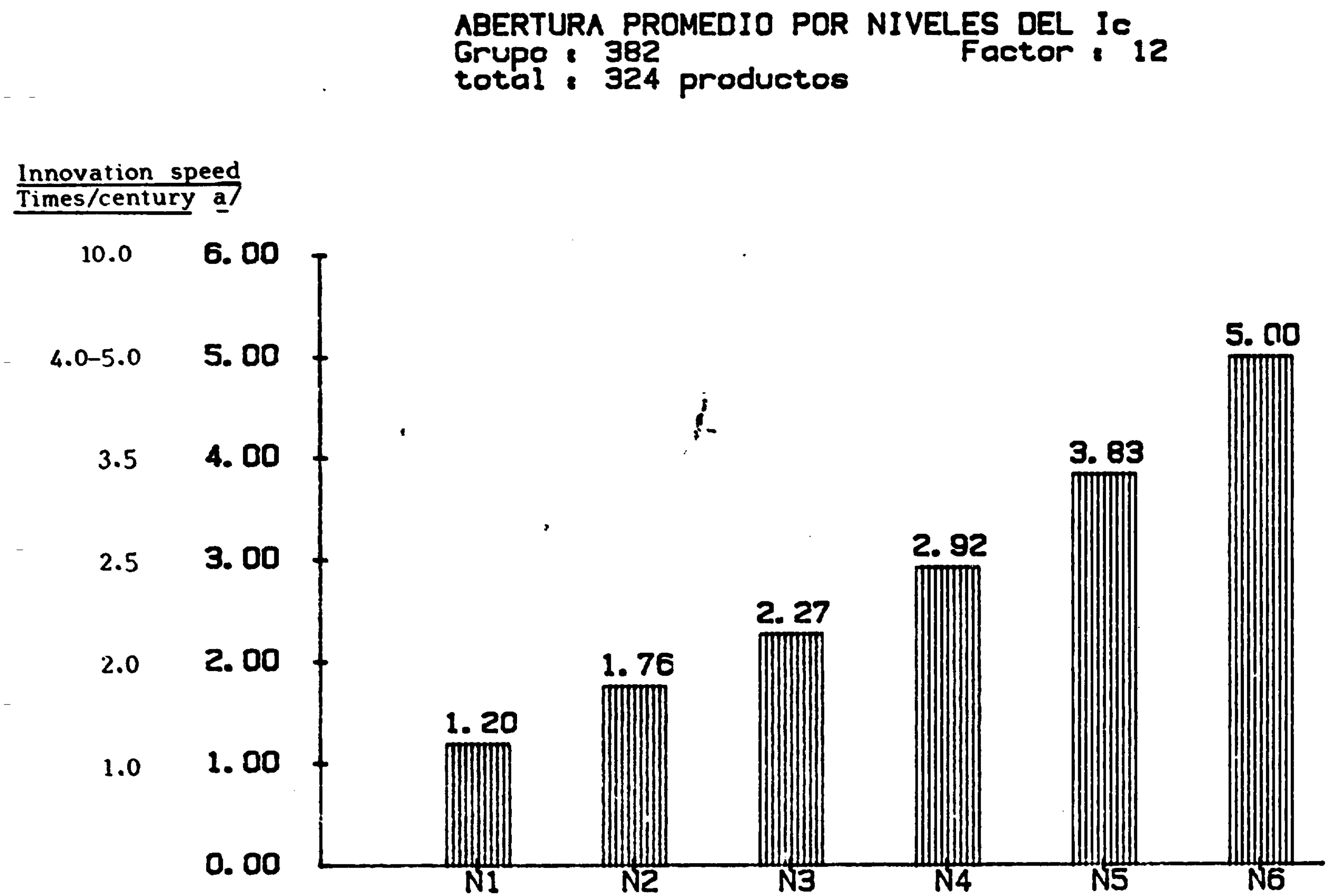
AVERAGE OPENING BY Ic LEVELS

ABERTURA PROMEDIO POR NIVELES DEL Ic
Grupo : 382 Factor : 11
total : 324 productos



a/ In connexion with raw materials and production equipment.

AVERAGE OPENING BY Ic LEVELS



a/ Related to project.

With the objective of familiarizing those interested in PROGRAM 5 and in POLs, below follows and exercize-example based upon N2-N3 levels. Considering the great variety of cases-countries on one side, and on the other the limitation of the sample - 324 forms-product for such a vast sector - it is not a question here of presenting an exhaustive example which might be wrongly extrapolated or interpreted. The formula exercize-example seems then the most adequate for the end pursued.

N2-N3 POLs come within the first industrial generation, exactly at the end of this period, due to the presence of N3. It is well-known that in order to set up B1 and B2 infrastructure a great effort is required. Even so, it is assumed that B manages to accompany with few restrictions the products requirements. Products needing openings equal to or above (4) are not desirable in B since the intention is to strictly apply formula A+B = LOCAL/REGIONAL.

Let us now assume that the interest is above all concentrated on the following sectors and subsectors:

a) Machinery for civil construction and housing.
b) Machinery for food elaboration and preserving.
c) Agricultural machinery for farms.
d) Metal-forming machine-tools.
e) Machinery for hoisting and load transport (crane-bridges, cranes, etc.).
f) Miscellaneous materials considered as final capital goods and components.

The intention is to select, in a first stage, the most simple material, establishing the limits indicated below:

P, weight of the products, up to (3).

Q, quality, up to the maximum of (3).

Hd, direct hours per ton; they should not exceed the 500 hours, that is, including (3).

Hs, Hours of engineering office per US$1000 of product. From the beginning it is advisable that such coefficient be not too high and that the maximum achieves opening (4), that is, 3.5 hours/US$1000.

T: industrial dimension measured in personnel occupied should not exceed opening (3), that is, 750 persons.

Fp: it is accepted that the product evolution related to production means and materials attains up to (3) included.

Fc: it is assumed that the product conceptual evolution do not exceed 2.5 times per century, namely opening (3).

B: it should in no case be equal to or above (4).

