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Progress Report

# WORLD-WIDE STUDY ON CAPITAL GOODS INDUSTRY *)

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## Introduction

1. The objective of this report is (i) to describe the progress made on the World-wide Study on the Capital Goods Industry and (ii) to outline the approach and initial findings. An indication is also given of the manner in which the study might be continued and completed.

2. It will be recalled that a preliminary version of the study on the capital goods industry was completed in April 1978 and transmitted to the members of the Industrial Development Board at its 13th Session (24 April - 4 May 1978). That version contained recommendations for further work and in-depth study, and a summary of its principal findings and conclusions are given below.

## Summary and conclusions of the preliminary study

3. The Preliminary Study on the Capital Goods Industry was directed towards two main objectives: (i) to describe the problems and development prospects of the capital goods industry; and (ii) to contribute to the formulation and organization of the world-wide study of this branch of industry. Capital goods are a complex grouping encompassing millions of products that form the basis for the accumulation of fixed capital. The approach adopted for the study requires a defined methodology that is applicable at national and international levels. The classifications used which are presented in a three-dimensional manner depend on:

(a) The final demand (the sectoral use of capital goods);

(b) The products as a function of technical routes (the method of production); and

(c) The degree to which the capital goods industry exists in the developing countries.

These interrelationships and their superposition permit a broad typology of capital goods.

4. In the preliminary study it was established that 97-98 per cent of all capital goods are produced by the industrialized countries and that the developing countries have only a 2-3 per cent share in production and 1.5 per cent share in world exports. Capital goods manufactured in the developing countries originate essentially from five countries: Argentina, Brazil, India, Mexico and the Republic of Korea, which produce some 80 per cent of the capital goods stemming from developing countries with market economies. Five other countries - Chile, Colombia, Egypt, Pakistan and the Philippines - produce another 12 per cent, the remaining 8 per cent being distributed among Algeria, Iran, Malaysia, Morocco, Nigeria, Peru, Sri Lanka, Thailand, Tunisia, Turkey and Venezuela. In the final analysis, it would appear that 96 countries and 18 territories do not have even an embryonic capital goods industry. Of the latter, 34 countries and 18 territories have less than one million inhabitants, 50 between one and ten million and 12 more than ten million.

5. These findings indicate the need for specific and realistic policies relating to the production of capital goods in each of the groups under consideration. This is of particular relevance to the group comprising the smallest and poorest countries where feasible production policies must be identified, as well as the range of capital goods to be produced.

6. The policy of basic needs which is being promoted within the United Nations system could serve as a first criterion in expressing final demand. In subsequent stages, it will be necessary to examine the implications this policy will have upon the capital goods industry in the countries concerned.

7. From the point of view of production processes, certain capital goods are common to a variety of end-uses. This would suggest new approaches to the strategy that developing countries should adopt when entering these fields of activity, and it would suggest that investment projects should be evaluated in terms of analogous product groups rather than on a product-by-product basis.

8. It is essential that the international community recognise the need to create and develop a capital goods industry in the developing countries. Without doubt, the absence of a capital goods industry is one of the most significant indicators of underdevelopment. Without a capital goods industry, the developing countries - even if they achieve rates of industrial growth corresponding to the objectives of the Lima Declaration - cannot escape from their dependence. In fact, dependence will be accentuated by industrialization. Their industrial fabric will depend exclusively on the industrial and technological centres of the industrialized countries. Domestic, and even sub-regional, integration of industries would become almost impossible. The problem thus takes on a political aspect. It relates not to interdependence, but to the selection of modalities.

9. By virtue of its direct action and the indirect measures needed for the associate infrastructure, the capital goods industry is a motive force behind, and a key to, development. It creates the conditions not only for the exploitation of the industrial system, but also for its perpetuation. The establishment of a capital goods industry is essential to the avoidance of those pseudo-transfers of technology, in which no provisions are made for assimilation of the technology transferred. Because it encompasses a large range of technologies, the capital goods industry and its associate engineering infrastructure make it possible to escape from a mimetic mode of transfer and thus open up the way to the creation of local innovative capacities.

10. The essential condition for the realization of appropriate technologies is the establishment of focal points whence a capital goods industry might grow, together with research and development capacities. Technologies with an intensive labour-content which incorporate less fixed capital are not generally developed in the industrialized countries. Consequently, this task can only be carried out by capital goods industries in the developing countries themselves.

11. A characteristic of the capital goods industries is their relative inexpense in terms of fixed capital investment for each job created. From this point of view, they are not "heavy" industries such as iron and steel production or agro-industry. Their establishment and development therefore contribute substantially to combating unemployment and under-employment in many developing countries.

12. However, these very industries require highly skilled labour. At the same time, improving skills could constitute an objective in itself, since its realization would contribute towards reducing those inequalities existing between the industrialized and developing countries. The availability of skilled labour requires not only specific training activities but also an adequate educational level. Basic training provides the "entrance ticket" into the capital goods industry activity. This implies a consequential orientation of the educational system over the long term in the developing countries.

13. The very logic of the Lima Declaration calls for the establishment and development of capital goods industries in the third world countries. The realization of the objectives would signify a rapid growth in manufacturing production and a sudden break with the rates observed in the past. A demand for capital goods would ensue which would be proportionately even greater. If this demand is only met through imports, the resultant deficits in the balance of trade will be insuperable. It is, therefore, essential that at least part of the equipment is produced locally.

14. An initial extrapolation into the future helps one to establish the probable magnitude of the growth of the capital goods industries in the developing countries and its implications for international trading.

15. Application of the UNCTAD and UNIDO models (World Industry Co-operation Model) would indicate that the general 25 per cent target set in the Lima Declaration will not be achieved in the capital goods sector. However, by the year 2000 a developing country share of some 15 per cent in the world production of capital goods would be consistent with the overall objective.

16. These projections, irrespective of the hypotheses, also suggest that the industrialization of the third world would constitute an enormous outlet for the capital goods industries in the industrialized countries, and thus become an essential factor in the advancement of their economies. Consequently, and according to the hypotheses used in the UNIDO model, net capital goods exports from the industrialized countries to the developing countries would be equivalent (despite envisaged local production) to between 40 - 60 per cent of their 1970 production (as against 4 per cent at present). This, therefore, involves a major modification in the structure of international trade, with mutual benefits.

17. The future will depend on the projects of the international partners, and the compatibility or incompatibility thereof, as well as on the degree and modalities of this co-operation. The image of the year 2000 cannot, therefore, result from mechanical projections of past trends. Whereas the latter may form a useful background for reasoning, the claim that the future will be a continuation of the past cannot be upheld. It is necessary to move on to prospective projections: this implies explicitly taking into account the actors concerned, their projects and their strategies, which lend concrete form to the objectives, problems and means of action.

