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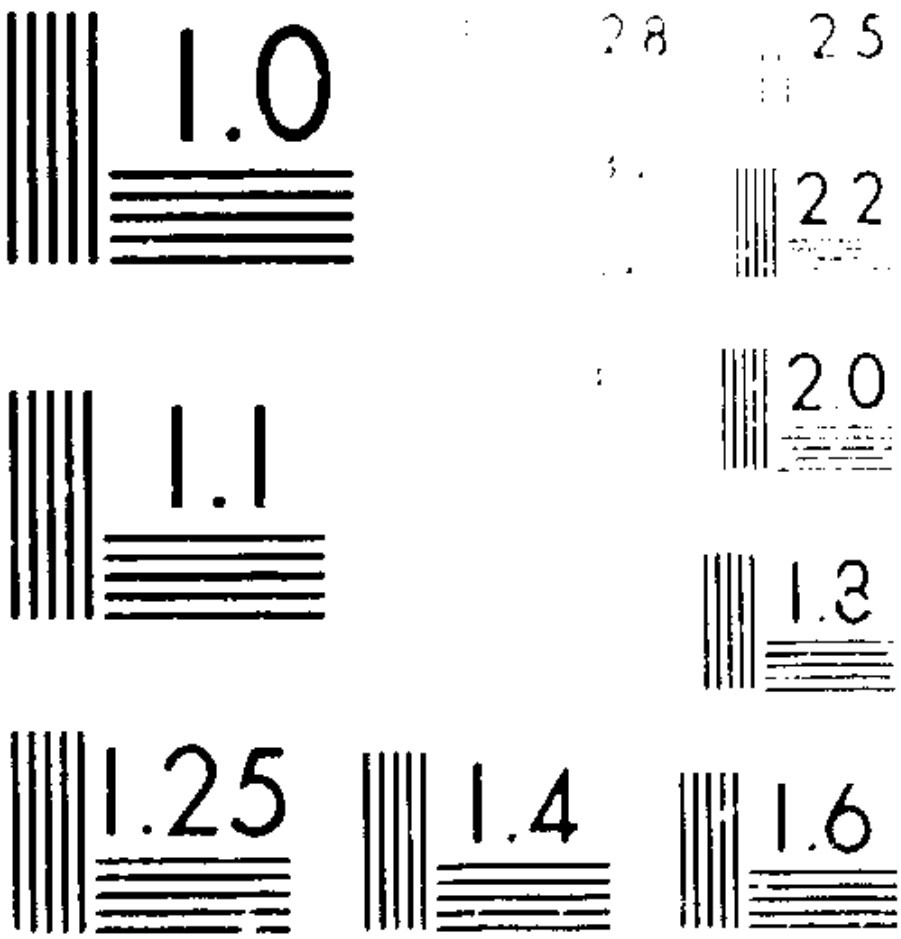
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TYPES OF TECHNOLOGIES IN THE SERVICE OF THE CAPITAL GOODS INDUSTRY'S DEVELOPMENT*

by

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C O N T E N T S

INTRODUCTION

The purpose of this paper is to draw attention to the classification of production engineering processes applicable for the capital goods industry in order to use it in the technological policy-making of developing countries.

The capabilities and scale of production of capital goods industries in developing countries as well as their share in the world production have been discussed and illustrated in other papers and therefore are omitted in the present one. In this paper, instead, those technological and organizational aspects of the capital goods sector and those elements thereof are emphasized which have to be consciously taken into consideration by appropriate decision makers and incorporated into a strategy of industrialization. It is obvious that, due to different tasks and ways of development as well as different conditions in developing countries there is no universal pattern of the industrial development strategy and therefore there could not be any universal pattern of setting up the capital goods industry. There are, however, some technological facts and data available which are, to some extent, of arithmetical nature and which have to be carefully and discerningly weighed while making choices which are included into a technological policy. This paper is intended to put them together and present for further consideration.

I. TECHNOLOGICAL GENERATIONS OF CAPITAL GOODS MANUFACTURE

1. The capital goods industry in the sense in which the term has been adopted in the UNIDO/ICIS report "Capital Goods in the Developing Countries" * involves mainly the metal processing. At the present time, indeed, the substantial part of this sector of economy constitutes the electronic industrial equipment and admittedly the utilization of plastics, composite materials, powders and non-metallic materials to manufacture machines and equipment is increasing permanently but still, however, the major part of production engineering processes involves operations giving geometrical shapes, changing structural and mechanical properties of metallic components as well as assembling them.

2. For the purpose of resent paper the term "technology" has a narrower meaning than that being usually adopted in economic publications. The nature of the capital goods industry implies that the term is related both to knowledge as well as machinery and equipment (which are used to design and to produce other machinery and equipment) and also their utilization.

Knowledge concerning metal processing and equipment constitutes at the present a wide and diversified spectrum of technology. For the purpose, however, decision-making concerning industrialization it is not necessary to be familiar with their details. The diversification of technology (production engineering) results from historical process of technological development and successive overcoming of technological, economic and social barriers typical for producers and utilization structures in developed countries. Therefore, for decision-making process more important seems to be the knowledge of reasons (causes) of diversification and their effects.

3. Among technological processes typical for the capital goods sector the following ones are usually specified :

a) Forging
b) Pressing and Stamping
c) Casting
d) Working of flat workpieces and rolled profiles (cutting, bending, welding)
e) Machining/of cutting and erosion type/
f) Powder technology
g) Heat treatment
h) Thermal, Thermochemical and chemical surface treatment
i) Working of plastic materials
j) Assembling

* ID/WG.324/3 Part 2 - Analysis of the main subsectors of capital goods, the end use economic classification.

This is a common set of technological processes sufficient for manufacturing, in any configuration, all basic products of electromechanical industry.

It should be pointed out that many of them such as forging, pressing and stamping, casting, machining, technology of sintered powders are both mutually substitutive and complementary ones. The substitution as employed in developed countries results for economic reasons, mainly in consideration of labour reduction criterion and lowering the costs of direct industrial scrap recycling.

4. Mutual proportions /as measured by amount of labour involved/ of individual production techniques in the entire structure depend to the great extent on the assortment structure of production and innovative trends in the industry. Generally, however, in a stabilized capital goods industry their proportions are as follows:

- assembling /including handling/	about 20 - 30%
- machining /of cutting type/	about 20 - 30%
- stamping and pressing	about 10 - 20%
- foundry	about 5 - 10%
- heat treatment	about 5 - 10%
- surface treatment	about 5%

Other techniques, although they can dominate in some enterprises /e.g. working of flat workpieces and assembling by welding together in the manufacture of boilers and vessels/, appear in general in smaller percentages than those given above.