Within Group 382, the sectors and subsectors of interest may be found in the following classification:

a) = 382.43;

b) = 382.40 and 41;

c) = 382.21;

d) = 382.31;

e) = 382.9,

making a total of 141 form products of N2-N3 level.

Applying to this total the elimination by the bonds attributed to each factor and to B as a whole, the listing of 51 products indicated in ANNEX 8 is obtained.

Every product is successively eliminated which uses opening (6), **special machines**, for A3 equipment, when more than two openings are dealt with in the POL under analysis. To that end point 2 of the main MENU of PROGRAM 5 is used. In that case 10 products are eliminated, constituting a residue of 41 products which are indicated in ANNEX 9.

Based upon this products residue, the DEGREE OF COINCIDENCE of A3 and B, factor by factor, with summaries by factor subgroups and groups is studied, which is illustrated in ANNEX 10.

This is only a first approach to the problem, since the concerns originated by a POL would be too numerous. ANNEX 10 serves as an essay for verifying whether the proportion of S2 in front of S1 is acceptable, which is the role corresponding to I2 and I3, as well as which is the DEGREE OF COINCIDENCE obtained in metal-forming and metal-cutting machines. Finally, the idea is to get an orientation although rough, regarding which is the size of the machines in use the POL might require and from thence add the directs and indirects using current proportionals to form a tentative T dimension.

On the other hand, it is easily observed also that if the additions of S1 and S2 are too high, that would indicate the POL is excessively large, out of proportion for belonging to the first industrial generation whether the administration be public, mixed or private. In this sense it would be advisable to reconduct the problem toward minor POLs by fractioning the listing of ANNEX 9. It will soon be discovered that it is possible to improve the DEGREE OF COINCIDENCE of the metal-forming and metal-cutting machine-tools through other combinations.

The same ANNEX 9 indicates four attempts composed in connexion with some coherences of a manufacturing type (to be verified later on) and others related to the facility of fractioning multi-purpose production in 2 semesters or eventually in 3 four-month periods, since it is generally preferable to concentrate production in one or two small series in certain periods of the year, than scattering the whole production along the entire year.

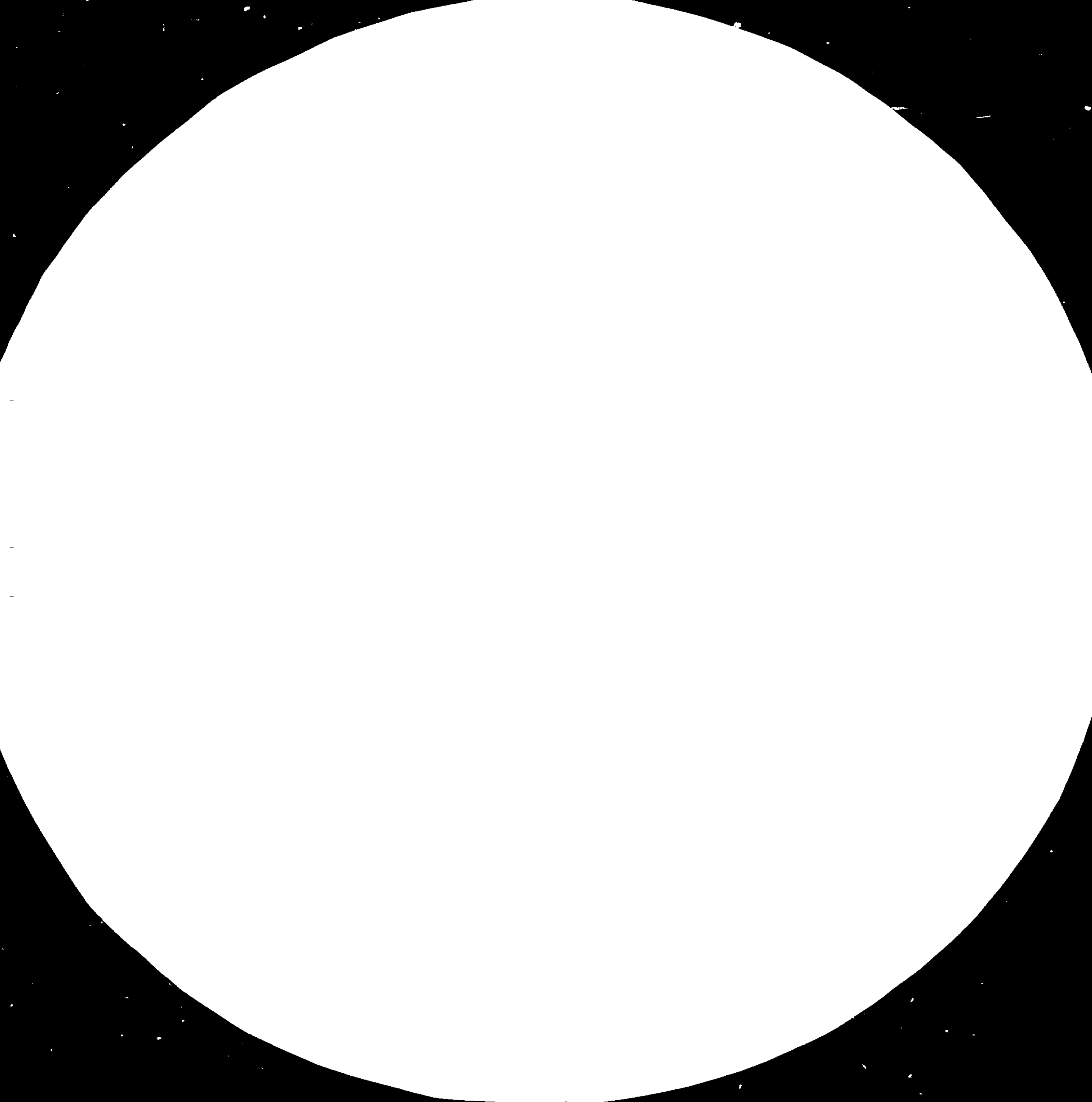
Solutions must be searched for within non too dishomogeneous ranks, observing whether it is possible to force adjustments in favor of POLs 7, 8 and 9, the actions of which have a great influence over the EMI.