## New developments in the world-wide study on the capital goods industry

18. The primary objectives of the world-wide study are:

(a) To establish a logistic base for the consultation process; and

(b) To assist national policy-makers in developing countries in providing information on the instruments and action needed to determine possible ways and means of initiating or improving the development of a capital goods industry.

This presents a dual requirement and a dual challenge: on the one hand, a capital goods policy has to be conceived for different categories of developing countries which form a very heterogeneous whole; on the other hand, no class of capital goods may be excluded a priori from the analysis. As a matter of fact, the major developing countries have

manifested their ambition to achieve by the end of this century the status of important industrial powers producing very sophisticated capital goods. At the other extreme, for the less developed countries the question arises as to which type of capital goods they could reasonably produce during the next twenty years. Consequently, the study must cover all aspects of capital goods equipment: from the simplest to the most complex.

19. The selection of capital goods equipment to be produced locally is a national responsibility. It is not the task of UNIDO to make this selection, but during the decision-making process, UNIDO can help policy-makers in developing countries by providing the elements they need for their decisions.

Outline of the world-wide study on the capital goods industry.

20. The study in progress is organized as follows:

Chapter 1. Typology of capital goods

- (a) End-uses of capital goods
- (b) Technological production routes:
  - (i) Technological complexity
  - (ii) Degree of automation
- (c) Classification by level of manufacturing difficulties
- (d) Classification by analogous production processes

Chapter 2. Production structure and international trade

- (A) Current situation of production and trade
  - (i) Concentration and specialization of production
  - (ii) Import-export markets, marketing distribution
  - (iii) Local production and export capacities of the developing countries.
- (B) Projections and prospects for the year 2000
- (a) Prinoipal actors and their projects:
  - (i) Market economy developed countries and large companies
  - (ii) Countries with centrally planned economies
  - (iii) Developing countries

(b) Global and regional projections
(c) Technological forecast
(d) Analysis of capital coefficients
(e) Evolution prices and financing requirements
(f) Employment prospects
(g) Evolution hypothesis: changes necessary for the international division of labour.

Chapter 3. Structural analysis of sub-groups (groups of capital goods for priority industries in developing countries)

(a) Main groups of products, manufacturing, localities, production conditions, complexity specifications, volume, product cycles
(b) Choice of technological alternatives, specific transfer mechanisms:
  (i) Capital goods common to all branches of industry, including machine tools and electric power generation and distribution equipment
  (ii) Capital goods for the iron and steel industry
  (iii) Capital goods for the petrochemical industry
  (iv) Capital goods for the fertilizer industry
  (v) Capital goods for the food industry
  (vi) Capital goods for the agricultural machinery industry
  (vii) Capital goods for the building industry

Chapter 4. Key role of engineering

(a) Basic facilities, mastering capacities of technological production routes, manufacturing of analogous capital goods products

Chapter 5. Research on capital goods production strategies in selected developing countries

(a) Methodology of research: terms of reference and design of analytical national case-studies
(b) Previous experience with regard to transfer, determination of production prerequisites, programming, policy measures and spatial organization at the national level in the following countries:

(i) Algeria
(ii) Brazil
(iii) Bulgaria
(iv) Mexico
(v) Republic of Korea
(vi) Spain
(vii) Yugoslavia

(c) Repercussions of basic needs policy on capital goods production and appropriate technologies

Chapter 6. International co-operation

Research on alternative forms of contractual arrangements within a consensus framework, with special emphasis on long-term sectoral development contracts

21. The study is directed towards the development of a strategy for entry into the production of capital goods which embraces all developing countries in concert with developed countries. No category or class of country is excluded.

Present status of the study

22. At present, those working on the study are deeply involved in analysing: (i) the typology; (ii) the present structure; (ii) the selection of sub-groups of capital goods; (iv) the impact of engineering; and **(v) in conducting a pilot study at the national level on the development** strategy for industry.

Typological aspects

23. In the international classification of activities (International Standard Industrial Classification of All Economic Activities, ISIC, Series M. No. 4, Rev.2) at its most disaggregated level, production is defined at a 4-digit level. It seems that this type of classification is not adequate when analysing the capital goods industry. Therefore, it has been necessary to adopt a classification system which is more detailed consisting of 6 or 7 digits. From the point of view of the manufacturing process, the Yearbook of Industrial Statistics, Volume II, 1976 Edition, fails to satisfy the requirements of the present study.

In order to cover specific sub-groups within this category, it has been necessary to add certain digits. By way of illustration, class 38 relating to engines has been disaggregated as follows:

3821.01 Internal combustion engines for gasoline

3821.02 Diesel engines up to 400 kW, series production

3821.03 Diesel engines over 400 kW, special order

3821.04 Gas engines and other

3821.05 Steam engines

3821.06 Steam turbines

3821.07 Gas turbines

3821.08 Hydraulic turbines

3821.09 Non-conventional engines (nuclear, etc.)

3821.10 Spare parts, special accessories for engines and turbines.

As a result, it has been necessary to analyse more than 400 groups of products.

24. Whereas in the capital goods industry the product can be considered as output, it can also be seen to be an input into subsequent stages of manufacture. Thus, the viewpoint depends in part on the complexity of the product in question. In the study, complexity has been measured in different ways. Although not perfect, the criterion of dollars per kilo has been applied (scale of value), and six classes chosen (coefficient a). A second criterion has been fixed: the technological life of a product or the pace of technological innovation (coefficient b), and output has been measured in terms of a and b.

25. Each group of capital goods has been classified according to these criteria: the inputs into the technological process representing in some way the explanatory variables of the output. The production function can thus be explained in terms of 38 input variables grouped according to basic facilities, technical support services and basic metallic components. For example, the basic facilities consist of iron and steel foundries, non-ferrous foundries, die-casting, centrifugal casting, other non-conventional processes, micro-fusion, shell moulding, free forging, die-forging and impact extrusion. The technical support services comprise such services as heat treatment,

metallizing, the manufacture and maintenance of machines, die-making and mould-making. The basic metallic components are components of light machines, as well as those of comparatively complex and heavy machines, hydraulic, pneumatic and electric elements for control systems, electronic and optical components, and elements used in vacuum, lubrication and refrigeration equipment.

26. Six levels of activity have been considered for each variable: Level 1 represents the first technical level of infrastructural support for the **electrical and mechanical industries. This level is generally characterized by the presence of skilled craftsmen. The workshops are normally small,** but they can supply different industrial products during the initial stages. At this level work is normally spontaneous, unrelated to any plans. However, it represents a certain embryonic status which is important to the acceleration of development.