Labour intensive pattern of the structure of production techniques is lineary correlated with a number of employees. The correlation is essential from a view-point of professional skills pattern of labourers as well as of training policy at the low and medium levels. The skills pattern has been subsequently correlated with a number of workplaces and the standard of their technical equipment suitable for a given technique. It is generally known for example that proportions of both already installed and newly build pressing machines and cutting machine tools are, naturally with some deviations, expressed by the ratio 1 : 3.

In this way the labour intensive pattern of production techniques determines at the same time the types of machinery and equipment used in the capital goods industry. Quantitative, mutually relative proportions of machinery, or better workplaces, required for various production techniques do not correspond to those of expenditures being connected with implementation of such techniques. In general the least expensive, on the average, workplaces are those for

assembling operations, a little more expensive are those for machining operations and yet more expensive in stamping and pressing. Generally the cost of technical equipment for a workplace is inversely proportional to the extent in which a given production technique participates in the labour consumption structure.

5. The evolution of production techniques and their mutual substitutiveness have been a result of changes occuring in the structure of productive forces in societies being in the course of development and at the same time, particularly in the sector of capital goods, evoked changes in productive forces. The evolutional development in this meaning is determined by successive technological generations.

It is difficult to give an exact definition of the term "technological generation". It has no equivalent terms in the production and turnover statistics. On the other hand it is of great importance for elaboration a technological policy and despite of lack of such definition it is intuitively used in the entire historical development of productive forces in developed countries.

By the term of successive "generation of technology" one should understand the state of knowledge and standard of equipment which as compared with those featuring the former one are substantially different as far as quality of product obtained and structure of involved productive factors (influencing the production costs) are concerned.

The capital goods industry shows relatively high stability as far as technology (production engineering) is concerned. This stability is much higher than it is the case in consumers goods manufacturing industries. This relative stability does not mean that the capital goods industry is innovatively inactive. It is just the opposite. Most of contemporary patents and otherwise protected designs have their origin in the capital goods industry and this industry takes advantage thereof. But production techniques, however, forming the basic scheme of this sector undergo relatively slow generation changes.

6. For practical reasons it is superfluous to analyze stepwise changes in production engineering over the whole period of technological civilization development. On the average such stepwise changes due to relatively long operating period of machinery, take place cyclically every 15-20 years. Therefore, it is enough to take into consideration only three successive generations in order to render possible to choose a practically adaptable generation even in the case of technological backwardness amounting more than 60 years. These three generations can be defined as follows:

1. Sophisticated generation, typical for technologically advanced producers and characterized by:

a) high expenditures for research and development work amounting up to 3% of total production value and large bank of "alienated knowledge"

b) high engineering expenditures, i.e., for design, production engineering, proper selection of materials, tooling, software, quality control and testing their order of magnitude comes to 10-15% of total production value

c) wide horizontal cooperation with specialized suppliers of standard and typical products such as assemblies and elements of electronic, pneumatic and hydraulic systems, drives, etc. featured by high stability and reliability of delivery as well as compatibility of quality standard of delivered products /value of products supplied within the framework of such cooperation comes to at least 30% of total value of all supplies necessary for production/

d) high standard of workplace technical equipment /capital-to-labour ratio above 20/

e) high power consumption /of about 10 KW per employee/

f) small proportion of piece-handling and machine-handling time as compared with the machine time

g) minimalization of physical effort, health hazards and environmental pollution

h) structure of manpower:

- 15-25% graduated engineers
- 20-40% setters and highly qualified operators having secondary technical education
- the remainder are in-plant trained workers having at least basic /primary technical/ education making them capable to acquire necessary knowledge and skill during their work; percentage of unqualified workers without any industrial background which can be assimilated comes to about 10%

2. Standard generations which were formed in 50ties and 60ties of the present century; commonly used until the machinery and equipment are reaching the end of their useful life and characterized by :

a) utilization to the great extent of so called general knowledge and therefore the engineering work there is mainly of reproductive /not creative/ nature taking advantage of generally available technical documentation

b) utilization of standard materials

c) high assortmental versatility

d) internal redundancy rendering the enterprise relatively insensible to cooperational disturbances

e) moderate standard of workplace technical equipment /capital-to-labour ratio of 3 to 10/

f) moderate power consumption at a workplace /of 1 to 3 KW per one employee/

g) high proportion of auxiliary time in the total production time

h) high proportion of manual labour in both main and auxiliary operations, substantial physical effort required in performing auxiliary operations, perceptible /at a workplace/ effects of running machinery

i) manpower /workplace/ structure
   - 3-5% graduates of engineering colleges
   - 15-25% foremen and setters having secondary technical education
   - the remainder are factory trained operators having basic /primary technical/ education and workers without strictly specified qualifications; this type of technology renders possible to assimilate up to 30-40% of workers without qualifications and industrial background.

3. Initial generation, typical for final phase of industrialization in backward European countries; is close to the standard generations but has the following distinct features:

a) specific type of general knowledge being acquired and utilized by foremen and forming a specific "wealth of experiences"

b) little demand for an engineer's skills

c) high proportion of manual and physically strenous work resulting mainly from a lack of powered equipment /very low power consumption/

d) great capability of assimilating unqualified and unskilled workers acquiring their knowledge and skill from foremen by on-the-job-training.

7. Examples of successive generations can be taken from the machining techniques.

To the initial generation belong machine tools arranged to cut with sintered carbide cutting tools having negative cutting angles. They are high-power machine tools adapted to operate at high cutting speeds. These types of machine tools were developed in 30ties and 40ties. They were provided with mechanical control systems based on arrangements of cams and as far as their mechanical features are concerned they have attained their maturity level already in that time. Material progress /i.e., development of new materials and improvements being made in methods of dynamical calculations rendered possible to design machine tool beds and mounting arrangement for rotary parts of such machine tools in such a way as to eliminate unfavourable harmonies of vibrations and therefore to improve both the accuracy and precision of machining.

The machine tool attendance, in particular, proper selection and adjustment of cutting parameters, required from an operator to acquire a predetermined level of skill. The versatile nature of such machine tools rendered possible to change easily geometrical configurations of workpieces being machined. Auxiliary times formed substantial encumberance of the machining time /they amounted upto 90% of worktime/ .