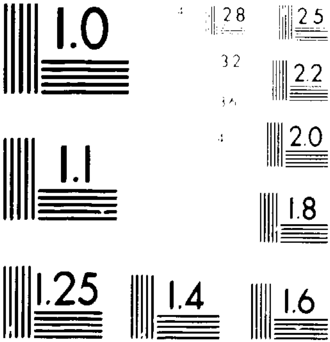
The listing of ANNEX 9 is excessively discontinuous to carry on a more precise discussion. Anyway, as an exercize, an attempt will be made to improve the degrees of coincidence in A3. One of the manners of doing so is the following:

- One POL constituted by the products of ANNEX 11, marked with A in ANNEX 9, through which substantial improvement is made on the degrees of coincidence of the use of metal-forming machines (from 72% to 86%) and of metal-cutting machines (from 58% to 72%). See ANNEX 12.
- One POL constituted by the products of ANNEX 13 (B), which also improves the use of metal-cutting machines from 58% to 65% (ANNEX 14), but which impairs metal-forming ones. The subcontracting of such services might overcome some inconveniences.
- One POL.7 (C) concern, centered on the problems of cold, to which all the maintenance of the cold facilities and a certain commercialization of imported material should be added.
- One (D) concern, also centered on the homogeneity of factor Hs, that is POL.7, to which maintenance activities and imported equipment distribution could also be added.
- Finally, products marked with F in ANNEX 9 are eliminated, that is to say, are not taken into account.

The summary of the above-adopted positions is presented in ANNEX 9.

Should the data stock of every sector and subsector contain hundreds of products up to N3 and N4 levels, the application of PROGRAM 5 just as it has been done would have furnished results more closely related to those of an authentic industrial profile. It is also possible that due to the magnitude of interesting sectors covered by exercize (6), the number of POLs would have been from 6 to 8 or even more, if more extensive information had been available. At any rate, the number of POLs would depend on the degree of development of the EMI and consequently of the country or region.





MICROCOPY RESOLUTION TEST CHART

The exercize-example is set within surroundings which correspond, as it has been mentioned previously, to the end of the first industrial generation, that is, when EMIs have been operating for 25-30 years and have controlled the basic technological problems relative to the products N1 and N2 levels and even some concerning N3.

The POLs of the exercize clearly show in which degree they depend in level and variety of services, of B infrastructure. This allows to verify rapidly whether existing infrastructure is sufficient in qualitative terms, or otherwise, which are the points to be reinforced.

It is not beside the point to insist here that in the way it has been dealt with, the problem interprets more the great reasonings and speculations, than excessively precise inquiries. PROGRAM 5 will make it possible to search for the best solutions for tens of POLs constituting an authentic industrialization program; best solutions obtained through numerous attempts (combinations) which may be carried out in very limited time.

But PROGRAM 5 and the methodology in itself, together with EMIs behavioral rules, may be of assistance in a vital point when composing POLs. The products should be added respecting first some preference among the eleven POL guide lines selected, and second, to do it bearing in mind the evolution of POL which once achieved a certain saturation in terms of volume and variety, will be interested in transforming itself into 2 or 3 minor POLs or either directly generating 2 or 3 specialized concerns, imitating in that sense more normal industrialization structures. This is real and it happened already in Latin America. The POL, which in that case could be called mother POL, would be conceived as a permanent catalyzer of capital goods industrializations, changing in the course of time its production composition as the interest arises for more specialized and/or conventional concerns. In other words, when LOCAL/REGIONAL market and B infrastructure thus justify and allow it.

This final observation is intended to set the POLs in a very exact position within EMIs. The latter should be considered exclusively as accelerators of the beginning of industrialization. POLs occupy a strategic place in EMIs, contrary to what a certain initial passivity of Hs might suggest.

POLs, especially once N1 and N2 phases have been surpassed, must be constituted according to a prospective approach and not with short-term objectives, operating in a permanently dynamic manner as generators of future more specialized concerns or of more restricted POLs, substituted by the incorporation of new products. Thus, in the course of an industrial generation, they would form authentic INDUSTRIALIZATION POLES for capital goods production in the Third World. Nevertheless and as always, the function of definitive solutions must be attributed to a single idea or to a single scheme. In this way, the POLs arising as POL.9, POL.4 and sometimes POL.8, will not have the same ends in a prospective scenery, since their degrees of operational elasticity are inferior to those of other POLs.

Although it is true that basic industrialization, that is, EMI assembly, may be carried out in the Third World up to N4 level included, in almost half the historic time (see Chapter 7, Vol.II, op.cit.1/) and according to inferior EMI dimensions than those of industrialized countries, it becomes imperative to establish POLs within the prospective optic, even more so than if they were specialized concerns. This recommendation achieves its real dimension if the exercize-example here presented is followed.

Anyway, it should be understood that the applicative field of POLs increases from N1 to N4, which is the same as asserting that the lower the performance of EMI in terms of N, the fewer will the combinations be for constituting multi-purpose concerns, and viceversa. From another viewpoint, it could be said that the opportunities of constituting EMI increase in direct proportion to the critic mass with which the EMI operates.

Chapter 5

MULTI-PURPOSE CONCERNS AND HUMAN RESOURCES

5.1 General considerations

This chapter does not intend to exhaust such a vast subject. It will only be limited to showing some original approaches which may be deduced from PROGRAM 5 as well as from the work "Recursos humanos y complejidad tecnológica de los bienes de capital" (Human resources and technological complexity of capital goods). 9/

When the structure of personnel occupied in concerns already operating as POLs is analyzed, it is soon verified that in principle there is no need for raising lessons different from those usually available. This is applicable to the eleven POLS examined. Thus it is recognized that the quality of instruction, the extension and diversification of courses and the intensity with which subjects are developed, are in fact independent from the more or less marked presence of POL within an EMI.

