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USSR MINISTRY OF THE MACHINE-TOOL
AND INSTRUMENT INDUSTRIES

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ROLE OF MECHANICAL ENGINEERING IN INDUSTRIALIZATION OF DEVELOPING COUNTRIES

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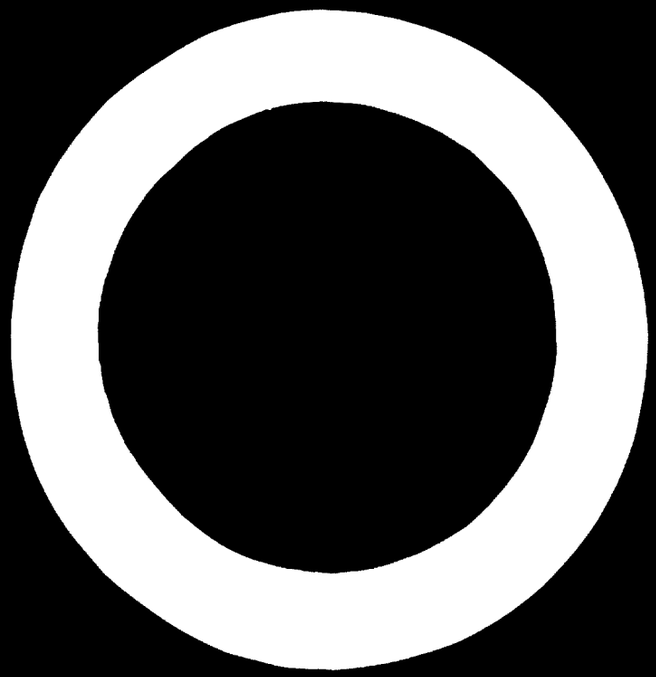

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THE ROLE OF ENGINEERING INDUSTRIES IN THE INDUSTRIALIZATION OF DEVELOPING COUNTRIES

SUMMARY

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Submitted by

The Government of the Union of Soviet Socialist Republics

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Technical progress and the engineering industry

1. The degree to which a country has industrialized is determined by the amount of machinery and industrial equipment it has in use and by their quality and complexity.

2. The pace of industrial development of any country—developing countries in particular—depends, to a considerable degree, on the speed and scale with which scientific achievements are introduced and applied to production technology, and new products are manufactured. Almost all scientific and technological achievements, both in industry and agriculture, are realized through machinery and instruments. This accounts for the special and significant role played by the engineering industry as a basis for technical re-equipment of a country's economy and as a means to speed up technical reconstruction and increase national income.

3. In long-term planning for industrial development it is necessary to know the period of time during which machinery can be used efficiently. There are two kinds of obsolescence of machinery: one is the so-called "technological obsolescence" and the other, "physical wear". Fifteen to twenty years ago "physical wear" constituted the decisive factor, but during the past ten years "technological obsolescence" has become the main factor by which the useful lifetime of machinery is determined.

4. In some branches of industry it is better to scrap old machinery even after a two to three year period of use and to replace it by technologically advanced machinery in order not to reduce profit. New trends and accomplishments in production and product development, as well as other factors on which technological obsolescence depends, should be carefully evaluated before new machinery or equipment are purchased. To neglect these factors can seriously deter the technological advancement of developing countries.

5. The use of second-hand and old equipment in developing countries must be considered economically worthless. This fact should be emphasized again and again because the use of such equipment only slows down industrialization.

Engineering industry and industrial development

6. Accelerated industrial progress is based upon the proper selection of the proportions for the development of a country's various branches of industry. Experience of the Union of Soviet Socialist Republics shows that the rate of development of branches that produce capital goods should be higher than the rate of over-all industrial development. The rate of development of the engineering industry in the USSR and in other developed countries is, for example, much higher than the rate of development of heavy industry as a whole.

7. The most important function of the engineering industry is to replace manual labour by machinery, by introducing mechanization and automation in all sectors of national economy. Mechanization should take place, first of all, in such highly labour-consuming industries as mining, building and agriculture.

8. Capital investment made in various branches of industry is determined by priorities set up for their development. Accelerated industrial development and a continuing increase of national income require capital investment to be made, first and foremost, in the leading branches of industry, such as mining, metallurgy and engineering. For industrial branches themselves, the main investment should be in the purchase of machinery and equipment.

9. Bearing in mind the importance of the unemployment problem in developing countries, attention should be focused on the development of branches of industry that are labour-intensive. Analysis of labour consumption of various branches of industry indicates that the engineering industry absorbs more labour than any other branch except mining, but the extent of development of mining depends on existing deposits of natural resources. This fact was taken into account in planning industrialization in the USSR. For example, in an agricultural republic such as Lithuania which has practically no natural resources, the development of such branches of engineering as machine tools, electronics and the electrotechnical industry were planned and developed in order to increase opportunities for employment.