The standard generations were established in 50ties and 60ties. Main changes featuring those generations were directed to automation of controlling processes. In 50ties numerically controlled /NC/ machine tools were introduced and in 60ties those with direct numerical control /DNC/ and computer numerical control /CNC/. They were, however, still of single-task type machine tools.

The contemporaneous sophisticated generation is represented by multi-task machining centres with computer controlled cutting parameters and robotized auxiliary operations. Progressive elimination of operator's direct labour in individual operations accomplished by capital substitution shifts the proportions between the manual labour of production phase and mental work of designing and programming phase making that still more and more of the former is replaced by the latter.

8. In order to choose appropriate generation of technology all sociological, economical and infrastructure related premises of decision should be taken into consideration.

The diversification of production techniques and their generations gives a wide choice for a complete production process from small handcraft mechanical workshop with a staff numbering only several persons and equipment standard requiring expenditures between 500 and 1000 US $ per each workplace through toolmaker's shops of processing plants separate repair workshops to machine building works and plants and equipment adapted for processing materials from local resources. The choice can be passively conditioned by existing conditions rendering difficult the investment allocation in this sector of production. Depending, however, on the scale, aims being set for the future and defined social purposes the choice can be of active nature in order to evoke, by investing in the capital goods making industry, such changes which are repayable at a slow rate and over prolonged period of time but are at the same time of such nature that they give qualitative transformations of economical and social standards of the country in the future.

II. TECHNOLOGY OF THE CAPITAL GOODS INDUSTRY AS AN INSTRUMENT TO ACHIEVE SOCIAL GOALS OF THE ECONOMIC DEVELOPMENT

9. Both the strategy and policy of developing countries in the realm of industrialization are directed towards an accomplishment of specific political and social tasks. Industrialization processes and models thereof should therefore differ from each other both in view of tasks being aimed at and conditions under which they are brought into effect. Among such conditions first of all one should keep in mind their different positions as far as natural resources, sources of capital and the diversification of human resources are concerned.

It is not the purpose of the present paper to analyze social goals and ways of achieving them under different conditions of developing countries despite of the fact that in this field lies the essence of limitation or elemination of extreme poverty in which live about one milliard of people in developing countries. There is no direct relation between the subject matter of the present paper and such problems as equlization of income distribution in individual groups of population, consumption range, attractiveness and motivation strength of social tasks. However, one should be aware of the fact that they represent factors essentially influencing the rate of productive force development in DCs as well as social benefits resulting from such a development.

It should be also pointed out that the economic development, as measured in terms of GDP, can not be identified with an increase of social welfare.

Deficiencies of the pricing system seriously distort its diagnostic and prognostic value. It is enough to say that the anti-import production as measured in terms of local market prices can increase the GDP despite of the fact that when related to prices and quality of the world market it can be featured by a negative added value. In many cases the high GDP value is associated with a poor development of productive forces. The most essential, however, is the difficulty to make a comprehensive estimation of development costs which, contrary to more or less fairly measured economical effects, consists of unmeasurable social benefits /such as better sanitary condition of society, amelioration of educational system, equalization of opportunities for social and financial advancement/ and on the other hand of losses resulting from wrong choice of a way of development or caused by the development itself, e.g., environmental devastation, excessive urbanization, discrepancies between social aspirations and attitudes demonstrated at workplaces and the like. Therefore it is not always possible, especially in terms of profits to determine the results of a choice made in the development process. This is also valid for capital goods sector.

10 10. Admittedly as one of the social tasks of industrialization the development of productive forces should be regarded. It is a paradox that developing countries where large reserves of human resources exist are suffering from a shortage of labour force. Paradoxical is too the fact that human resources constitute at the present no wealth of DCs but only a burden.

Among conditions of economic development there are usually listed the structure of skills and characteristics of attitudes in the work process and in particular industrial discipline, conscious responsibility and motivation. Certainly these are not sufficient but obviously necessary endogenous conditions of productive forces.

In the development processes none of main groups of workers in the contemporary industry should be either omitted or neglected. These groups are as follows:

- staff of production organizers and managers of various production links as well as the staff at various decision originating levels which determine a technological policy and principles of bringing it into effect,
- staff of technical project and design originators /engineering personnel/,
- managing staff of executive level /intermediate level supervisory staff/,

- crew of skilled (qualified) workers,
- crew of workers without professional qualifications.

The above description of personnel structure is simplified one to some extent but at least these five groups appropriately harmonized in their mutual relations in view of qualification level, proportions in number of workers and consistency of attitudes form personnel conditions of developed productive forces. They form also a social value of greatest worth, greater than natural resources.

The shaping of an industrial personnel structure is, similarly as other sociological process, burdend with a some inertia typical of this type of social transformation.

Without ignoring the importance of training the personnel abroad as well as the importance of the system of available education it should be stated that the attainment of necessary proportion in the whole personnel structure is impossible without practical education on the job (learning by doing). The skill in design and manufacturing tools for a work, ie., the objectified labour is a necessary and basic element of so understood education system through which all developed countries have passed. It seems that this element could not be neglected.

The capital goods industry puts higher requirements than other industries. It is featured by a prolonged period of attaining maturity, low profitability, high degree of complexness, strong and increasing competition and high risk level. These factors cause that national private capital prefers to avoid investments in this sector. For that reason the intervention of the state and its conscious policy in this field are necessary. The development of the capital goods industry, apart from other tasks, should be regarded as a component of educational system.

11. The purpose of national economy is to establish material bases for satisfying social needs. The basic functions of the state such as provision of food, health protection, security, creation of conditions for family development are at the present related to the development of industry and its infrastructure. It should be taken into account that still for many years to come developing countries will not be able to obtain the return of the invested capital. In retrospective view, however, the "relay race" type of importation of technological equipment can lead to the permanent disequilibrium of the balance of payments and to technological dependence limiting possibilities to obtain the optimal value added.

The word "dependence" should be properly understood. The technical development and international exchange and co-operation connected therewith establish a network of relationships rendering the partners permanently dependent from each other.

The manufacture of the whole spectrum of capital goods, except for some exceptional cases, is impossible even in very large countries. The capability, however, of objective reproduction of capital goods related to at least basic resources of the country /agriculture and/or exploitation of raw materials/ is a main factor rendering smoother the effects of fluctuations of the world market and therefore giving some kind of "independence" in the above intended meaning of the word.