Every attribute belonging to technical instruction directed to manual labor, technicians and professionals must then be extracted from the EMIs context. The knowledge of such context is facilitated through the direct and indirect contribution of Ic (op. cit.1/, Vol.III, as it may be appreciated in the synthesis of Chapter 4.

Thus it has been possible for instance, to trace the correlation Industrial dimension-Product complexity, T-N, demonstrating that the correlation is not disorderly. This means that a minimum of managerial critic mass, that is T, is required for dominating

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9/ Work carried out for UNIDO applying to the first time to this subject the concepts of the Complexity Index. F. Vidossich, Santiago, July 1982. Spanish edition.

CALIFICACION DE LOS KH POR TAMAÑO DE EMPRESA

Cuadro 16

	Nº KH	Denominación del KH	T1 Mano d. Obra	T1 Cuad Medios	T1 Ingenieros	T2 Mano d. Obra	T2 Cuad. Medios	T2 Ingenieros	T3 Mano d. Obra	T3 Cuad. Medios	T3 Ingenieros	T4 Mano d. Obra	T4 Cuad. Medios	T4 Ingenieros	T5 Mano d. Obra	T5 Cuad. Medios	T5 Ingenieros	T6 Mano d. Obra	T6 Cuad. Medios	T6 Ingenieros
			E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C	E I A C
I	08	Diseños y cálculos corrientes del producto		X X	X		X X	X X		X X	X		X X	X X		X X X	X X		X X	X X
I	14	Literatura técnica de acompañamiento del producto		X			X			X	X		X	X		X X	X X		X X	X X
II	15	Procesos de producción y métodos		X			X X	X		X X	X		X X	X		X X	X		X X	X X
II	17	Tiempos		X			X X			X X			X X X			X X			X X	X
II	18	ProgramaciónCN,CNC, Ópticos y otros especiales		X	X		X	X		X X	X		X	X		X X	X		X X	X X
II	21	Metrología	X	X		X	X		X	X X		X X	X X		X X	X X X		X X	X X	X
II	22	Órdenes de fabricación, fichas de trabajo y simil.		X			X			X X			X X X			X X			X X	X
II	23	Planificación producción. Previsión plazos entrega		X			X			X	X		X X	X		X	X		X X	X X
II	24	Compra mat. prima, semielaborados y componentes		X X			X X			X X			X X	X		X X	X		X X	X X
II	26	Control de calidad de (24)	X	X		X	X		X	X X		X	X	X	X X	X X	X	X X	X X	X X
II	28	Herramienterías: mantención, calibraje, mont.,etc.	X X			X	X X		X X	X X		X X	X X X		X X	X	X	X X	X X	X
II	29	Preparación trabajo, corte materiales, similares	X	X		X	X		X	X X		X	X X		X	X X		X X	X X	X X
II	30	Preparación de las máquinas	X			X X			X X	X		X X X	X X		X X X	X X		X X	X X	X X
III	31	Directos con máquinas, A/B	X X			X X			X X X			X X X X			X X X X			X X X X		
III	32	Directos sin máquinas, A/B	X X			X X X			X X			X X			X X X			X X X		
III	33	Directos: montadores; A/B	X X			X X	X X		X X	X X		X X	X X		X X	X X		X X	X X	
III	34	Mano de obra auxiliar de la producción	X			X			X			X			X X			X X X		
III	35	Capataces y subcapataces	X	X X		X	X X		X	X X		X	X X		X X	X X		X X	X X	
III	36	Controles de calidad en el curso del trabajo	X X			X X	X X		X	X		X	X X		X X	X	X	X X	X X	X X
III	37	Controles de calidad finales	X X	X		X	X		X X	X X		X	X		X X	X X	X X	X X	X X	X X
III	39	Dirección de la producción		X	X		X	X X		X X	X X		X	X X		X	X		X	X X
IV	40	Administración de los stocks, almacenes, etc.		X			X X			X			X X			X X			X X	X X
IV	41	Mantención de máquinas, equipos e instalaciones	X X			X	X X		X	X		X X X	X		X	X	X X	X X	X X	X
IV	42	Técnicos de ventas		X			X X			X	X		X X	X		X	X		X X	X X
IV	43	Asistencia técnica postventa	X			X			X X			X	X X		X X	X X	X	X X	X X	X X
IV	45	Informática		X			X	X		X	X		X X	X		X	X		X X	X
I	01	Selección y definición del producto - Marketing						X			X			X X		X	X X		X X	X
I	06	Puesta a punto de prototipos						X	X	X	X	X	X X	X X	X	X	X	X X	X X	X X
II	19	Concepción y diseño equipo aux. de fabricación					X			X X			X			X X	X		X X	X
I	07	Of. técnica de ventas: oferta eq no estandarizado								X	X		X X	X		X X	X X		X X	X
I	10	Normas técnicas internas y otras								X	X X		X	X		X X	X		X X	X
I	13	Documentación técnica y biblioteca								X			X			X			X	
	03	Laboratorios de investigación aplicada											X	X X	X	X	X X			
I	09	Diseños y cálculos de instalaciones completas											X X	X X		X	X X	X X	X	X X
I	11	Especificación servicios, partes y p.de terceros											X	X		X	X		X X	X X
II	20	Elaboración propia de eq. aux. de fabricación										X	X X		X	X		X X	X	X
II	25	Contratos y manufactura de terceros											X	X		X	X		X	X X
I	27	Control de calidad (25)										X	X		X X	X		X X	X X	X X
I	04	Centros de cálculo														X	X		X	X X
I	05	Puesta a punto de plantas piloto													X X	X	X	X X	X	X X
I	12	Análisis proyecto según métodos y procesos														X	X		X	X
II	16	Procesos de fabricación de concepción propia														X	X		X	X X
III	38	Pruebas de performance especiales y/o según normas														X X	X X		X	X X
IV	44	Departamento de Sistemas														X	X		X	X X
I	02	Laboratorios de investigación teórica																X	X	X

E, I, A and C, how the different instruction levels vary with the T dimension increase of the industries. Those symbols represent:

- **E.** **Embryonal, Elementary** instruction.
- **I.** **Intermediate** level instruction.
- **A.** **Advanced** level instruction.
- **C.** **Complete** instruction (in knowledge and variety of specializations).