Machine-tool industry--most important branch of the engineering industry

10. Development of the engineering industry is practically impossible without the production of machines by machinery. The machine-tool industry is unique because it produces machines that are used to manufacture other machinery, tools, instruments and industrial equipment.

11. In the USSR development of the machine-tool industry was intensified in the republics and parts of the country that had been backward in the past. Establishment of the machine-tool industry in Armenia, Byelorussia and Lithuania has insured an increase in their national incomes and has transformed them into highly industrialized parts of the USSR.

12. At the early stage of development of the machine-tool industry in the USSR, the production of all-purpose machine tools was organized because such machine tools were urgently needed to develop basic branches of the engineering industry. At the present stage more attention is devoted to production of high precision machine tools that are needed to expand the automotive, aircraft (nuclear) and other branches of the engineering industry. As a result of proper planning, the Soviet machine-tool industry now produces practically all kinds of machine tools in quantities sufficient to accelerate the development of the engineering industry.

Practical aspects of establishment of the engineering industry in the developing countries

13. In the course of industrialization the following stages of development of the engineering industry can be distringuished:

First stage: Importation of machinery and industrial equipment needed for industrialization and organization of facilities for repair and maintenance of existing machinery;

Second stage: Organization of production of products needed constantly in large quantities for the engineering industry and to satisfy requirements of the population;

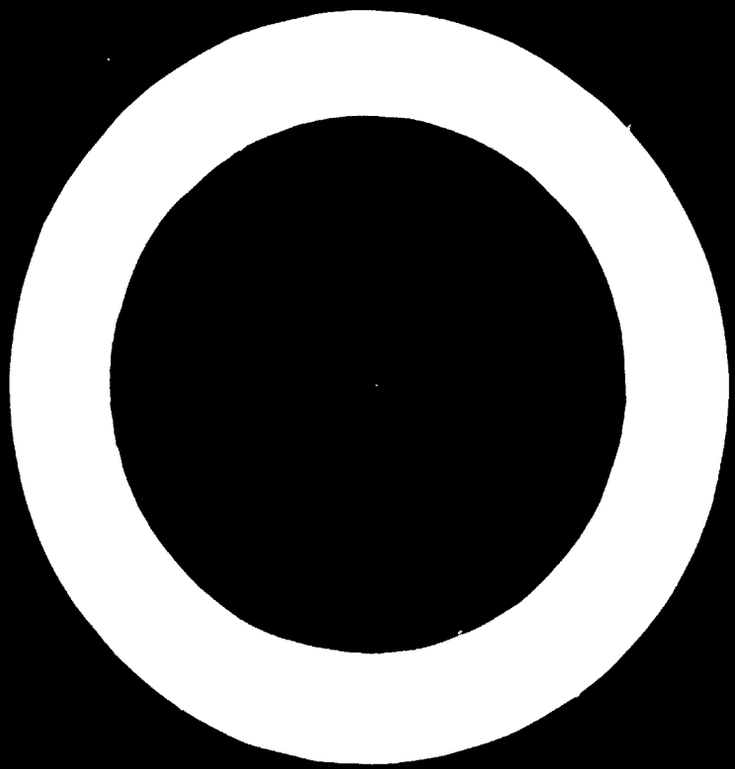
Third stage: Development and manufacturing of machinery and equipment that can be competitive on the world market and can be exported to developed countries;

14. Production of machinery during the early period should be limited to those types that are vital to develop leading branches of industry, mainly those for which raw materials are available in the country.

15. At the early stage of development of the engineering industry it is not always possible to organize the manufacture of all necessary and complicated components for modern machinery. Experience of some developing countries shows that complicated components such as bearings, electrical motors and other electrical equipment must be imported at the beginning and later production can be set up.

16. It is difficult to produce a competitive product and to enter it on the export market, but it is more difficult to constantly meet the requirements of the world market. The level of design of an engineering product must be high and it should match modern achievements. It is difficult to imagine how the Soviet engineering industry was able to reach the high level of development that it has now if, at the beginning, the broad network of pilot plants, experimental laboratories, design centres and research institutes had not been created to help to establish the engineering industry. At that time many Western experts considered it a "technical adventure" and squandering of limited resources of young Soviet Russia.

17. Training of professional and working cadres is another important problem facing developing countries. According to some opinions because developing countries do not have trained working and professional staffs, they must be oriented to use simple "adopted" technology and simple less productive machinery. That is completely wrong both from an economic and social point of view.