In the strategy of industrial development and in the concept of ensuring its "sovereignity" the balance of payments is a factor of great importance. The flow of funds to developing countries during 70ties underwent remarkable transformations. Funds coming from official assistance channels have been reduced in favour of greater increase of private capitals. Thus liabilities of developing countries attained the amount of 244 billion US $ in 1977 and mean yearly increment of negative balance had been raised from 15% in 1970 to 25% in 1977. In this context became vital the problem of proportions between various levels of processing in the structure of turnover and consequently of the value added produced in developing countries.
At the present in this structure the unprocessed goods (raw materials for further processing) appear in greatest amount - 33%, partially processed goods - 21% and then unprocessed goods for direct use - 11%. An increased level of processing is connected with the development of processing facilities and an increase of the endogenous share of developing countries in such development. These facts form an important criterion of assortmental oreintation in the structure of capital goods production for the final use. It is therefore the key problem in the productive force development in the sector of capital goods to have an answer to the question "how much of its profit accumulation a state is able to allocate for capital goods development as compared with amounts being allocated for the development of industries producing goods of direct or general use ?".

Excessive development of capital goods sector is unfavourable in view of satisfying the current social needs such as direct consumption, health protection, education, etc. Therefore, the limitation of superfluous

luxurious consumption eceeding relative affluence under specific conditions and establishing the central reserve of goods for redistribution in order to satisfy needs in the future, from one of main problems in the optimization of the social life standard.

Experiences acquired by planned economy countries which during the period of 35 years have made an advance from the developing to developed economy shows that the proportion of accumulation being allocated for development of capital goods should be high for several decades. The great discrepancy between the surplus of labour force and lack of equipment for workplaces in Poland in the time after the Second World War called in particular for development of the machine-building sector /especially due to the fact that political situation in 50ties rendered impossible to purchase investment equipment in market economy countries/. Within 1950-70 production in Poland raised by 7.8 times but increase in production of raw materials, machinery and equipment (jointly) amounted 9.6 times whereas that of consumer goods 5, 8 times. These proportions are yet more distinct while excluding from the account the mining industry (raw materials production); the production of capital goods raised within this period of twenty years by 13 times. Of course, this type of strategy leads to relatively slower ratio of increase in production in those industry lines where consumer goods are manufactured. However, the level of productive forces attained within this period rendered possible to make changes in proportions of accumulated profit allocation in 70ties and to develop in relatively short time the production of a wide spectrum of consumer goods based on domestic technologies.

It should be, therefore, specially stressed that the choice of a way of development assuming the participation in creating technologies in the future requires the key question to be answered namely; how wide is the acceptation of delayed demand within the society especially in the sphere of unnecessary luxurious surplus. The answer is conditioned by social and political aspects only.

12. One of more difficult for solving is the problem of choosing the appropriate generation of technology. Due to the surplus of labour in many developing countries the choice of technology is directed to those being labour consuming and relatively capital saving ones which are in turn typical for standard or initial generations. Let us consider whether such choice is correct and to what degree. Each generation has a peculiar qualification (skill) structure of the entire set of personnel groups. Besides of some exceptions practically none of developed countries has such a structure

already prepared to the extent rendering possible to adopt any of those three generations in general. In other words, in the case of each generation difficulties in adopting it and deficiency of appropriately skilled labour force should be taken into account. The technological reasons therefore should not be regarded as sufficient for taking a decision in this respect.

They key for choosing the technological generation should be sought among economical and social reasons of policy of the state. Erection of relatively modern machine-building works with a high cost of workplace equipment leads to the so called enclave type technological development.

In such enclave type development "isles" are formed having not sufficient ties with the remainder of society and causing inequalities in employment and standards of living.

On the other hand this type of industrialization renders possible to gather in such "enclave" selected and most suitable personnel from the entire country solving in this way the problem of labour deficiency.

The command of modern technology gives opportunity for attaining high labour productivity. Equally important is the attainment of maturity in technological skill by the staff, which could be used in the future as a reserve of skilled personnel while erecting further plants. This is especially important in the case of machine-building industry because of high versatility and professional mobility of the personnel employed in this industry line.

The "enclave" type development of capital goods making industry has appeared in years 1918-1939 in the course of industrialization of so called Centralny Okręg Przemysłowy /Central Industrial Region in Poland/. In that time modern industrial plants were quite newly erected in a region without any background of big industry and those plants have attained their technical maturity, high innovative activity and ability to competite on world markets within 10 years. They became at the same time a source of skilled personnel for precision goods production, aircraft building, machine tools and public works machinery industries and for other industrial branches.

An alternative for the enclave type development is a model of uniform industrial development. This model is characterized by relatively low mean level of expenditures for workplace equipment. Such not expensive workplaces give low labour productivity and are of a little advantage as far as training is concerned. For social reasons, however, this model is of equalizing nature and is a relatively best solution of the problem of complete employment of manpower surpluses. As far as organizational aspects of this model are concerned it activates small rural workshops of only local significance

which are directed to take advantage of local manpower resources and locally available materials as well as to satisfy mainly local needs.

The development of the capital goods making industry should take into account the adoption of both models in appropriate mutual proportions.

III. QUALITY ASPECTS IN THE CAPITAL GOODS MANUFACTURE

13. While choosing production techniques, their configuration and generations the problem of production quality level to be attained for social and economical reasons plays quite important role. The quality problem is frequently a cause of misunderstanding since it is quite common opinion that high quality level can be attained only by means of technology (production engineering) of the highest generation. The terms "low quality level", "high quality level" or "satisfaction of international standards" are too little precise one for serving as criterion of such a choice.

The measure of quality level is the probability of suiting the product to user's needs and capabilities being characteristic for a given social milieu in which the product is to be used. Such needs and capabilities as well as milieux of users are highly diversified. Studies on the patterns of such diversification of demand as well as on characteristics resulting therefrom are the only way of quality optimization. Among those characteristics the most important ones are those belonging to the following four main groups:

The first includes "structural" characteristics of the users' milieu representing such properties as: technical conventions, systems of measures, standardized modular series, systems of joints and connections and many other provisions of standards and codes constituting bases of the standardization system. In developed countries such standardization systems have been established for decades. They are, however, as it is generally known, not identical and differences therebetween are much greater than it could result from differences for example between metric and English systems. Developing countries in general have had no their own national standards and even when such national standards exist they should take into account some violations of national standards due to various technical conventions being in force in countries from which technologies are imported.

From the view-point of suiting the production to such structural characteristics there is none universal criterion or criteria to estimate a level of quality. The ISO can constitute some kind of common basis but one should be aware of the incompleteness of this system.