Naturally, the **model-table** interprets the whole EMI in operation and not only a subsector or sector, and specifically the EMIs operating with critic **mass** proportioned to the **N** level of the products they manufacture. As always, some isolated cases cannot be taken as a rule in this respect.

Through this table of reference it may be understood how **POLs**, due to their being linked to **N** and **T**, in the end would not go too far beyond their needs of human resources from those required by EMIs, even if they were strongly present.

The structure or equilibrium differences which might arise in relation to the **model-table** would not depend fundamentally of whether the production is specialized or by means of a **POL**, but rather on another more remarkable fact, namely, that of manufacturing by creating, analyzing and designing the products or then simply reproduce them under licence. In reality, when a manufacturing licence is acquired, there is a certain **relief** on some K.Hs., as indicated in the first column **TR.K.H.** with **x** and with **/o**. With x the K.Hs. are pointed out which are usually wholly transferred with the licence, while with **/o** are indicated those K.Hs. which are only partly transferred (some documents and/or technical assistance) or which may also be optional.

What in fact happens, and this is exactly illustrated by the **model-table**, is that up to **N3**, total K.H. transfer is scarcely applied to Groups II and III. This means that an undeniable local effort must be made here. Then, if in specialized concerns it is evident that up to N3 technological level K.H. Groups II and III must receive a formation **without errors** (see op.cit.9/), with still more reason this will be valid for POLs or a group of POLs belonging to intensive industrialization programs in the Third World. This because POLs condense in a single production unit a larger variety (acquired) of Group I K.H. than a specialized concern of the same dimension, requiring as a counterpart large operational elasticity and agility in Groups II and III. For such reason POLs must emphasize the formation of K.Hs. II and III, anticipating it to the development of K.H. I. This need is clearly pointed out in the **model-table**, as indicated in the following summary:

T	Nr.KH I	%	Nr.KH II	%	Nr.KH III	%	Nr.KH IV	%	Nr. Total	%
T1	2	14	11	69	8	89	5	83	26	58
T2	4	29	12	75	8	89	5	83	29	64
T3	7	50	12	75	8	89	5	83	32	71
T4	10	71	15	94	8	89	5	83	38	84
T5	13	93	16	100	9	100	6	100	44	98
T6	14	100	16	100	9	100	6	100	45	100

Another complementary aspect is represented by the marked percentage presence of technicians in front of the remaining types up to managerial dimension T3. Although this is only a model, the role by them represented should be considered, especially when the technical institutes which prepare them are well equipped for carrying out this task.

Due to its operative variety, the POL requires a strong participation of indirects, above all in K.H. Groups II and III, stronger than that of specialized production concerns. It will therefore be advisable to accompany the sound formation of machine operators amd assemblers, namely of directs, with that of technicians, anticipating the quality and efficiency of their formation to that corresponding to professionals.

When POLs operate at N4 level instead, they should be able to count with the solid participation of elements pertaining to superior formation, regardless of their proportion being low, about 3% of total personnel occupied, due to the acquisition of K.H. Such proportion may even be lower for POLs operating with N1, N2 and N3 products.

From the viewpoint of human resources, POLs do not present therefore specific qualitative requirements of their own. Only some proportions are modified in the structures of personnel, which are added to the distorsions caused by apprenticeship. In individual terms, the greater pressure is exerted over K.H. 39, **Production management**, which by definition must be very efficient, followed of course by production programming, K.H. 23.

To conclude, one might affirm then that the quality and variety of the professional formation required by POLs does not differ greatly from the rest of the concerns constituting EMI and that its establishment depends directly on the correlation T-N, as deduced from model-table 16. Further details may be obtained by consulting the work already mentioned in 9/.

5.2 Use of PROGRAM 5

Let us observe again the exercize of Chapter 4. Suffice it to leaf through summary pages of factors A3, that is, of production equipment, to obtain a good guide line regarding the variety of factors used (horizontal reading) and their degree of sophistication or productivity (vertical reading). Totals of columns S1, S2 or I1, I2, etc. do not correspond to personnel occupied. They indicate how many times the factors of an specific production technology have been used, on the basis of data of specialized concerns which make text in this sense.

Now then, considering that POLs are justly constituted for producing only a fraction of the variety and quantity manufactured by specialized concerns, it is easily understood how each coinciding point of the machines in use should manufacture parts for quite different products. Thus, the vertical additions will not coincide with the machines in use required for the POL and consequently direct personnel will be inferior to such additions.

But it has already been seen that POLs cannot operate adequately if they move away from the characteristic critic mass of the products they are intended to manufacture. Considering that in the exercize of Chapter 4, T3 was set as a limit, in a first attempt the following intermediate values could be selected: 400-450 persons occupied for ANNEX 12 POL, and 300-350 for ANNEX 14 POL. Applying in each case proportions known between directs and indirects - for instance 60%-40% - and assuming that about 70% of the directs be with machines, quantities comparative with additions (S1+S2) will be obtained at once on one side, and on the other the qualifications required in each K.H. variety. If instead of two POLs there would be a real case of 20-25 POLs, with T between 200 and 500 persons occupied, the advantages derived from PROGRAM 5 will be understood as regards the fact of advancing in some years the technological speculations in relation to their real application, and therefore dealing with the subject of professional training with due anticipation and precision.

The same occurs with summaries related to B1 and B2. Here, more than the correlation **number-machines**, the information should be used to refer it to specialized manual labor requirements and their respective indirects. Because the subject is **infrastructure** or the famous **industrial weave**, the speculations on POLs through PROGRAM 5 will have the double merit of not only determining with anticipation the qualificative profiles required in an industrial program, but also of automatically tracing the basic lines for a technological diagnostic of the existing technological weave, establishing whether it is qualitatively prepared or not for absorbing an specific program being conceived.