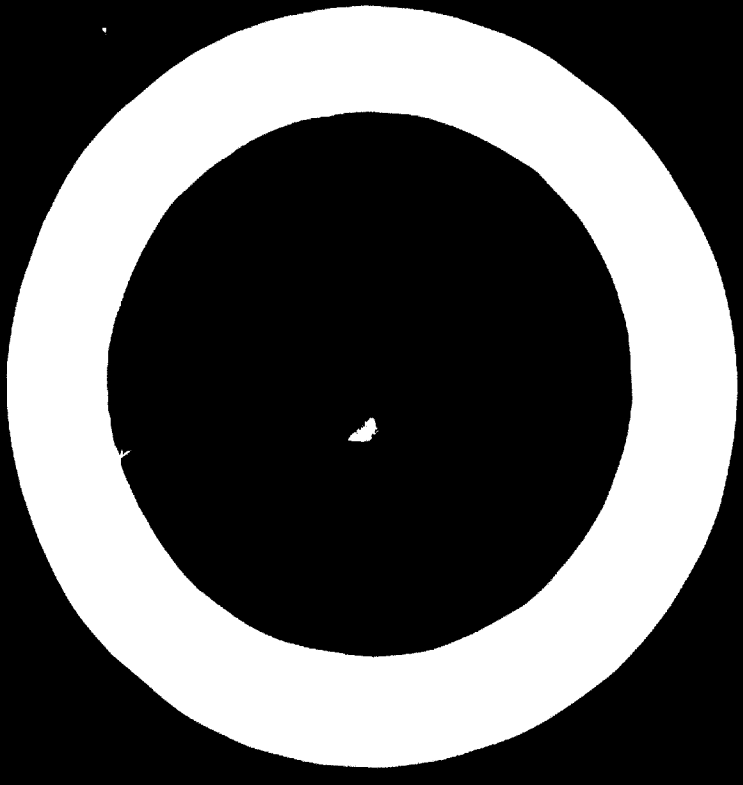


USSR MINISTRY OF THE MACHINE-TOOL AND INSTRUMENT INDUSTRIES

Prof. A. E. PROKOPOVICH

ROLE OF MECHANICAL ENGINEERING IN INDUSTRIALIZATION OF DEVELOPING COUNTRIES

Moscow 1967



I. TECHNOLOGICAL PROGRESS AND MECHANICAL ENGINEERING

I. 1. A decisive factor in the development of the productive forces of society are the instruments of production. The level and scale of the development of the instruments of production determine, above all, the development of the productive forces.

The employment of machines marked a breakthrough in the development of the productive forces.

The industrial revolution at the close of the XVIII century generated by the wide employment of machines represented a tremendous advance in the development of the productive forces in many countries and speeded up the rate of their industrial growth.

The replacement of manual labour and hand tools by machines, a process that began more than 200 years ago, has not slowed down. On the contrary, this pro-

cess is steadily developing and improving on the basis of the fundamental sciences.

A major stage in the development of industrial machines was the invention of engines powered at first by water, then steam, electricity and, in recent years, by atomic energy.

Today, human society is going through a technical revolution generated by the turbulent growth of the fundamental sciences (physics, chemistry, mathematics). The economic and technical results of this revolution are broader and deeper than those brought about by the discovery of steam and electric energy.

The present stage of technological progress is characterized by a reduction in the time required for the extensive practical realization of scientific discoveries.

Formerly, it took many years for a scientific discovery to reach industrial realization. Today this period has been cut to 5 - 10 years. For example, the principle of generation of focused light rays (laser) was discovered a little over 10 years ago. Today this principle is already being put into practice in medicine, intercommunications, processing of materials and in other fields.

At the present time the development and industrial application of a wide variety of synthetic materials

based on the latest advances in the field of chemical sciences is undergoing especially rapid development.

Within the last few decades scientific breakthroughs that are changing the character of engineering and industry have led to the emergence of new branches of industry, such as radioelectronics, atomic and radioactive engineering.

I. 2. The industrial importance and economic efficiency of scientific discoveries and research is seen in new materials, new technological layouts, and new superior products.

At the present time the rate of development of any country, including the developing countries, is largely dependent on the speed with which new scientific discoveries are translated into concrete designs, technological processes, and equipment, and the scale on which they are applied.

A peculiar feature of technological progress is that nearly all scientific and technological achievements in industry and agriculture are, as a rule, realised through machines and instruments.

It is this that determines the special role and importance of mechanical engineering as the basis for the technological reconstruction of industry and a rising national income.