27. Level 2 is more advanced. Generally, the enterprise is modest in size: quality standards are adhered to in respect of materials, manufacturing processes and the final product. Characteristic of this level is the broader range of products, their increased weight, greater complexity and diversity of application.

28. Level 3 relates to the 38 selected variables. It permits the manufacture of a significant variety of capital goods with a broad range of applications. Infrastructural improvement permits the augmentation of weight, the manufacture of semi-finished products, and an increase in the components' power and size. Technical support services undergo a parallel increase. This level corresponds to the final demand of an electro-mechanical industry that occupies a significant position in the national economy.

29. Level 4 reflects a fully developed situation. It requires good mastery of heavy goods manufacture on the one hand, and of micro-mechanical manufacturing on the other. Product complexity is greater, followed by a high standard of quality and of management. At this stage, laboratories and R + D centres come into effect, as does the intensive utilization of dynamic and/or functional control of the manufactured products.

30. Levels 5 and 6 reflect the e[illegible]tion of superior variables within level 4: they are strictly limited to particular industries, such as the aero-space industry, military-related industries and advanced-technology industries. For instance, the majority of the OECD countries have capital goods industries at level 4: however, a few, such as Canada, the Federal Republic of Germany, France, Italy, Sweden, the United Kingdom and the United States as well as the Soviet Union and certain other planned-economy countries have reached levels 5 and 6.

31. For all 38 variables, the technological levels necessary for the production of each group of capital goods have been identified. For example, in conventional steel foundries the following five degrees of complexity have been considered.

(i) Elementary, without norms and standards, and manual operation.

(ii) According to specific standards, carbon steel manufacture of average weight and complexity.

(iii) Special steels with chrome, nickel, molybdenum, manganese and others: semi-mechanical foundry, complex parts, and greater weight.

(iv) Special alloys: large parts, automatic equipment, superior quality control.

(v) Very complex technology for highly specialized products, generally of large dimensions, particularly for military and aero-space applications.

32. Another example of manufacture with five degrees of complexity would be the construction of moulds and shell mouldings for metals, plastics and similar materials.

(i) Low quality, large tolerances: small workshops with general equipment, simple parts with limited weight and without warranty;

(ii) Average workshop with various pieces of equipment: uniform quality, production of average scale and parts of average size.

(iii) Well equipped workshop: production of heavy parts, significant degree of know-how, guaranteed precision, normal service-life, systematic quality control, and complex shapes.

(iv) Very well equipped workshop: production of very large parts with high degree of complexity, manufacture of special parts, high level of know-how, guaranteed high precision, large-scale production, quality-control laboratory.

(v) Applications specifically for material used in aeronautical engineering, turbines, engines, military material, R + D.

This systematic fundamental analysis, which would not seem to have been undertaken hitherto, is now in the final stages.

33. For the second phase of the study, the following methodology will be applied:

(1) The different groups of capital goods will be classified according to the different levels of complexity;

(2) The comparable technological production routes will be re-grouped and analogous groups of capital goods will be classified according to the processes used in their manufacture.

34. The objective is to present a table which shows the levels, complexity and constraints, as well as the various production potentials open to a country or firm that has mastered certain technological production routes. This new information material can be used as follows:

First use: In the course of a second stage, it will be possible to translate the capital goods typology into a symmetrical questionnaire which permits the accurate evaluation of the capacities and potentials of existing production plants in the developing countries. At present, data and case studies exist, but unfortunately they are based on different methodologies which for the most part preclude the application of existing information. At a later stage, a survey designed to collect existing information as well as retrieve new information according to the method described above, will be conducted and used in the studies on capital goods in Latin America and in the ECLA/UNIDO studies.

Second use: The analysis of barriers and difficulties as well as the evaluation of existing capacities should permit national policy-makers to select reasonably their own objectives with respect to entry into, or the development of, a capital goods industry.

Third use: Examination of the difference between objectives and existing capacities should lead to the elaboration of a special national action plan for the effective increase in the levels of technological capacity. Not only will the different variables be considered in relation to established needs thus yielding selected objectives, but existing capacities will also be considered in terms of desired levels and the ways and means of achieving these levels will be identified.

35. Typological analysis of the capital goods permits the disaggregation of the technological processes involved and should provide new information on the content of technologies to be transferred. As stated above, it is important to emphasize that this type of analysis offers operational applications in comparison with the studies of technology transfer, which, over the past ten years, have generally tended to consider solely the socio-level aspects of the transfer process.

36. It is clear that the industrial configuration, the channels and the modalities of payment in technology transfer are extensively influenced by the industrial production system. The technology transferred for the production of capital goods in small runs is not the same in content as that transferred for mass-production or continuous production methods in the chemical industry, for example. The levels of technology, the channels of transmission and the sequence of operations can differ greatly.

37. It is planned to hold a meeting of experts to examine the whole methodology and the results obtained in November 1979 in Vienna. At a later date, research efforts will be directed towards the measurement of the complexity of capital goods, particularly in conjunction with the quantity of information and the level of mechanization and automation.[1/]

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1/ "Determination of the Level of Production Mechanization and Development of a Plan for the Elimination of Heavy Manual Labour" State Committee for Automation and Machine-Building of the State Planning Commission of the USSR represents an example of the type of study required.

A more elaborate example of disaggregation of technological process

38. The typological analysis described above can be refined, without any change in the methodology. An engine designed for agricultural uses and multipurpose application (Fig. 1) serves as a good illustration. The engine can be analysed in respect of both its components and the different manufacturing functions. The matrix (See Diagram 1) presents the results of this analysis. The criteria of complexity from levels 1 to 5 have been fixed for each fabrication variable (foundry, forging, machining, sheet metal, heat treatment, and finishing), and the link between the length of production run and the requisite technological levels is clearly visible. In other words, the technological constraints associated with the method of production are identified at the operational level.

39. It should be pointed out that this analysis also permits the identification of the technological content that has to be transferred, since the majority of engines, however simple, are heterogeneous in terms of technological content. From the operational point of view of technology transfer, it is essential to avoid the frame of generalities with the focus on legal analysis and to concentrate upon the analysis of technological facts.

40. Table 1 shows how these analyses can be used to determine possibilities for the national integration of manufacturing. Reading this table from the right to the left, the different possibilities open to countries or firms are suggested, ranging from the import of complete engines to their assembly, from the production of the engine block to the complete manufacture of all the individual components. The choice confronting the planners can be presented as a function of both the technological level and of the feasibility of mass production runs.