Although PROGRAM 5 was not prepared for dealing with the subject of manual labor, its usefulness is recognized until the opportunity arises of elaborating a more complete specific PROGRAM applicable to any type of industrialization, up to at least T4.

Chapter 6

SUMMARY OF THE TECHNOLOGICAL COMPLEXITY INDEX METHODOLOGY

In order to familiarize the reader with the origin and the language of the Ic, technological complexity Index of the products, its composition structure is presented in this brief chapter.

As a matter of fact, considering that the subject has been dealt with extensively,1/ the only way of summarizing it is showing how the Ic is calculated.

The **Ic**, technological complexity Index of an electro-mechanical product is defined as "**the quantity of complexity contained in a certain product, revealed through 103 characteristic factors, selected in due time, the participations and influences of which may be addible**".

Technological complexity has therefore been identified with every kind of technical difficulty found along the sequence:

PRODUCT CONCEPTION - LABORATORY - PROJECT - PRODUCT ADJUSTMENT - PRODUCT EVOLUTION - MANUFACTURE - ASSEMBLY.

Consequently, the 103 factors should reflect in a fairly condensed synthesis, every technical and technological aspect arising since the product conception up to its internal or external assembly.

The previous sequence is materialized in three very differing atmospheres, namely:

- **The concerns responsible for the final product.**
- **Infrastructure** (industrial weave) **concerns.**
- **The suppliers of components.**

The factors interpret these three atmospheres and represent them gathered in three large groups:

A. **Manufacturing or production unit factors.**

B. **Infrastructure factors.**

C. **Component factors.**

On their turn, these will originate another subdivision:

Symbols		Groups
A	A1	Global production unit factors
	A2	Know-how factors
	A3	Production factors
B	B1	Semi-finished product factors
	B2	Third parties' specialized services factors
C	C	Metallic component (and accessories) factors

Finally, the factors in each group are distributed as shown below, with indication of the progressive number of the factor, its symbol and its denomination, through which one will be able to have an idea regarding the extension of the subject covered by the Ic.

A1 - GLOBAL PRODUCTION UNIT FACTORS

Progressive Factor Nr.	Symbol	Factor Denomination
001	P	Weight
002	Q	Quality and responsibility
003	Vt	Variety of types produced
004	Vm	Variety of models produced
005	S	Manufacture characteristic series
006	M	Assembly
007	Hd	Direct hours of manufacture per ton of final product
008	Tm	Minimum manufacture dimension advisable

A2 - KNOW-HOW FACTORS

Progressive Factor Nr.	Symbol	Factor Denomination
009	Hs	Number of hours of engineering office per US$1,000 of final product a/
010	L	Laboratories
011	Fp	Product evolution due to production means and to materials
012	Fc	Conceptual and intrinsic product evolution
013	Ig	"Mini-Engineering"

a/ 1976 US$.

A3 - PRODUCTION FACTORS

Progressive Factor Nr.	Symbol	Factor Denomination
014	E.01	Oxygen-cutting
015	E.02	Cutting without shaving production
016	E.03	Tinplate, sheet and plate press-breaking, folding, bending, flanging, cambering
017	E.04	Cold metal-forming of wires, bars, bands, profiles and tubes
018	E.05	Riveting, threading, upsetting, rotary metal-forming, etc.
019	E.06	Punches, combined machines, universal and specific
020	E.07	Cold stamping and deep-drawing presses
021	E.08	Shaft straightening, plate leveling, plate drawing and others
022	E.09	Lines for plate profiling, specific extrusion, wire drawing
023	E.10	Other cold metal-forming machines
024	E.11	Horizontal lathe work, single spindle
025	E.12	Vertical and horizontal lathe work with two or more spindles
026	E.13	Semi-heavy and heavy lathe work, vertical, horizontal and face lathe work
027	E.14	Specific lathe work such as spherical, globoid, for relieving, threading, oval, etc.
028	E.15	Shaping and slotting machines, planers for keyseats
029	E.16	Heavy machines, others: planers, planer-milling machines, milling and boring machines
030	E.17	Milling machines, except the heavy ones of E.16
031	E.18	Drilling machines and radial drills
032	E.19	Every type of metal-cutting threading machine

(Cont. of A3)

Progressive Factor Nr.	Symbol	Factor Denomination
033	E.20	Boring machines
034	E.21	Broaching
035	E.22	Cylindric, internal-external grinding
036	E.23	Special grinding: threads, profiles, cams, spline shafts, etc.
037	E.24	Surface grinding and grinding machines, others
038	E.25	Superfinishing: honing, lapping and polishing
039	E.26	Machines for gears: cutting and chamfering-rounding
040	E.27	Machines for gears: shaving, grinding, SFC lapping, HV lapping, coupling and others
041	E.28	Multi-functioning machines: transfer machines, machining centers, etc.
042	E.29	Machines conceived and manufactured by the utilizer himself
043	E.30	Assembly machines and robots
044	E.31	Combined metal-forming and metal-cutting machines or other combinations
045	E.32	Electric machining and leading-technology machines
046	E.33	Materials metal-cutting: circular, hack-shaving, band shaving, others
047	E.34	Metal-cutting machines others and miscellaneous production machines not elsewhere considered
048	E.35	Every type of weld
049	E.36	Winding machines, coilers, etc. for electric motors and others
050	E.37	Machines and/or installations for filling, emptying, gluing, engraving, etc.
051	E.38	Machines for plastic, rubber, etc.