The second group includes physical characteristics of the users' milieu such as temperature distribution patterns of the environment in which given products are to be used, corrosion hazards, environment pollution level, etc. Acquaintence with those characteristics forms an important component of the know-how of companies specialized in exporting goods to various parts of the world. The command, however, of suiting the products to climatic peculiarities of southern countries can be of great advantage for products made in developing countries in their trade with neighbour countries.

The third group includes the economic characteristics of the user's milieu and individual segments thereof and provides the economic informations such as relations of prices of productive means, income levels, demand-to-supply relations, income and price flexibility rations, etc. Economic factors are those which influence most seriously the qualitative diversification of products especially in the sphere of general and luxurious consumption. The capability of making products consistent with those factors is of particular importance for markets in developing countries.

Finally the fourth group includes sociological characteristics of the users' milieu consisting of data such as users' customs and fancies, susceptibility of the market to demonstration effects, level and diversification of qualifications (skills) in handling the product, etc.

14. The diversification of quality is a natural result of diversified conditions of use. One of the ways of diversification is the establishment of successive generations when the manner in which particular function of products changes as a result of employing another physical principle /e.g. the use of rocking dye for stamping toothed wheels/gears/instead of machining/. This problem has been already discussed previously. Other ways of diversification should be, however, also taken into account. The creation of various classes of products from popular through standard to sophisticated ones is connected with substantial differences in manufacturing expenses, work-time expenditures, perfectness of finishing, materials being used, etc. Sophisticated products, however, should not be regarded as better suited for predetermined needs than popular or standard ones. They are simply different. Another way of diversifying the products is the creation of different varieties of products with the purpose of narrowing the product function in order to provide greater effectiveness due to narrower specialization at the cost of product's versatility. Taking into account these three ways of effecting the quality diversification the quality control system is capable of selecting most favourable diversification range from the view-point of producer's own technological capabilities and predetermined segment of needs to be satisfied. The production quality control in developing countries has neither such a tradition nor such a mastery in

the production quality control as it is the case in developed countries. The quality control, however, from the point of view of not too far future for economic or social reasons will become a problem which has to be urgently solved.

15. The characteristics of production techniques being used in the capital goods industry is essentially influencing the quality of production of other goods. This influence, however, is often overestimated. There is an opinion that it is impossible to manufacture a machine or equipment of defined precision and accuracy using the machinery of lower precision and accuracy. Should this opinion be true more machinery of still higher and higher accuracy and precision would never be made. A factor compensating lower accuracy of machine and dimensional dispersion resulting therefrom is the finishing manual working. Lack of personnel for such finishing working and high cost of manual labour in developed countries has lead to the inverse solution, i.e., compensation of errors and inaccuracies resulting from manual working by precise machines. This part of capital investments which is connected with preparative and post-machining operations, automation of inspection and measurement type operations and narrowing natural tolerances of machinery can be replaced successfully in developing countries by increased proportion of direct labour requiring relatively less technical knowledge but high manual expertise.

16. The mutual compensation of workmanship quality between the equipment on one side and operator and compensative techniques /finishing, selection/ on the other reduces the risk of "improper" quality even while using backward technologies. The highest risk is to be expected in the machining where the stiffness of the bed, plays in bearings, linearity of feed and co-linearity of the spindle are main causes of dimensional dispersion. Most essential, however, as far as quality in the capital goods sector is concerned is the problem of material requirements.

17. The material which is predominantly used in the capital goods industry is steel and more accurately ferrous alloys. This is the only material of large-scale use the properties of which are dependent both on the steel making metallurgical process and on the heat treatment of components or workpieces. The concentration for many years of the steel making industry in barely several centres of metallurgical industry in the world has lead to similarly great concentration of the engineering knowledge concerning the production of this material. In parallel thereto, however, over many decades, the knowledge of the heat treatment processes has been formed in many places where various industries, especially machine-building industry, were located

being main consumers of the steel. So, since steels are under discussion, it is worth to consider two aspects conditioning the quality in machine-building industries.

The first is commercially available variety of steel grades reasonably diversified from the view-point of either their chemical compositions or mechanical properties /tensile strength, compressive strength, bending strength, shear strength, surface strength, impact strength/, basic technological properties /plasticity, drawability, machinability/, physical and chemical properties /electrical and thermal conductivity, corrosion resistance, etc./ and initial geometrical configuration. The commercially available assortment of steel grades includes several thousands of alloy steel grades. From the view-point of acquiring sufficient mastery of heat treatment and maintaining homogenous structure of the production process in the machine-building industry the choice should be practically limited to not more than a dozen or so grades as far as those being permanently used are concerned. It is difficult task for those being responsible for compilation of company or national standards.

The second problem consists of sufficient knowledge and necessary experience in the field of heat treatment employed in the manufacturing processes of the machine-building industry. This requires not exactly the manual skill but rather the thorough knowledge about a behaviour of an iron-carbon alloy as well as familarity with all irregularities and disturbances occuring in the process of thermal toughening. Contemporary techniques of heat treatment and combined heat and chemical treatment, similarly as the other ones, are directed towards a high degree of automation and great strictness of technological instructions in order to avoid errors. This leads in general to lowering the requirements concerning the professional knowledge among directly attending operators but at the same time to increase such requirement relating to intermediate level personnel such as setter, medium level supervisory personnel and maintenance staff attending heat treatment equipment and the controlling and measuring devices and instruments associated therewith.

18. Despite of predomination of steel, cast steel and cast iron as materials being used in the capital goods industry this industry line requires substantially wider variety of initial materials then other industries. Particularly high requirements in this respect appear in most modern generations of technology *e.g.*, in the foundry regarding moulding and core sand, bindings, resins, additives; in the welding regarding fluxes, electrodes, protective (controlled) atmospheres, etc. When we add to those initial materials widely used non-ferrous metals and their alloys, plastics, insulating

materials for anticorrosive coatings as well as typical set of standardized components and assemblies /cables, switches, contactors, bearings, gears, motors, connectors, components of pneumatic and hydraulic systems, gaskets, etc./ we have to deal with a very ample set of necessary supplies which requires an efficient system of the modern materials control organization. The material control is easier to be run when we have to deal with big lot or mass production. This kind of production is especially recommendable for developing countries. The advantages of the capital goods industry consists, among others, in its great versatility and capability to realize special orders. In this case, all matters connected with functioning of technical subsidiaries, materials control and supply system cause that both the production and preparatory processes become especially difficult and complex ones, requiring the highly qualified personnel.