I. 3. Technical development and new generations of all categories of equipment, instruments and mechanisms

is governed by the general laws and tendencies of the development of science and engineering. A characteristic phenomenon at this stage of the development of engineering, equally applicable to all branches of mechanical engineering and metal working, is the ever-growing tendency towards the greatest possible intensification of the working processes. This is in the continuous and sufficiently vigorous growth of speeds, for example, in aviation; taking into account rocket propulsion, speeds have increased within the last 25 years from 200 - 300 km to 1000 - 3000 km/hr while successful research is under way for the design of aircraft capable of carrying passengers and cargoes at speeds exceeding 5000 km/hr.

In a number of industries working processes are speeded up by raising service pressures especially in power engineering and chemistry.

The use of high pressures and temperatures have resulted in the solution of what were formerly regarded as fantastic problems - the production of new materials, such as boron nitride, and artificial diamonds.

The mechanical methods of processing materials are being increasingly replaced by electro-physical and electrochemical methods.

The use of high service pressures, along with other factors, have made it possible to change radically the physical and mechanical properties of many metals.

A general rule in the improvement and development of production methods and, hence, machines is the increasing change over from discrete to continuous processes.

This tendency is most evident in metallurgy, and in the chemical and food industries. Mechanical engineering has so far been affected to a lesser degree.

The above-mentioned general rule has led, for example, to a breakthrough in methods of cargo transportation. In all countries oil and other liquid products are preferably delivered by pipelines instead of rail, river or sea transport because pipelines ensure uninterrupted delivery. Some pipelines are over several thousand kilometers long and carry many million tons of oil products. The cost of transportation by pipeline is much less than by tank trucks or tankers. In most cases, therefore, products like gas are transported by pipeline.

Thus, since 1913 the overall length of oil pipelines in the USSR has increased 28 times while their freight turnover rose about 450 times. Since 1950 the length of gas pipelines has increased almost 20 times and the supply of commercial gas - over 100 times.

The high efficiency of continuous means of transportation has stimulated successful industrial experiments for the development of a pipeline for the transportation of coal, ore and other free-flowing materials.

The development of continuous methods of transportation can be traced in the evolution of earth-moving machines and transport vehicles. The simplest primitive tool, the shovel, has developed into an excavator which is essentially also a shovel but with a power drive, and a bucket which today has a capacity of dozens of cubic meters. However, this machine operates in successive cycles. In machines like bucket wheel excavators working in conjunction with belt conveyors (conveyor bridges) excavation and transportation are combined. A still higher degree of continuity is achieved by applying the hydraulic method of excavation and transportation of free-flowing materials.

Continuous transportation is a major characteristic of the technical level and organization of production in nearly all industries. In many cases continuous transportation (belt, flight and overhead conveyors, pneumatic transport) is becoming the main type of intra-factory transportation.

In a number of engineering branches, such as metallurgy, power engineering, transport, the unit capacity of machines is rapidly increasing. For example, not very long ago blast furnaces were built with capacities up to 1000 m^3 while now their capacity is 2000 - 2700 m^3 and more.

Power generating units operating with high temperatures and pressures now have an output of 500 - 600 -

- 700 kW and over. The wide application of high-speeds in working processes and continuous methods of production have become possible thanks to the development of automatic control and regulation.

Ever-increasing importance is attached to electronic computers and associated equipment not only for effective automation of working processes but also for production management, including advanced planning.

Modern machines, particularly those used in automated systems, have to meet the constantly growing requirements of reliability, durability and strength in operation.

I. 4. Taking into account the cost of equipment, the correct estimation of its service life is of considerable importance.

In the industrial development of a country, it is important to clearly visualise the lifespan of new equipment. As is known, the lifespan can be regarded from two aspects, i.e. moral depreciation and physical depreciation. Whereas 15 - 20 years ago, physical wear was a decisive factor, within the last decade moral depreciation has played a predominant role in a number of industries due to a higher rate of technological progress. This applies in particular to the production of new synthetic materials, medicines, and processes based on entirely new physical or chemical methods.

In some industries advanced methods reach a stage when in 2 - 3 years it is economically profitable to scrap old equipment and buy new machines since operation of obsolescent equipment may lead to serious losses due to unjustified production expenditures. Therefore, both in the purchase of equipment and in the organization of its production it is important to take account of the tendencies in technological development, the prospective demand for the product and a number of other factors on which moral depreciation depends. Underestimation of these factors may lead to a technical lag in individual industrial powers.

In this connection it is necessary once again to emphasize how economically indefensible and, in some cases, harmful for industrial development to adopt a theory about the use by developing countries of worn equipment, that has been dismounted and discarded in the technically advanced countries.