(Concl. of A3)

Progressive Factor Nr.	Symbol	Factor Denomination
052	E.39	Machines and/or installations for pickling, washing, degreasing, with sandblast, etc.
053	E.40	Furnaces and dryers
054	E.41	Miscellaneous galvanic processes and others
055	E.42	Baths and various superficial protections including enamel and insulation
056	E.43	Paint
057	E.44	Destructive and non-destructive quality controls of own manufacture
058	E.45	Quality controls of raw materials, cast, forged, third parties' pieces and components

B1 - SEMI-FINISHED PRODUCT FACTORS

Progressive Factor Nr.	Symbol	Factor Denomination
059	B.01	Cast iron, conventional processes
060	B.02	Carbon steel casting and common alloys
061	B.03	Non-ferrous casting, conventional processes
062	B.04	Strategic materials casting
063	B.05	Die-cast, centrifugal and others
064	B.06	Other processes: micro-casting, shell-molding, shielding and others
065	B.07	Free forging, excluding strategic materials
066	B.08	Stamped forging, excluding strategic materials
067	B.09	Strategic materials forging
068	B.10	Specific extrusion and other metal-forming processes for the utilizer's exclusive application

B2 - THIRD PARTIES' SPECIALIZED SERVICES FACTORS

Progressive Factor Nr.	Symbol	Factor Denomination
069	B.11	Tension relief, annealing, etc.
070	B.12	Thermic treatments, cementation and others
071	B.13	Superficial metallic deposits, protections, galvanoplastics, etc.
072	B.14	Manufacture and maintenance of metal-cutting and cold-forming tools, excluding simple and serial ones
073	B.15	Dies
074	B.16	Drop-forging dies, shields, etc. for hot metal-forming
075	B.17	Molds for plastic and others
076	B.18	Jigs, clamp-jigs and general manufacture auxiliary equipment
077	B.19	Light boilershop services, ferrous and non-ferrous
078	B.20	Medium boilershop services, up to plates of $1\frac{1}{4}$" or 30 mm. thickness
079	B.21	Complete gears or tooth cutting only
080	B.22	Fine specialized machining
081	B.23	Specialized medium and semi-heavy machining
082	B.24	Cold pressing
083	B.25	Metallic and other labels for identification, use instructions and maintenance

C - COMPONENT FACTORS

Progressive Factor Nr.	Symbol	Factor Denomination
084	C.01	Mechanical components of one or few pieces
085	C.02	Mechanical components of several pieces, up to 100-150 kg.
086	C.03	Mechanical components of several pieces, the remainder
087	C.04	Hydraulic components
088	C.05	Pneumatic components
089	C.06	Vacuum components
090	C.07	Electric control and checking components and related applications
091	C.08	Electric power and other components for different industrial applications
092	C.09	Electronic components
093	C.10	Electric motors, stepless motor variators and others
094	C.11	Components for linear, angular and plane measurement
095	C.12	Lubrication components and eventual friction bearings
096	C.13	Refrigerating components with water or liquid circulation
097	C.14	Cold components
098	C.15	Components for steam, gas, corrosive or not, every temperature
099	C.16	Electric instruments
100	C.17	Optical, infrared and other instruments - Rays in general
101	C.18	Instruments, others
102	C.19	Specific metallic components of the product or its branch
103	C.20	Specific non-metallic components of the product or its branch - Selected list

In short, the factors selection resulted as indicated below:

Symbol	Group	Factors Nr.
A1	Global production unit factors	8
A2	Know-how factors	5
A3	Production factors	45
B1	Semi-finished products factors	10
B2	Third parties' specialized services	15
C	Component factors	20
	Summary	
A	Manufacture factors	58
B	Infrastructure factors	25
C	Component factors	20
TOTAL FACTORS (A+B+C)		103

Each factor may participate with up to 6 degrees of use intensity called **factor openings**, from (1) to (6), thus forming a matrix of 103 x 6 technological situations starting from which the product **Ic** will be determined. Openings from (1) to (6) represent increasing technological difficulties to which points are assigned; these points accompany in geometric progression the increase of technicality and/or of difficulty characterizing the participation of each factor.

For different reasons, not every **factor-opening** correlation is usable; those effectively used will be 480 instead of the theoretical 618 (103 x 6).

The **Ic** matrix will then be composed of 480 points. To each of them a description of the matter therein contained is attributed in the first place, followed, through fairly arduous reasonings, by the points corresponding to the degree of technological difficulty implied by each point. In this way a background scenery is obtained, on the basis of which the most different electro-mechanical products are considered.

The following is the procedure for calculating the Ic of a product. First, attention is drawn on the intervening factors, pointing them out on the Ic form. In this respect, a form is added as an example, just as it is used in field works, where it is clearly indicated which are the 480 possible correlations of the factors-openings matrix. In the second place, it is carefully analyzed which is the opening corresponding to each factor, using to that effect the "ENGINEERING MANUAL FOR CALCULATING THE Ic", ANNEX A, op.cit.1/. Finally, considering that to each factor-opening correlation a definite point corresponds, the sub-totals of A1, A2, A3, B1, B2, and later on of groups A, B, C, are calculated in order to obtain the final score, that is, the number identified with the product Ic.

Of course, the great number of combinations offered by the Ic matrix is easily recognizable, since the factors intervene according to products in varying quantities, from a minimum of 10-12 for example, to the total of 103, and also with a marked intensity difference of participation characterizing highly differing technological profiles.

This is the reason why the Ic scores obtained from a large number of quite varied electro-mechanical products be diluted between the extremes of 25 and 560 points, interpreting the most simple and the most complex products, respectively.

These scores constitute therefore the extremes of the Technological Complexity Scale, Ec, along which any electro-mechanical product may be situated.