## Structural analysis of selected sub-groups

**41. A detailed analysis is being made of sub-groups of capital goods in the following industries:**

**Iron and steel industry**

**Generation and distribution of electricity industry**

**Equipment common to all branches of industry**

**Machine tools industry**

**Petrochemical industry**

**Fertilizer industry**

**Agricultural machinery**

**Construction and building industry**

**Food industry**

42. The sectors selected are either those which have been the subject of world-wide consultations (iron and steel, petrochemicals and fertilizers), those for which consultations have been proposed to the Industrial Development Board (agro-food industries), or those which are of great importance to the developing countries (construction and building industry).

43. Furthermore, it transpired in the course of the consultations held thus far that it was essential to study the capital goods industries as an industry up-stream of the relevant sector[2/]. This interest stemmed either from the problem of growing investment costs, supply constraints, or the difficulties of arbitrating between domestic manufacturers and external suppliers of equipment in developing countries with established or embryonic capital goods industries.

44. Moreover, negotiation of industrial arrangements with one particular sector is generally not restricted to the agreements between companies or governments, nor to agreements between developed and developing countries. It most frequently involves triangular negotiations with equipment manufacturers as one of the interested parties. This configuration varies according to the nature and degree of vertical integration between manufacturers in the branch under consideration and suppliers of equipment needed for the manufacturing process. Furthermore, in the developed market economy countries, certain iron and steel companies also manufacture equipment, and their promoting the establishment of competitive plants might clash with their interest in selling equipment. In the petrochemical industry, on the other hand, these interests are generally dissociated.

45. The interests of capital goods manufacturers in the industrialized countries may or may not be consistent with those of national industries in different sectors. Consequently, in order to appreciate on a realistic scale the full extent of sectoral negotiations, a structural analysis must be made of the degree to which the capital goods industry is integrated, both upstream and downstream, with the different branches of economy. This vertical integrative study must be supplemented by a horizontal study identifying the capital goods used by all sectors of industry. These goods in their various categories constitute a factor in all investment projects, the importance of which is quite considerable in terms of cost.

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2/ See "System of Consultations. Analysis of experience gained in 1976-1979, and suggestions for further development of the system in 1980 and 1981, including financial aspects. Report by the Secretariat, UNIDO document submitted to the Permanent Committee, Twelfth Session, Vienna, 17-23 April 1979, ID/B/C.3/83.

46. All sub-groups selected will be analysed with respect to site of production; leading companies and concentration of production; systems and conditions of manufacture; degrees of complexity in manufacturing and specifications; production structure; volume and scale of production; product life; international distribution of products at various stages of manufacture; specific mechanisms for technology transfer; and selection of technological alternatives. Since these analyses are designed to provide the developing countries with objective information on possible entry into the manufacture of certain groups of capital equipment, particular care has been devoted to the barriers facing the potential manufacturer. These barriers vary from industry to industry: they can be technological in nature, but they can also result from market forces. Thus, the scope of the analysis extends and takes on a socio-political context. By way of illustration, the ongoing analyses related to the iron and steel industry, to the generation and distribution of electricity, and to capital goods common to all branches of industry are outlined below.

Capital goods for the iron and steel industry

47. The iron and steel industry has been selected as a pilot sector, on the basis of which the analytical methodology has been refined. It should be recalled that investment in the iron and steel industry encompasses engineering studies, building and engineering work, the assembly of mechanical, electric and electronic equipment, erection of metallic structures, as well as other costs. In general, equipment costs represent 45 to 50 per cent of the total investment.

48. First, a list of equipment used in the various branches of the iron and steel industry was drawn up, comprising several thousand items. These items were subsequently regrouped according to principal blocs of equipment and their technological components. These can be classified according to two principal technological production routes: classical (BF + BOF, OH, LD) and new (DR + EF). In certain areas the blocs overlap: viz. preparation of raw materials and scrap, reduction of ore, preparation of coking coal, blast furnace, converters, electric furnace, continuous casting equipment, hot and cold rolling mills, tubing equipment, finishing and general equipment, and pollution control equipment.

49. At the bloc level, the main technological production routes comprise both material and equipment which together form a technological production route specific to that level.

50. Thus, at the level of the blast furnace, the level-specific technological production route can be seen to embrace such items as heavy to very heavy metallic structures, piping and tubing, valves, electric equipment, electronic measuring and control equipment, and refractory equipment. Direct reduction embraces average metallic structures, heavy to average equipment for rotary kilns, piping, valves, mechanical equipment (pumps, compressors, turbines), electric equipment and catalysts.

51. Identifying equipment in terms of blocs reveals that metallic structures, such as electric and electronic equipment, are omnipresent. Large foundries and forges are needed for rolling operations while large vessels are necessary for the manufacture of equipment and casting operations. Analysis in this manner also shows that large-scale rolling mills account for the same costs as metallic and mechanical equipment, while refractory materials are an important item in numerous blocs.

52. The analysis also provides an overview of the international division of labour among the equipment manufacturers in the iron and steel industry. It would appear that in the developed market-economy countries numerous suppliers of equipment in the iron and steel industry also produce capital goods for the chemical and petrochemical industries.

53. The study covers four large national manufacturing entities in the Federal Republic of Germany, France, Japan and the United States, as well as in certain other countries: Austria, Italy, Sweden, the United Kingdom and the USSR. The major assets of the principal actors in the different blocs are seen to be the patents, research, experience and know-how of which they dispose, as well as their engineering capacity.

54. Engineering remains the lynchpin since it not only opens up the capital goods package, but it also permits the package to be re-arranged with national equipment manufacturers and local services. On the basis of the study, it can be concluded that the production of capital equipment for the iron and steel industry cannot be separated from participation in the construction of iron and steel plants, which is the prerequisite for a

progressive learning process leading to the mastery of the technological production routes. Furthermore, examination of conditions governing entry into the iron and steel industry and subsequent developments in Algeria, Brazil, India, Italy and Tunisia, all of which are heterogenous countries, shows different, but converging experiences.

55. Without propounding a law in the scientific sense of the term, it would nevertheless seem that a sequential logic of progression exists that excludes the possibility of leaping ahead and omitting certain stages. Consequently, at the outset, the production of capital goods for the iron and steel industry begins with the production of metallic structures and simple vessel units, thereafter proceeding to the production of heavier units (Tunisia).

56. This is followed by mechanical welding operations, the construction of overhead travelling cranes and certain components for the processing of ore, and the integration of mechanical equipment, such as gear-boxes (Algeria).

57. The subsequent stage embraces the construction of principal equipment for operations both upstream and downstream of the iron and steel process, ranging from agglomeration to finishing: blast furnaces, converters and electric furnaces, continuous casting, cold and hot rolling mills. This stage is in progress in Brazil; it is more advanced in India and has already been completed in Italy.

58. A simultaneous feature of the latter stage is that it is reached when the sector has the capacity not only to construct blast furnaces, converters, or rolling mills, but also to produce complete entities, including the mechanical, electric and electronic systems, as well as the sub-systems comprising the measuring and control equipment.