Obviously, it is technically and economically absurd to offer the developing countries equipment that has proved unprofitable in one or another country. Clearly in such cases the word "developing" loses all meaning since the rate of development of these countries will undoubtedly be lower than that of the developed countries which use modern equipment, modern technology and turn out modern products.

All possible support should be rendered to those developing countries that have banned the import of worn equipment. Naturally, this does not refer to particular types of equipment for small repair shops, for domestic purposes, etc.

I. 5. Thus, in organising production of all types of machines and also their purchase, account must be taken of the entire complex of modern trends so as to obtain maximum economic effect from the funds spent for starting production.

II. MECHANICAL ENGINEERING AND INDUSTRIAL DEVELOPMENT

II. 1. Efficient development of the productive forces depends upon accurately established proportions of the development of the various branches of industry. The experience gained in the USSR shows that the means of production must develop faster than industry as a whole. Mechanical engineering in the USSR and other countries is also developing considerably faster than heavy industry.

In the past twenty years alone with an increase in the total national product in the USSR of 6.5 times, industrial output grew approximately 8 times, output of the means of production, about 9 times. Output of the mechanical engineering and metal-working industries increased in this period 12 times.

These rates of industrial development ensured a substantial increase in the national income which rose 6.8 times within twenty years.

In other socialist countries mechanical engineering is also developing faster than other branches which leads to a corresponding increase in the share of mechanical engineering in the gross output of the entire industry.

Table 1

Proportion of Mechanical Engineering in Gross Output of All Industry, per cent

Country	1956	1963
Bulgaria	9.3	20.4
GDR (1955)	29.5	36.3
The Korean People's Democratic Republic 1949	8.1	23.5
Poland	8.0	24.4
Rumania	13.3	26.6
Czechoslovakia	20.8	31.4

However, it must be noted that a faster rate of development of mechanical engineering also characterises such powerful industrial countries as France, Britain, USA, etc.

II. 2. Modern mechanical engineering can be classified into three main groups:

Group 1 - the most important includes industrial machines (machines, tools) which can be subdivided into transporting, conveying and technological types.

Group 2 includes engines, both prime movers that convert power resources, and secondary engines. Both groups of machines refer mainly to instruments of production.

Group 3 comprises household appliances.

As industrial and technological progress proceeds in vigorous strides, machines and instruments find an increasing use for domestic purposes. This refers primarily to such commodities as radios, watches and clocks, vacuum cleaners, washing machines, etc.

Transport equipment can be divided into two branches : (a) commercial transport facilities, such as trucks and public transport facilities, including buses, taxis, street cars, and (b) private means of transport, such as bicycles, motorcycles, cars and more recently private planes.

The development of new technologies suitable for domestic use, such as television, has led to rapid growth of the third group of products.

The discovery of new design principles ensuring new solutions of earlier technologies greatly increased the demand for these products, for example, the appli-

cation of semi-conductors in radio engineering has led to the creation of pocket and portable radios and a sharp jump in the demand for these goods.

As the demand of the population for durable household commodities is met, industrial output becomes stabilised, this being mainly due to the durable nature of these products or to population growth. This stabilization of demand has been reached in many countries with regard to clocks and watches, domestic sewing machines, radio sets, refrigerators. However, this applies mostly to the industrially developed countries. The level of consumption of modern household appliances in underdeveloped and developing countries is still very low and, with rising living standards, the demand for these commodities in the next decade will gradually increase.

Nevertheless, the main task of mechanical engineering is to supply up-to-date instruments of production to all branches of the national economy, to ensure a substantial saving in manual labour and in materialised labour.

II. 3. The range of modern machines, instruments and mechanisms is extremely great, numbering millions of types.

It is a general practice to subdivide machines according to the branches of the national economy they service - railway equipment, agricultural machinery, etc.,

or according to large groups of machines, such as automobiles, tractors.

The development of individual branches of mechanical engineering is primarily determined by the development rate of the corresponding branches of industry.

II. 4. The paramount function of mechanical engineering is the replacement of manual labour by machines, all-round mechanization and automation of technological processes in all branches of the national economy. Priority here is given to the mechanization of heavy and labour-consuming work (mining, construction, agriculture).

Tables 2, 3 and 4 give data on the dynamics of mechanization in the USSR of individual processes related to timber cutting, coal mining, construction. In these industries, a rise in productivity of labour was achieved together with a radical improvement in working conditions.