FUENTE:

DENOMINACION PRODUCTO:

DATA:

Nº:

GRUPO:

Nº	SIM.	1	2	3	4	5	6	MIN	MAX	MED
001	P									
002	Q									
003	Vt									
004	Vm									
005	S									
006	M									
007	Hd									
008	Tm									
TOTAL A1										
009	Hs									
010	L									
011	Fp									
012	Fc									
013	Ic									
TOTAL A2										
014	E.01									
015	E.02									
016	E.03									
017	E.04									
018	E.05									
019	E.06									
020	E.07									
021	E.08									
022	E.09									
023	E.10									
024	E.11									
025	E.12									
026	E.13									
027	E.14									
028	E.15									
029	E.16									
030	E.17									
031	E.18									
032	E.19									
033	E.20									
034	E.21									
035	E.22									
036	E.23									
037	E.24									
038	E.25									
039	E.26									
040	E.27									
041	E.28									
042	E.29									
043	E.30									
044	E.31									
045	E.32									
046	E.33									
047	E.34									
048	E.35									
049	E.36									
050	E.37									
051	E.38									
052	E.39									

Nº	SIM.	1	2	3	4	5	6	MIN	MAX	MED
053	E.40									
054	E.41									
055	E.42									
056	E.43									
057	E.44									
058	E.45									
TOTAL A3										
059	B.01									
060	B.02									
061	B.03									
062	B.04									
063	B.05									
064	B.06									
065	B.07									
066	B.08									
067	B.09									
068	B.10									
TOTAL B1										
069	B.11									
070	B.12									
071	B.13									
072	B.14									
073	B.15									
074	B.16									
075	B.17									
076	B.18									
077	B.19									
078	B.20									
079	B.21									
080	B.22									
081	B.23									
082	B.24									
083	B.25									
TOTAL B2										
084	C.01									
085	C.02									
086	C.03									
087	C.04									
088	C.05									
089	C.06									
090	C.07									
091	C.08									
092	C.09									
093	C.10									
094	C.11									
095	C.12									
096	C.13									
097	C.14									
098	C.15									
099	C.16									
100	C.17									
101	C.18									
102	C.19									
103	C.20									
TOTAL C										

ESPAÑOL : FUENTE — DENOMINACION PRODUCTO — DATA — GRUPO
FRANÇAIS : SOURCE — DENOMINATION PRODUIT — DATE — GROUPE
ENGLISH : SOURCE — PRODUCT DENOMINATION — DATE — GROUP

COMO PROGRAMAR LA INDUSTRIA ELECTROMECANICA
TOMO I — FRANCO VIDOSSICH

In order to avoid erroneous interpretations it should be clarified that the product must not be identified with large groups or product compositions, as would be the case of a bakery, a foundry or a facility for brick manufacturing. In such cases the Ic will only refer to an oven for bread, a cupola with certain characteristics, a press for bricks, etc., and not to the group to which they are bound for.

Ec scale, just as any other scale, may be fractionated. If it is subdivided into 6 segments in geometric progression, fields of similar and comparable technological levels are obtained, called N1, N2,...., N6, respectively, from the most simple to the most complex.

Another subdivision into 100 segments originates Uc complexity unit, devoted to more academic speculations which escape from the objectives of this essay.

In order to have an idea of the subject or of the definitions contained in openings from (1) to (6), group A1 factors are selected as an example:

Factor 001: **Weight.**

1. Light and current industry.
2. Medium industry.
3. Semi-heavy industry.
4. Heavy industry.
5. Microelectro-mechanical, fine optics and microelectronic industry.
6. Super-heavy industry.

Factor 002: **Quality and responsibility.**

1. Without national and/or international norms.
2. With some elementary norm, without it implying juridical responsibility. Geometric, functional and/or materials norms.

3. With national or international norms ISO type for instance, with juridical value in case of divergence between the seller and the utilizer in general.
   Responsibility of the object limited to the fact that it is a non-dangerous product or which may cause grave damage to third parties due to malfunctioning.

4. With national or international norms related more to safety than to the precision of the product, reversing the order of both which characterizes point (3). It is applied to common ground collective transport, to vertical transport, to load transport, etc. Homologation certificates.

5. The same as (4) but extended. That is to say, mass collective transport such as railway and maritime. High-speed transport in general. Aeronautic norms for aircrafts, light helicopters and hovercrafts. Homologation certificates.

6. Norms for passenger airplanes, astronautic, etc. Homologation certificates according to advanced and/or highly demanding and special norms.

<u>Factor 003:</u> **Variety of types produced.**

1. Up to 3 basic types.
2. From 4 to 15 types.
3. From 16 to 50 types.
4. From 51 to 250 types.
5. From 251 to 500 types.
6. With more than 500 types.

<u>Factor 004:</u> **Variety of models produced**

1. Up to 3 models.
2. From 4 to 7 models.
3. From 8 to 15 models.
4. From 16 to 30 models.
5. From 31 to 50 models.
6. With more than 50 models.

<u>Factor 005:</u> **Manufacture characteristic series.**

1. Continuous or very high series.
2. From 5,000 to 500 models per year or repetitive series of 5,000-500 models, produced at regular intervals during the year, according to requirements.

3. From 500 to 100 models per year or same number repeated during the year at regular intervals, according to requirements.
4. From 1 to 3 models per month.
5. Repetitive unitary manufacture.
6. Special unitary manufacture, non repetitive.

Factor 007: **Direct hours of manufacture per ton of final product.**

1. Up to 125 direct hours/ton of final product.
2. From 126 to 250.
3. From 251 to 500.
4. From 501 to 1,000.
5. From 1,001 to 2,000.
6. With more than 2,000 direct hours per ton.

Factor 008: **Industrial dimension.**

1. From 50 to 100 persons occupied (direct and indirect).
2. From 101 to 250.
3. From 251 to 750.
4. From 751 to 1,500.
5. From 1,501 to 5,000.
6. With more than 5,000 persons occupied.

Factor 009: **Number of engineering office hours per US$ 1,000 of final product (1976-77 US$)**
(First factor of subgroup A2)

1. Up to 0,5 hours of KH/1,000 of finished product, FOB factory, without packing or eventual sale taxes.
2. From 0,6 to 1,5.
3. From 1,6 to 2,5.
4. From 2.6 to 3.5.
5. From 3,6 to 4,5.
6. From more than 4.5 hours/US$ 1,000.

For all remaining factors a vast description of the subject related to each opening exists, according to the patterns of factor 002, **Quality and responsibility**, and even with further detail.

How the Ic was calculated is thus briefly exposed. A thorough understanding of the numerous nuances and of the background logic upon which the technological complexity matrix is based will be obtained by reading op.cit.1/.

In this manner we assume to have supplied a general idea regarding the Ic, indicating at the same time the symbols and terminology most frequently used in the text.