19. The capital goods industry is a typical industry line which requires the internal integration in the country involved and acts favourably in attaining such integration. It performs the following functions connected with the horizontal integration:

1. Maintenance of machines operating within the country,
2. Manufacture of standardized components and assemblies used in various fields of national economy,
3. Provides the equipment forming structures, i.e., such products which should be mutually complementary ones such as an agricultural

The investment activity of various companies in a developed country, various sources of imported technical equipment and the activity of various advisory services are conductive to the formation of excessive technical diversification and non-complementary of technical structures. One of key conditions for establishing a national industry is to create basis of the industrial standardization system.

The standardization is an activity connected with imposing technical restriction in order to rationalize a national economy and to establish a technological order rendering possible an easy development of co-operation. The latter industrial standards are introduced the higher are the costs of adopting them.

From the view-point of the capital goods industry it is especially important to bring into order the following groups of problems:

- principles of incrementing (graduation) parametric series,
- basic standardized parametric sequences (series) of voltages, wattages, etc.

- geometrical dimensions and requirements regarding mechanical properties of connecting and jointing elements,
- fit system,
- parametric sequences (series) of structural profiles and shapes,
- parametric sequences of basic groups of standardized products included in generally available catalogue products such as bearings, couplings, gears, low and medium capacity motors, etc,
- chemical compositions and qualitative properties of recommended grades of steel, cast steel, cast iron, non-ferrous metals, plastics, sinters and powders,
- basic groups of cutting tools in particular turning tools, milling cutters, broaches, drills and screw-taps,
- gauges and the like
- basic replaceable assemblies of machines such as chucks, tool holders, headstocks,
- important technical problems of general nature such as principles of commissioning procedures, codes of gauge legalization, quality certificate issuing procedures, etc.

The problems listed above refer mainly to national standardization. There along or, if need arises, even earlier the company standards have to be introduced in larger plants of the electric and machine-building industries. The purpose of the latter is to rationalize and to make stable the materials, tools and replacement parts control as well as to compile codes for testing and inspecting assemblies of products being manufactured and lists of the latter ones.

20. The capital goods industry is one of those industries which sets up a high requirement regarding reliability and safety of the manufactured products. For that reason therefore all things serving for measuring and inspecting purposes are especially important ones. Besides a typical set of workshop's measuring instruments such as gauges, indicators and the like the gauge and standards (measurements) chambers are also typical for this industry line. The purpose of such chambers is:

- legalization and adjustment of workshop's measuring instruments,
- examination of chemical composition of materials,
- testing the materials being used for their mechanical and physical properties.

Similarly as in other technologies there are characteristic methods and equipment for measuring and quality control purposes being typical for successive generations. The equipment of a gauge and standards ~~chanbers~~

are suited to capabilities of a personnel with medium qualifications. Instructions being required can be included in general codes, which should be compiled by a governmental authority being responsible for metrological matters. This authority should be also responsible for arranging and running some training centres for a personnel to be employed in the industrial metrology.

IV. ORGANIZATIONAL PROBLEMS OF THE CAPITAL GOODS INDUSTRY

21. As far as size of works is concerned the capital goods industry, contrary to other industries, shows great diversification. In developed market economy countries this industry consists predominantly of small plants employing less than 500 employees. At the same time about a half of the total number of people being employed in this sector work in medium and large plants employing above 500 persons. The general model of this sector is of concentric nature - on the average there are about 10 plants co-operating with a single big one.

22. In developed planned economy countries the more integrated model has been established. Predominant is here the group of enterprises consisting of those employing from 500 to 1000 persons but at the same time in the organizational structure of this sector, however, many enterprises employing several thousands of employees are encountered. This organizational model is then of network type one showing various co-operational inter-relations. The spectrum of products manufactured in the capital goods producing enterprises in planned economy countries is therefore more complex and diversified one; often individual departments form organizationally separated units with only a small degree of interdepartmental co-operation.

23. Beside of the enterprises being organizationally separated an important role in the capital goods manufacturing industry is played by some departments of enterprises belonging to other sectors of economy. They are for example maintenance departments having predetermined capabilities of building new, unique and individually manufactured machines, toolmakers' shops the main purpose of which is current regeneration of tools and chucks but being also capable of manufacturing unique components of production tooling. Furthermore to the sector of capital goods can belong to some extent a number of piloting departments in various research and development institutes as well as separated technological departments of other enterprises and institutions.

24. In the organization of the capital goods making industry the type of specialization is also of great importance. There is not a need to give the definition of the term "specialization" but it is worth to give some attention to two different forms of the specialization each having different economic and organizational consequences.

The first of them is so called "operational (functional) specialization" the objective of which is a predetermined group of technological operations being carried out irrespective of the nature of production and appropriation of components being produced. An example of such operations can be production of castings in a specialized foundry in which castings for various types of products are made. This form of specialization requires the mastery of all matters concerning materials, metallurgy, foundry equipment and machinery, production of predetermined grades of cast iron and/or cast steel and production of castings within a predetermined range of overall dimensions and tonnage while meeting requirements regarding mechanical properties of such castings.

The operational specialization leads in general to the organizational concentration of plants utilizing similar technological processes and to establishing technological and research and development facilities for solving problems concerning materials, operations, processes and technological equipment.

This form of specialization is employed mainly in the production of machinery components or blanks or semi-products for manufacturing the machinery such as castings, forgings, welded profiles, etc.

The co-operative nature of so specialized technologies is featured by a wide assortment of offered production and high versatility resulting therefrom. The degree of assortmental deconcentration depends on the structure of customer's industries. Obviously the assortmental deconcentration leads to relatively small production lots and consequently to the necessity of making frequent changes in processing equipment. The characteristic feature of the assortmental deconcentration consists of the time devoted to preliminary and post-processing operations takes substantial proportion of the total worktime. This causes a decline in economic effectiveness of the production.

To avoid the occurence of negative effects of the assortmental deconcentration the following two types of preventive measures are taken. Firstly the products are classified according to type and orders are grouped according to the technical similarity therebetween. Such classification (so-called typification) have to be considered as one of most important activities of the company standardization department. This classification changes the nature

of production offer from passive to the active one. Customer's enterprises have therefore their choices limited to the assortment contained in the catalogue and therefore should suit to some extent their needs to the offer which in turn at the customer confines to some extent the flexibility of his own actively but on the other hand such a situation is of advantage for the producer since it causes a reduction of process costs and an improvement of production quality.

The second form of the specialization is the so called "product specialization" based on establishing of permanent relations with a selected group of customers having stable assortment of orders.