59. The above process is only possible if research and study capacities are developed and plans are made and subsequently realised on the basis of accumulated experience.

60. In the light of the experience of Latin America in the field of direct reduction and the manufacture of capital goods, as well as of the experience of the national integration policy relating to capital goods production in India, the laws governing entry into, and growth of, a capital goods industry in the iron and steel sector of the developing countries can be specified.

60a. In the study, an analysis has been made of the degree to which capital goods of local origin have been incorporated in the construction of six direct reduction plants in Brazil, Mexico and Venezuela, whereby the direct reduction equipment has been broken down into nine groups. Three levels of integration have been established.

The first level (between 60 and 100 per cent) encompasses electrical equipment of average complexity, the vessels (simple and relatively complex), and piping.

The second level (30 to 60 per cent) relates to catalytic processes calling for relatively complex vessels and to the variety of reforming processes which require most complex boiler technology involving such factors as corrosion, welding and metal qualities.

The third level (from 0 to 30 per cent) comprises high-performance mechanical equipment and equipment closely related to patented manufacturing methods.

60b. The degree to which locally produced capital equipment is integrated bears a direct relation to the degree of local participation in the different engineering works[3/]. It can be seen that almost complete mastery (80 to 90 per cent) of the detailed study operations coincides with the incorporation of capital goods at the first level. The progressive attainment of supplies engineering and project engineering skills runs parallel with the integration of capital equipment at the second level. Lack of skills in basic engineering would appear to correspond to a low degree of equipment integration at the third level.

60c. This integrative process, however, does encounter certain obstacles. Analysis of the Indian experience would suggest that, although difficulties have been overcome in respect of certain blocs, such as the construction of frames, the building of blast furnaces, vessels, converter, and the manufacture of heavy rolling mill components (cages and cylinders), certain other items of equipment present problems. This "hard core" comprises high-performance mechanical equipment, heavy duty or sophisticated electrical equipment, and measurement and control equipment. The difficulties encountered in integrating this hard core lie in the insufficient mastery of the most advanced technological production routes calling for precision engineering, high-quality metals and electronics, and in shortcomings in conceptual study capabilities.

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3/ In Latin America, a distinction is made between "ingeniería de construcción" (detailed engineering), "ingeniería de abastecimiento" (engineering of supplies) and "ingeniería básica y conceptual" (basic and project engineering).

60d. Reducing this hard core is of particular importance not only to India but also to other relatively advanced developing countries, for once full integration is achieved, the threshold to international competition and export markets has been crossed. This hard core also represents the key to international co-operation, as activities along its periphery enable the developing countries to join the ranks of the fully developed iron and steel industrial powers. Thus, in the final analysis, the study should permit the conception of the levels of technical assistance needed to pass through the different stages of the production of capital goods and the establishment of iron and steel plants.

60e. In this connexion, an idea was proposed in the Second World-wide Study of Iron and Steel Industry[4/], whereby in analysing the prospects of the developing countries in the capital goods and engineering sectors, the economies of scale in the iron and steel industry should be questioned and the trend towards innovative scaling-up should be inverted in favour of innovative scaling-down.

Equipment for the generation and distribution of electricity

61. An initial study of the equipment for the generation and distribution of electricity has been conducted which confirms the immense importance of the industry supplying this equipment in all countries. The ability to supply equipment at all times in response to the growing demand for electricity is essential to the development of the industrialized countries, and it can be provided only by a powerful industry.

62. This sector is even more important in developing countries which are at the initial stage of development and whose investments are effected according to priorities, a significant portion thereof being devoted to the generation of electricity. However, industrialization in these countries, in particular the establishment of basic industries with a high consumption of electric energy, creates the need for electric generation and distribution equipment. At present, with the exception of some relatively more advanced countries, the developing countries are almost completely dependent upon the technological contribution of certain industrialized countries in the establishment of the electricity production sector. The study was thus

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4/ Prepared by the Sectoral Studies Section, ICIS. UNIDO/ICIS.89, 20 November 1978.

directed towards establishing how the developing countries could set up the basis for an electro-mechanical industry capable of producing these capital goods either independently or with outside technological assistance.

63. Using the same methodology as described above for the iron and steel industry, different types of equipment have been analysed in terms of their degree of complexity and their technological evolution has been studied. Furthermore, those firms with know-how have been identified and the problem of effecting a transfer of technology has been analysed. With respect to conventional thermal power stations, this analysis has been undertaken for boilers, condensers, water and steam turbines, gas turbines, piping, valves, generators and control and measuring equipment. With respect to gas power stations, the analysis has been directed towards the different types of turbines and compressors, while diesel power stations have been analysed with regard to technologies and equipment currently available.

64. Up till now, it has not been possible to estimate the production of electric generation and distribution equipment in developed planned-economy countries. The industrial potential of these countries is nevertheless significant and they play a prominent role in the international competition for equipment supplies to power stations and distribution grids.

65. Even if only developed market-economy countries are considered, certain characteristic features emerge. The production of steam boilers in the United States exceeds that of Europe and Japan. The output of Japan is equivalent to one third of the United States production while that of the Federal Republic of Germany, which is equal to the total production of the rest of Europe, is equivalent to one quarter of the US output. The United States also leads, albeit to a lesser degree, in the production of electric generators. Japanese production of electric generators amounts to 60 per cent of the US output, that of the Federal Republic of Germany to more than one third, and that of France to 17 per cent. In respect of distribution gear, the gap between US production and that of other countries is less marked. Japan has attained a level equivalent to 60 per cent of the US output, the Federal Republic of Germany 40 per cent and France 31 per cent.

66. Seen in its totality, the manufacture of generation and distribution equipment is dominated by the United States, the situation being governed in essence by:

(i) The size of the US market for generating equipment: it is the largest in the world and is protected against entry by foreign firms.

(ii) The demand for electricity in the United States which is the highest in the world.

Market domination by US firms is reflected in the technological level they have attained, the patents they have registered, and the research and development they have undertaken.

67. In 1975 world trade in this equipment amounted to $ 16 billion, equivalent to 11 per cent of international trade in mechanical and electrical equipment (groups 71 and 72). In the period 1965-1975, international trade in this type of equipment expanded more rapidly than for mechanical and electric equipment as a whole: in fact, world-wide trade in electric generation and distribution equipment increased fivefold (based on current prices) in the period under consideration.

68. Certain equipment such as gas turbines and nuclear reactors have enjoyed rapid growth, particularly when viewed against the low level of world-trade in this type of equipment registered in 1966 and the boom in gas/turbine power stations at a time when hydrocarbons were in adequate supply.