Table 2

Mechanization of Timber Cutting in USSR (%)

Process	1940	1960	1965
Felling of trees	-	97	99
Carrying timber to upper storage yards	5.6	91.6	96
Removal of timber	32.8	94.5	99.4

Continued

Process	1940	1960	1965
Productivity in terms of complex output per man	100	176	197

Table 3

Mechanization of Coal Mining in USSR and Growth of Labour Productivity (%)

Process	1940	1960	1965
Cutting and breaking of coal	94.8	99.2	99.5
Keeping of coal	0.1	48.8	67.9
Casting of coal and rock	15.2	99.9	100
Loading of coal into railway cars	86.5	99.98	99.9
Increase of labour productivity	100	137	164

Table 4

All-Round Mechanisation of Construction Work in USSR (%)

Process	1958	1960	1965
Earth-moving operations	83.0	90.3	94.2
Erection of concrete and reinforced-concrete structures	82.4	86.6	94.6
Preparation of concrete	76.6	79.0	79.7
Preparation of mortar	60.5	61.5	62.8
Concrete and reinforced-concrete work	67.9	72.1	82.1

Other branches of industry in the USSR are characterised by similar figures. A particularly large effort was made in equipping agriculture with large quantities of modern machines.

In 1910 agriculture in tsarist Russia had:

Sothas and scythes	7,800,000
Wooden ploughs	2,200,000
Steel ploughs	4,200,000
Wooden harrows	17,700,000

Due to intensive development of tractor and agricultural machine building, agriculture in the USSR in 1965 had:

Tractors (in terms of 15 hp tractors)	3,032,000
Grain combines	520,000
Cargo trucks	982,000
Tractor ploughs (1964)	907,000
Sowing machines (1964)	1,154,000

The energy capacity of agriculture in 1910 was 23.9 million horsepower, including 23.7 million horsepower provided by draft animals, whereas in 1965 it was 236.6 million horsepower with only 3.7 million horsepower accounted for by draft animals.

II. 5. Capital investments are made in accordance with proportions and trends in the development of individual industries. In order to ensure the necessary rate of industrial growth and raise national income, capital investments are directed, above all, to the key industries, with an ever-increasing share of these investments going to expenditures on equipment.

Table 5

Changes in the Structure of Capital Investments in Industry of the USSR (% of total)

	1950	1965
Assembly and construction work	51	48
Equipment, tools, accessories	41	44
Miscellaneous	8	8

The increase in expenditures on equipment is a characteristic feature of the national economy. However, in some cases, especially in countries with very high or low temperatures, expenditures on buildings and structures are higher. In underdeveloped and developing countries the greatest share of capital investments goes into new construction. In the developed countries capital investments on a greatly increasing scale are directed to the technical reconstruction of existing enterprises. This involves a still greater share of capital investments in equipment.

Capital investments in the Soviet Union in 1965 for the expansion, reconstruction and technological equipment of existing enterprises were as follows (% of total volume of capital investments):

Total for industry	61
Mechanical engineering	73
Light industry	46
Coal industry	71
Electric power stations	28
Chemical industry	46

Less than 50% of capital investments for reconstruction was made in the light and chemical industries, and in electric power stations.

II.6. The general trend of laws of development affecting the structure of production expenditures can be clearly seen in mechanical engineering as in other industries.

The development and upgrading of methods of production and organization are accompanied by a systematic increase in expenditures for raw materials, semifinished products and components, and by an increase in the share of expenditures connected with depreciation of equipment and a reduction in the share of expenditures on wages and other social needs. Moreover these tendencies continue, as a rule, in spite of steadily rising wages.

The problem of employment for the developing countries is of great importance in determining which industries can and must be given priority. In these conditions, the share of manual labour also plays an important role. An analysis of expenditures in various branches of industry reveals that labour consumption among the manufacturing industries is highest in mechanical engineering. Of course, the specific labour consumption in the mining and timber industries is higher but the development of these industries is determined both by the natural resources in a given country, and by the possibilities of employing a section of the population on heavy work.

II. 7. This factor is taken into account in the USSR in planning the development of industry in the economic regions and national republics. For instance, in Lithuania which possesses comparatively few resources of raw materials, the problem of employment was

solved by the intensive development of precision machine-tool building, instrument building, i.e. industries which require great amounts of manual labour.

In the eastern and northern regions of the Soviet Union characterized by adverse climatic conditions priority was given to industries which require a minimum amount of manual labour, for example, power engineering, non-ferrous metallurgy, etc.

The development of mechanical engineering in the eastern republics depends primarily upon natural resources. For example, Uzbekistan produces textile and cotton-picking machines, Kazakhstan - agricultural and mining machines. Naturally, the production of equipment in the USSR is organized on the principle of the most practicable geographical distribution and extensive inter-republican co-operation.

II. 8. Mechanical engineering is a highly profitable branch of industry. Table 6 gives some data on the profits of Soviet industrial enterprises in a number of industries.