25. For the product specialization it is a characteristic feature that there is a very narrow assortment of end products /often there is only one end product/. It is well-known that the size of production lot in the capital goods industry has been greatly diversified. The production of such goods as cutting tools, components of standard joints and connections, rolling bearings etc. is of mass nature. In big lots such goods as agricultural tractors and implements, multi-purpose transportation facilities, hand tools and the like. Finally unique machinery and equipment are manufactured usually in small lots or even individually. Such diversification does not result from and is not related to the level of technology modernization but in the first line results from technological versatility.

26. The measure of technological versatility is the technological flexibility of the production process. The technological flexibility is determined by a percentage of technological equipment which can be used despite of changes in production, in particular while replacing a given production assortment with more modern one. The characteristic feature of the capital goods making industry is the great flexibility, much higher than that for example in automotive industry, chemical industry, alimentary industry,etc. Transitionally, in the middle of the present century, the trend to the specialization of production lines and narrow specialization of machinery has lead to reduction of flexibility also in the machine-building (engineering) industry. The trend presently existing in the machine-building industry is, however, featured by the return to the production and use versatile equipment having high flexibility but at the same time great automation of auxiliary operations.

The main cause, indeed, of the great mechanization are manpower shortages and high costs of manual labour in developed countries but other causes should not be, however, neglected. The automation of auxiliary operations such as workpiece and tool setting, selection of cutting parameters, measuring and control operations being connected with the manufacturing process is of great

importance in attaining high quality level at a low level of operators' qualification and experience.

In industries manufacturing in big lots the automation of setting and control operations ensures great reproducibility /little dispersion of dimensions and other features/. In industries with a great assortmental deconcentration this automation renders possible to take advantage of optimum tooling change programmes and to attain accuracy and precision nearing the process capability.

27. Most simple organizational form in the capital goods sector are rural workshops and small regional plants. This type of producers is an important factor in the industrial activation, utilizing local resources of raw materials and local manpower resources. The specific feature of this type of producers is very low capital investment /up to 10,000 US $). The technologies being used there are adaptable to local manpower resources and their qualifications (skills). As far as the size of such producing unit is concerned the number of employees is between several and less than twenty persons and they are simple for managing and organizing them. They are an ovular form of producing plants oriented to operational specialization with relatively wide range of technical services. The level of the offer given by such producers can be easily suited, as far as prices and quality are concerned, to local requirements and capabilities. Although such small units are usually of technical service type ones but they are capable, without difficulties, to develop the production of hand forged tools, cast or welded components of machinery and agricultural implements etc.

The regional industry has no features of the capital goods industry in a full meaning of this word. In such rural workshops the production, if any, is generally accomplished without technical documentation and without any supporting engineering subsidiaries. This form is of great advantage for training manual capabilities but does not form any industrial background and is devoid of industrial discipline and work sharing.

28. The simplest but important and forming an integral component of the capital goods sector is an industry line which constructs and erects stationary technical facilities such as vessels, tanks, boilers, vertexes of industrial pipelines and piping systems requiring welding operations, heat exchangers, and other technical structures. The basic materials are: sheet metal, pipes, rolled profiles, etc. mainly of ordinary carbon steel. Basic technologies being used include cutting /mechanical or oxygen/, bending

and assembling /welding, pressure welding riveting/ being easy for acquiring and getting mastery thereof. The technological equipment being used is relatively simple and except of precision welding in the case of particularly important pipings and pipelines does not require any complex know-how. In this industry line none heat treatment is used except of particular and exceptional cases when stress relieving treatment is required.

Welded constructions (structurals) are an assortmental group of great demand. The transportantion of ready products over long distances is very expensive due to special arrangement of constructional components and therefore the location of a steel construction manufacturing plant in the neighbourhood of the place where such constructions are to be installed is of competitive advantage.

The welded construction industry requires engineering subsidiaries featured by relatively simple nature of work performed. Except of complex high-pressure vessels and pipelines the designing work is of a routine nature. The technical documentation is easily readable in the producing workshop.

29. Within the capital goods sector consisting of many relatively complex industry lines the tool making industry appears to be relatively simple one. This takes important position due to the importance of tools and due to restitutive nature of the demand for tools as well as due to social and economic advantages of this industry line. From the view-point of production engineering this industry line employs such technologies as: forging, dye pressing, heat treatment, machining and assembling. The assortment is highly diversified due to both the complexness and requirements regarding quality. There are such relatively simple tools as turning tools and so complex ones as broaches and measuring instruments. This industry poses high requirements regarding the qualification, experience and technical discipline of the personnel. Due to the mass production, however, as well as fine segmentation of the production process this industry can assimilate relatively high proportion of personnel acquiring the professional knowledge and qualifications. The preparation of production is devoid of complexness especially in the case of technical documentation since large portion of the knowledge required is of general nature.

In the tool making industry the control of materials plays an important role especially as far as proper material selection is concerned. Equally important is the heat treatment and combined heat and chemical treatment during the manufacturing process. It is required to test simple and composite materials for their properties as well as to perform the proper

laboratory quality control during the manufacturing process.

The qualified staff in the tool making industry form an important and valuable source of personnel for toolmakers' shops of all industrial plants. It should be noted that in toolmakers' shops of the electro-mechanical industry and those of maintenance plants up to 10% of total number of employees should have ample knowledge, great experience and be capable of working with a minimum of supervision because of individual nature of the technical work performed. In this context the tool making industry constitutes an irreplaceable school in which highly qualified staff of other industry lines acquires its knowledge and at the same time an indispensable condition for developing countries to attain technological independence.

30. The main position in the sector of capital goods takes the machine tool and equipment building industry which forms a part of the sector in question being crucial one for production techniques and posing the highest requirements especially regarding the personnel to be employed, scientifical and research works required and all matters relating to materials control.

Usually the machine tools industry development scheme includes as a first step the maintenance workshops. Overhauls and repairs require the mastery of machine tool assembling and disassembling procedures, regeneration or replacement of various assemblies, adjustments etc. In maintenance workshops it is usual to make within their own capacities first some rapidly wearing components and then even entire assemblies of machine tools. The next step of development can include not only the renovation but also the modernization of machines. In many cases small plants are utilizing used machines being purchased for the second hand and are not capable of making repairs, regenerating and modernizing such machines. Therefore, selling up the specialized maintenance workshops should be considered as a necessary step of industrial development. Maintenance workshops constitute in substance a properly equipped basis for undertaking the production utilizing some standard, commercially available subassemblies and with the aid of an experienced producer either from a developed country or from any developing country advanced in production of machines.