69. Structural analysis of international trade reveals the importance of electric generators (63 per cent of total international trade in this sector), whereas other equipment plays a relatively weak role.

70. In 1966 the Federal Republic of Germany, France, Italy, Japan, United Kingdom and the United States accounted for about 68 per cent of the international trade in this field and by 1975 their share had increased to 76 per cent with the European Common Market alone attaining a share of 50 per cent. The share of the planned-economy countries in world trade of generation and distribution equipment reached about 11 per cent in 1966 and 9.5 per cent in 1975.

71. The European countries and the United States are major importers of generation and distribution equipment and account for 55 per cent of world imports. The European Common Market is the principal import zone (20 per cent). Whereas in 1975 the developing countries imported about

$ 7,110 million dollars, o· 43 per cent of total world imports in this sector, their share in 1966 amounted to 34 per cent. The Middle East countries have experienced the most rapid growth in electrical equipment imports. In 1966 their imports represented 3 per cent of total world trade, and by 1975 this share had risen to 10 per cent.

72. Certain developing countries (Brazil, India, Mexico and the Republic of Korea) are exporters, albeit on a modest scale, and their appearance on the international market during the period 1966-1976 is worth noting. This encouraging sign, however, must not be allowed to detract from the fact that these countries' balance of trade for groups 71, 72 and 73 still shows a clear deficit[5/].

73. In summary, the study surveys principal types of material, the major firms and their characteristics, and the mechanisms of technology transfer. Technological complexity differs substantially according to the type of material, while the possibility of taking up manufacturing differs from developing country to developing country. The barriers, however, are not only technical in nature. UNCTAD studies in particular have revealed the propensity towards cartels and other restrictive commercial practices which can restrain or impede the aspirations of the developing countries in this sector.

Capital goods common to all branches of industry

74. The ongoing study encompasses 32 principal product groups (machine tools will be the subject of a separate study owing to their importance) comprising the following finished products: metal tanks and boxes; centrifuges and filters for liquids and gas; lifting and loading machinery; fork-lift trucks and other industrial trucks; packaging machinery; steam-generating boilers; air-conditioning machines; refrigerators (non-domestic); apparatus for treating material (hot, cold); pumps for liquids;

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5/ The analysis performed by the UNIDO Secretariat on UNCTAD statistics shows that the unilateral presentation of export data relative to groups of capital equipment for certain developing countries tends to be deceptive. Only certain countries enjoy a positive export balance in respect of the electric industry groups; however, their final import/export balance still appears weak, while the other developing countries suffer from a high deficit in their balance of trade.

pumps for gas; internal combustion engines (aircraft); lacquering and galvanizing facilities. Intermediate products are also treated, consisting of the components of numerous capital goods: universal plates and sheets (iron and steel); iron and steel bar, rods, angles, and shapes; hoops and strips of iron and steel; iron and steel wire; tubes, pipes and fittings of iron or steel; unworked iron and steel castings; aluminium bars and angles; non-electric wire products; tools for use in machines; metal manufactures (not elsewhere specified); ball, roller or needle-roller bearings; valves to regulate flow of fluids; transmission shafts; clutches; gears; couplings; electric-power machinery; electrical apparatus for breaking and protecting electric circuits; insulated wires and cables.

75. Sufficiently detailed statistical data on production are not available, thus making it impossible to rank the items mentioned above in the world-wide production of capital goods. In any event, it has been possible to compare the produots in SITC class 7. In 1976, capital goods common to all the sectors accounted for about 21 per cent of the world trade in capital goods in class 7 or $ 52 billion (planned-economy countries not included).

76. If it is recalled that the production of these capital goods is generally relatively easy and that they are often locally produced, it follows that their volume in international trade must be lower than the position they take up in world-wide production. They probably represent about 30 per cent of the estimated figure which is broken down in terms of the cost of investment projects in the various sectors. As in the study of the capital goods needed in the iron and steel industry, this study is designed to determine the conditions, and possibilities, of entry by the developing countries into this important branch.

Studies of other sub-groups

77. As already indicated, the study on machine tools is being organized, as is that on capital goods for the food industry. The study on the capital goods in the building industry is almost complete. The studies on petrochemicals, fertilizers and agricultural machinery industry are in progress.

## Links between the world-wide and regional studies

### Regional study in Latin America

78. The United Nations Development Programme (UNDP), the Economic Commission for Latin America (ECLA) and UNIDO agreed to carry out a joint regional study on the capital goods industry. This programme, which was initiated in 1979, will extend into 1980 and 1981 at a cost of $ 600,000.

79. The immediate objectives of the study are to:

(i) Determine current demand for capital goods in Latin America, (overall and by sector);

(ii) Project overall demand for capital goods in Latin America in 1985 and 1995;

(iii) Project, in the medium and long term, the demand for equipment in important sectors, such items as equipment for the food industry, agricultural machinery, construction machinery, machine tools, transport equipment, equipment for the petro-chemical and fertilizer industry; heavy-duty electrical machines, equipment for the iron and steel industry, and capital goods for mining and oil industry;

(iv) Assess current demand for capital goods in the public sector;

(v) Assess current capital goods production capacities (overall and by sector);

(vi) Identify the means applied by the Latin American countries to promote capital goods industries;

(vii) Identify sectoral development openings in countries with small and medium markets;

(viii) Survey world supply of capital goods and the features of international trade in respect of the selected and other strategic sectors; and

(ix) Assess the potential for expansion in domestic production and the region's capacity for external negotiation.

80. It is foreseen that UNIDO will furnish data on the world supply situation and related projections, as well as conduct a special analysis of selected groups of capital goods. A joint UNDP/ECLA/UNIDO meeting scheduled for May 1979 will offer more precise information on the plan of work and especially on the application of the typology developed by UNIDO for the identification of local production capacities in the capital goods sector.

### Other regional studies

81. At present, steps are being taken by the Industrial Development Centre for Arab States (IDCAS) and UNIDO to carry out a techno-economic study for the development of the capital goods industry in the Arab

region. Similar co-operation is foreseen with the Economic and Social Commission for Asia and the Pacific (ESCAP).

## National case studies

82. A pilot study in which an analytical method applicable to other national case studies was defined, has been carried out in Spain. The country was selected by virtue of the fact that it succeeded in establishing capital goods industry within a very brief period. The findings of the study have been evaluated in order to establish a unified methodology for country-level case studies to be carried out either directly or within the framework of the regional studies above described.

83. The study begins with a description of the evolution of the capital goods sector. It analyses the diversification of production and the technological levels achieved in the different sub-groups. These facts are related to the country context, to both its domestic historical dynamics and its international environment. Particular endeavour is made to identify clearly the specific internal and external variables.