Table 6

Profits of Industrial Enterprises in USSR in 1965

	Profit, per cent of fixed and circulating capital
Industry as a whole	13
Mechanical engineering	16.7
Ferrous metallurgy	8.6
Electric power production	4.6
Timber and wood-working industry	6.9
Chemical industry	16.4
Light industry	29.9
Food industry	24.4

In Soviet industry only the light and food industries yield a higher profit with respect to fixed capital.

II. 9. Thus, mechanical engineering successfully combines the possibility of exerting a decisive influence on the technological level and rate of development of all industries and agriculture, ensuring a high level of employment and at the same time being one of the most profitable branches of industry.

Table 7 gives comparative data for several countries on the development rates of industry, mecha-

Table 7

Dynamics of Growth of Industrial Production, Mechanical Engineering Output, Labour Productivity and National Income (1950 = 100%)

Country	Mechanical engineering output		Labour productivity in industry		Industrial production		National income	
	1960	1965	1960	1964	1960	1965	1960	1965
1	2	3	4	5	6	7	8	9
USSR	427	764	197	237	304	458	265	361
Bulgaria	717	1622	177	232	397	685	278	381
Hungary	334	531	147	180	266	388	187	295
GDR	387	565	224	291	292	390	240	286
Poland	784	1764	229	273	338	508	208	277
Rumania	585	1336	220	294	340	649	268	406
Czechoslovakia	457	624	211	239	282	364	207	227
USA	164	229	147	177	147	191	133	166
England	153	181	131	153	135	159	127	149

Continued

1	2	3	4	5	6	7	8	9
West Germany	336	412	160	199	242	321	217	267
France	245	264	181	216	178	231	160	202

nical engineering, the growth of labour productivity and national income.

Understandably, the growth of labour productivity and national income is determined by a number of other factors, but there is no denying the influence of mechanical engineering on the improvement of these indices.

III. MACHINE-TOOL CONSTRUCTION AS A MAJOR BRANCH OF MECHANICAL ENGINEERING

III.1. The quantitative and qualitative development of mechanical engineering is impossible without industrialized production of machines, instruments and mechanisms.

The technology and organization of machine production are governed by the general trends of technological progress in industry. The production of high-quality machines with a minimum expenditure of labour and funds calls for the use of appropriate technological equipment which under modern conditions can be expressed by the term "machine tools".

The branch dealing with the construction of machine tools includes the production of a whole complex of technological equipment used in making mechanisms, instruments, cutting tools, measuring gauges and other types of technological equipment. However, statistical data in

many countries include under the title of machine-tool construction only metal-cutting machines and press-forging equipment. In some countries measuring gauges, cutting and auxiliary tools are not included under machine-tool construction.

III. 2. Machine-tool construction as a branch of mechanical engineering develops in conformity with the general laws of development of mechanical engineering. However, the greatest stress in the development of machine-tool construction is on the need for the fullest utilization of raw materials and semifinished products.

Technological progress in machine-tool construction has also influenced the size of machines. In recent years there has been a marked tendency towards differentiation of equipment according to size.

Along with medium-sized equipment (mainly related to servicing the needs of man) the trend has been to sharply increase the dimensions of machines as well as to miniaturise them, particularly in electronics.

Machine-tool construction, today, takes into account the need for machines to produce the required sizes of equipment.

In connection with the growing demand for precision in the manufacture of mechanical engineering products (bearings, instruments, etc.) it is necessary to solve the problem of design and rapid development of the production of precision equipment and instruments.

III. 3. Machine-tool construction in the USSR and other countries is developing faster than all the branches of mechanical engineering and metal working as a whole. Table 8 summarizes the data on the dynamics of output of metal-cutting machines.

Table 8

Growth of Output of Metal-Cutting Machines

Country	1950	1964
Bulgaria	899	6883
Hungary	-	12500
Viet Nam	-	1078
GDR	2420	43300
Korean People's Democratic Republic	150 (1954)	3097 (1963)
Poland	3800	29300
Rumania	-	6987
Czechoslovakia	12900	21700
USA	162000	154000
USSR	71000	184000

In analysing the figures given in Table 8 it must be borne in mind that the trend in recent years has

been increasingly towards qualitative changes in machine design, consequently the cost of gross output has risen considerably faster than the increase in production.

III. 4. A characteristic feature of machine tool construction in the USSR is its high growth rate in a number of previously backward national republics.