The development scheme for production of other machines should be of the same or similar nature. A number of automotive industry plants have started their production activity from the phase of maintenance

and repair workshop through the licenced assembling workshop to the self-dependent vehicle manufacturing plant.

31. Along with development of the capital goods industry, undertaking the production of complex machines and equipment the demand for standard and special components of machine, entire assemblies and some other structural parts rises. The asortmental index of necessary supplies for the machine-building industry contains several thousands of items and this number is doubled every ten or fifteen years. More intense is the development of final phases of natural resources processing the faster rises the necessity to create permanent technological relations of co-operative nature and to determine reliable, also in the future, principles of technological divison of production in individual assortmental groups in auxiliary lines of industry. As auxiliary ones in respect to the capital goods industry those industries should be understood where such components and assemblies which are indispensable in the machine-building industry are being made, for example electric motors, combustion engines of predetermined parametrical sequence of capacities and efficiency dependent on the generation in use; drive components such as gears, clutches, couplings, electrical accessories, transformers, generators, switchgears, switches, etc., components of pneumatic and hydraulic systems, connectors, unions, jointing elements, rolling bearings, etc.

As far as the organization is concerned it is important to choose properly the horizontal integration scale of the capital goods industry. The small on the average size of mechanical industry plants renders impossible the integration within a single enterprise. The integration scale should be the countrywide in a predetermined range while the remainder of the entire range should be within the international integration.

Higher is the range of intercountry integration it is easier to solve problems of interchangeability, modular consistence and complementarity of the industry by means of national standards and various technical codes.

The risk of technological anarchy and negative effects thereof /small scale production, high costs, lack of relations with the worldwide industry/ render, however, impossible the attainment of complete intercountry integration. The capital goods industry requires therefore the integration of international nature with a set of problems resulting therefrom and leading to technological anarchy more painful in its effects as far as the service costs and organization, repairs and interchangeability of assemblies are concerned. It seems that the solution of international integration by forming co-operative relations between developing countries belonging to

a group in which investment products of close generations are manufactured. The technical co-operation and permanent principle of technological work share within the framework of cooperation between countries having planned economy were the essential factor of speeding up their development within the last three decades.

32. The investment problems within the sector of machine building industry are in general less complex than in the case more capital consuming industry lines such as metallurgy, mining industry, chemical industry, etc. On the basis of experiences gained in the time of standard generations one can assume that the average output per one employee of direct production labour amounts 4 to 10 tonnes. This requires 4 to 10m^2 or directly productive area per one employee and correspondingly 10 to 20m^2 of useful surface area and 15 - 30m^2 of total area of the plant. On the average in standard generations of machining the ratio of fixed capital to the value of sales is from 1 to 2. The working capital including materials, standard catalogue parts and components, inventories of finished goods and goods in the course of production amounts from 30% to 50% of the value of sales. The added value changes markedly depending on the degree of processing, degree of product complexness, product rentability and rareness. In the production of machine tools this amount can reach 60% to 65% as related to the value of production or 200% approximately as related to the material costs.

SUMMARY

a) The capital goods industry is one of those segments of economy which most strongly influence the development of productive forces. It establishes the complete personnel structure necessary for an industrial development process but especially gives skill and creates social attitudes. The development of this segment of economy is an indispensable component of the industrialization process.

b) The requirements being posed by the capital goods industry regarding the technical infrastructure of a country and initial qualifications of the personnel are diverified depending on the generations of technologies being in use. The diversification of technologies renders possible to choose, for practically any conditions, a suitable generation of technical work supporting means.

c) The use of most modern technological generation of high complexity is unnecessary. It seems to be purposeful, depending on local condition, to use such generation in enclave type industrial centres the purpose of which is to make substantial technological advancement. The most suitable, instead, it seems to be to take the advantage of standard and initial generations, which render possible the uniform industrial activities, give opportunity of acquiring skill through the work and furthermore, because of technological versatility, render the operational (functional) type specialization possible.

d) The selection of technology to be followed while developing the capital goods manufacturing industry depends on specific conditions of individual countries. The purpose of this sector is assumed to be the rise in the value added in relation to those natural resources constituting the reserve of economic advancement /agriculture, resources/. At the same time attention should be paid to the fact that the material reproduction of those means of production which are related to the exploitation of natural resources is a basic factor smoothening the effects of world trade fluctuations in relation to individual countries.

e) The influence of technical generation onto the production quality is undoubtedly overestimated. Within the set of technologies being available there are surely possibilities to compensate for the effects of lower technical equipment level as far as quality is concerned by employing additional technologies. The quality of product, however, is mainly influenced by the human factor /management, subsidiary

engineering personnel, supervisory staff, workers/ and, in the case of capital goods industry, by materials. Therefore, of particular importance are such factors as quality control policy adopted, appropriate national standardization as well as selection and treatment of materials, especially steels, cast iron and non-ferrous metals.

f) An important link in the capital goods industry is the production of stationary constructions of steel such as vessels, tanks, frames where the basic technologies are cutting, bending and welding. This production makes an indispensable element of the industry in each country. Similarly indispensable within the sector of capital goods production is the tool making industry not only in the range of standardized tools and tools included in catalogues but also making unique special purpose tools. These two industry lines are relatively ease in acquiring mastery thereof, have important educational advantages and can become easily economically competitive ones.

g) The industrial development requires to provide appropriate maintenance and repair subsidiaries capable of performing works of various required for maintaining the industry serviceable. Repair and maintenance workshops form an important link for the development of larger and complex industrial plant, among them plants manufacturing machine tools, means of transportation, agricultural machines, etc. The development maintenance facilities should, therefore, take high ranked position in the technological policy of a country.

h) An important feature of the capital goods industry are plants of relatively small size. This sector of economy can form therefore an important factor in developing the rural industry showing relatively low outlay for technical equipment of a workplace. As development proceeds this sector begins to become integrated with larger plants of machine building industry which are of enclave type, and represent higher technical level. The versatility of the rural tool making industry as well as another rural plant such as maintenance and repair workshops and complementary industry can form an important factor compensating shortages of managing staff and lack of technical subsidiaries in developing countries. On the other hand it is purposeful when the government establishes suitable subsidiaries rendering technical services for small plants having similar production programmes.

i) The capital goods making industry is of substantial advantage from the point of view of technical integration within a country. When a system of standards and national co-operative relations are established, the personnel flow takes place and development activities are initiated in the field of adoption or creation of new technologies. Earlier this sector is established the lower are costs of establishing it and lower social losses resulting from the lack of such sector in the national economy.