84. The study then proceeds to analyse the economy of the capital goods sector of the country, its organisation, the technology assimilation factor, the degres of internal integration, disruptions and constraints. An attempt is also made to derive conclusions applicable to other countries.

85. It is planned to conduct similar case studies in other countries. Initial contacts have been established with Bulgaria remarkable for the development of a capital goods industry in a fundamentally agricultural country.

## Long-term technological forecasting

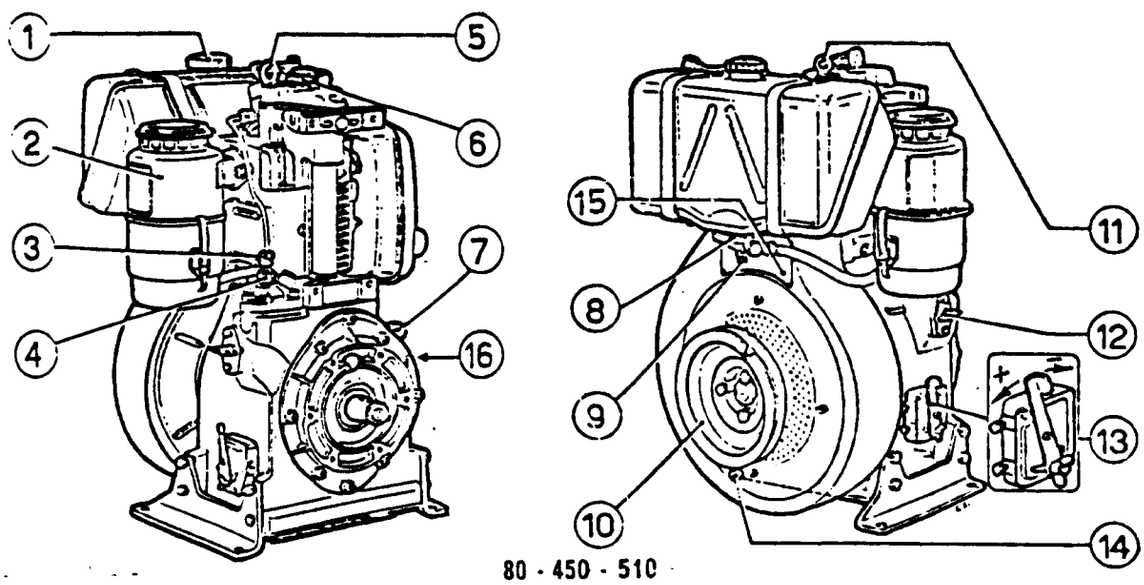
86. The industrial machinery in the year 2000 will not be comparable with that of 1979. Despite the economic recession in certain market-economy developed countries, technological progress has not stopped. Moreover, the developed countries with centrally planned economies are also conducting important research and development projects in the capital goods sector. Furthermore, it should be remembered that regardless of the share they achieve in the year 2000, the developing countries can only implement their industrialization plans through appreciable imports of equipment from the industrialized countries.

87. Consequently, the principal question thus remains one relating to the evolution of future machines. To what extent will innovation come about as the result of electronics' invasion of the sector? What degree of progress and what outcome can be expected of automation? Will the difficulties currently hindering the automation of numerous device industries be overcome? The answers to these questions are of outstanding interest - not only to the developing countries, but also to the developed countries.

88. Faced with the need to import technologies appropriate to present and future needs, and given the problems associated with labour and management, as well as the risks inherent in market operations, it is essential that the various options open to the potential manufacturers are presented together with a range of alternatives. An evaluation exercise of this kind calls for a special study on long-term forecasting. Initial contacts in this respect have been established with the Massachussets Institute of Technology and other forms of collaboration are being considered.

## DISAGGREGATION OF THE TECHNOLOGICAL PROCESS - AN EXAMPLE (Fig. 1)

### Multipurpose Engine for Agriculture




80 - 450 - 510

1 - Fuel filler cap
2 - Air cleaner
3 - Injection pump delivery screw
4 - Delivery line union
5 - Starter plug
6 - Oil filler cap and breather
7 - Oil dipstick
8 - Fuel filter
9 - Fuel filter bolt
10 - Starting pulley
11 - Lifting eye
12 - Starting extra fuel and stop.
13 - Throttle
14 - Oil drain plug
15 - Engine model
16 - Serial number

### CHARACTERISTICS

- CYCLE: 4 Stroke Diesel
- BOSCH SYSTEM Direct Injection
- FLYWHEEL BLOWER Air Cooling
- GEAR PUMP Forced Lubrication
- ROPE STARTING
- ROTATION (Flywheel side)
  Clockwise LOA
  Counterclockwise LOA sin.

| | | | 80 - L6 | 450 - 451 | 510 - L8 |
|---|---|---|---|---|---|
| Bore | Bohrung | mm. | 80 | 85 | 85 |
| Stroke | Hub | mm. | 80 | 90 | 90 |
| Displacement | Hubraum | cm3 | 402 | 453 | 510 |

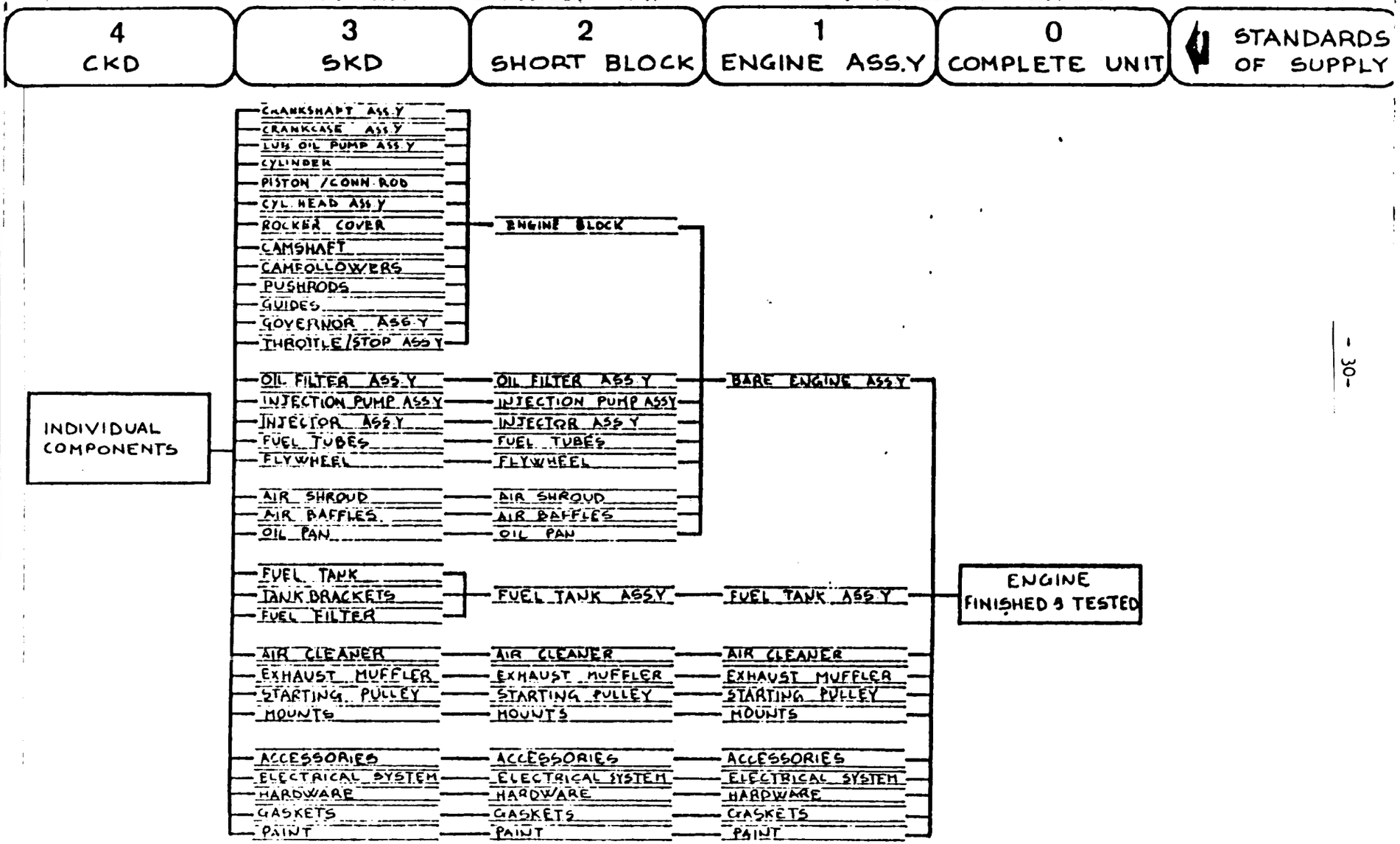
Diagram 1

| GROUP | COMPONENT | FOUNDRY | | | | | FORGING | | | | | MACHINING | | | | | SHEET METAL | | | | | HEAT TREATMENT | | | | | ASSEMBLING | | | | | TESTING | | | | FINISHING | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | | | 1 | 2 | 3 | | |
| ENGINE BLOCK | CRANKSHAFT ASSY | | | | | | | | | △ | □ | | | | △ | □ | | | | | | | | | △ | | | △ | □ | ○ | | | | | | | | | |
| | CRANKCASE ASSY | | | △ | □ | ○ | | | | | | | | △ | □ | ○ | | | | | | | | △ | | | △ | □ | ○ | | | | △ | | | | | | |
| | LUB. OIL PUMP ASSY | | | △ | □ | ○ | | | | | | | | △ | □ | ○ | | | | | | | | △ | | | △ | □ | ○ | | | | △ | | | | | | |
| | CYLINDER | | | | △ | □ | | | | | | | | | △ | □ | | | | | | | | | △ | □ | ○ | △ | □ | ○ | | | | △ | | | | | | |
| | PISTON/CONN ROD | | | | | △ | | | | △ | □ | | | | | △ | | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | |
| | CYL HEAD ASSY | | | | | △ | | | | | | | | | △ | □ | | | | | | | | | △ | □ | | | | | | | | △ | | | | | | |
| | ROCKER COVER | | | △ | □ | ○ | | | | | | | | ○ | ○ | ○ | | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | |
| | CAMSHAFT | | | | | | | | | △ | □ | | | | △ | □ | | | | | △ | | | | | | | | | | | | | | △ | □ | ○ | | | | |
| | CAMFOLLOWERS | | | | | | | | △ | □ | ○ | | | △ | □ | ○ | | | | | □ | | | | △ | □ | | | | | | | | | △ | □ | ○ | | | | |
| | PUSRODS | | | | | | | | △ | □ | ○ | | | □ | ○ | ○ | | | | | □ | | | | △ | □ | | | | | | | | △ | □ | ○ | | | | |
| | GUIDES | | | △ | □ | ○ | | | | | | | | △ | □ | ○ | | | ○ | | | | | | | | | | | | | | △ | □ | ○ | | | | |
| | GOVERNOR ASSY | | | | △ | □ | | | ○ | | | | | ○ | | | | | ○ | | | | | ○ | | | | | ○ | | | | | △ | □ | ○ | | | | |
| | THROTTLE/STOP ASSY | | | | △ | □ | | | | | | | | ○ | | | | | ○ | | | | | ○ | | | | | ○ | | | | | △ | □ | ○ | | | | |
| INJECTION LUBRICATION | OIL FILTER ASSY | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | △ | | | | | | |
| | INJECTION PUMP ASSY | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | △ | | | | | | |
| | INJECTOR ASSY | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | □ | | | | | | |
| | FUEL TUBES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ○ | | | | | | |
| | FLYWHEEL | | △ | □ | ○ | ○ | | | | | | | | □ | | | | | | | | | | | | | | | | | | | | △ | | | | | | |
| COOLING | AIR SHROUD | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | | | | | | | | | | △ | □ | ○ | | | | |
| | AIR BAFFLES | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | | | | | | | | | | △ | □ | ○ | | | | |
| | OIL PAN | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | | | | | | | | | | | △ | □ | | | | | |
| FUEL SYSTEM | FUEL TANK | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | | | | | | | | | | | △ | □ | ○ | | | | |
| | TANK BRACKETS | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | | | | | | | | | | | | | | | | | |
| | FUEL FILTER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | |
| EXTERNAL PARTS | AIR CLEANER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EXHAUST MUFFLER | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | | | | | | | | | | | | | | | | | |
| | STARTING PULLEY | | △ | □ | ○ | | | | | | | | △ | □ | ○ | | | | | | | | | | | | | | | | | | | | | | | | |
| | MOUNTS | | △ | □ | ○ | | | | | | | | △ | □ | ○ | | | | | | | | | | | | | | | | | | | | | | | | |
| ANCILLARY FINISHING | ACCESSORIES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | △ | | | | |
| | ELECTRICAL SYSTEM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | △ | | | | |
| | HARDWARE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | |
| | GASKETS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | |
| | PAINT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | △ | □ | ○ | | | | |

KEY TO SYMBOLS.
△ UP TO 500 UNITS/YEAR
□ 501 TO 2000 UNITS/YEAR
○ ABOVE 2001 UNITS/YEAR

Table 1

# SINGLE CYLINDER AIR COOLED DIESEL ENGINE



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