Table 9

Share of Soviet Union Republics in Production of Metal-Cutting Machines (1965, per cent)

	USSR	RSFSR	Ukrainian SSR	Byelorussian SSR	Georgian SSR	Lithuanian SSR	Armenian SSR
Territory	100	76.2	2.7	0.9	0.3	0.3	0.1
Population	100	54.6	19.6	3.7	2	1.3	0.9
Production of metal-cutting machines	100	55.5	13.4	12.9	2.5	7.6	4.9

The development of machine-tool construction in such republics as Armenia, Byelorussia and Lithuania has contributed to higher employment, rapid industrial development and the growth of national income.

Table 10 characterizes the growth rate of gross industrial output in several national republics (per cent of 1940 level)

Table 10

	1950	1960	1965
[illegible]	175	324	791
[illegible]	175	494	715
Lithuanian SSR	191	1030	1791
Armenian SSR	249	708	1236

III. 5. The development of machine-tool construction in the USSR has traversed stages characteristic of many other already industrialised countries and, as practice has shown, this experience under present conditions will be useful to the developing countries in creating their machine-tool industry.

Before the Great October Socialist Revolution, Russia had practically no machine-tool industry of its own. Certain types of crude equipment were made at small repair shops and mechanical engineering plants. Industry's demand for metal-working equipment was met by imports.

The first stage in the development of the national machine-tool industry was to organize production

of all-purpose machines required by many branches of the mechanical engineering and metal-working industries. These machines included turning lathes, milling machines, drilling, planing and tool-grinding machines. It should be noted that these machines even in the industrially developed countries comprise more than 50% of total output. Apparently, the developing countries will also find it expedient to start their machine-tool industry with production of these machines. In the first stages the best foreign prototypes were adopted. As industrial and technical experience was accumulated, advanced Soviet designs were developed and put into production.

The next stage in the development of the national machine-tool industry in the USSR was marked by the creation and production of specialised types of equipment required for mass production in mechanical engineering and metal-working plants, primarily in the automotive, tractor and bearing industries and in the instrument-making industry. For this purpose special multipurpose multiple-spindle machines were developed for machining housings, crankshafts, pistons, piston rings, bearing races, balls, etc.

This stage called for dramatic qualitative modification in the machine-tool industry, the development of integrated systems and wide standardisation. The solution of this problem became feasible due to the fact that by that

time the country already had comparatively large numbers of its own engineers, designers and technologists.

An important stage embracing the forties and fifties was characterized by the organization of production of heavy and unique equipment for the power, transport machine building, metallurgical and other industries.

And, finally, at the present stage, the problem is being solved of creating the required nomenclature and organizing production of sufficient quantities of high-quality precision equipment for the bearing, automotive, aircraft and other industries.

The experience of the machine-tool industry in the Soviet Union may be useful mainly for the large developing countries, such as India, Brazil, etc. For small countries with a limited overall demand for metal-working equipment, it is practicable in most cases to build up the national machine-tool industry chiefly for the first group of equipment. With respect to the other groups only certain essential equipment should be produced to meet the special requirements of the machine-tool industry.

III. 6. Due to correct planning policies, the creation and development of the national machine-tool industry was able to meet the requirements of rapidly developing Soviet mechanical engineering. The data given in Table 11 characterize the growth of the number of metal-cutting machines and press-forging equipment in the USSR.

Table 11

Types of equipment	1908	1940	1958	1965
Metal-cutting machines, thousands	75	710	1916	2760
Press-forging equipment, thousands	18	119	394	580

In step with the development of technology and organization of production in mechanical engineering the structure of the metal-cutting machine production is also changing in the USSR (see Table 12).

Table 12

Changes in the Structure of Metal-Cutting Machine Production in the USSR (per cent of total)

Type of machine	1940	1963
Turning lathes	26.8	24.8
Boring machines	0.2	1.2
Drilling machines	27.2	18.4
Grinding and polishing machines	3.6	15.7
Milling machines	6.3	11.4
Broaching machines	0.1	0.3
Planing machines	0.3	0.2
Shaping machines	3.5	2.3
Other types	32.0	24.7

The improvement of mechanical engineering has brought about a decrease in the demand for turning lathes, drilling and planing machines and an increase in the demand for milling and grinding machines.

As Table 11 shows the machine-tool industry today still enjoys a stable demand for many earlier types of equipment. Thus, even under present conditions of intensive, large-scale, mass production, there is still a demand for the comparatively simple, shaping, drilling and turning machines. Therefore, while creating new groups of equipment and expanding their production, it is still necessary to conduct persistent and intensive work aimed at continued maintenance of the technical level of earlier types by modernizing and replacing them with new improved models.

III. 7. The most characteristic feature of all types of equipment is their further automation chiefly through the use of electronic systems.

The large-scale production of complex parts is characterized by the employment of program-controlled machines which make possible automation of the working cycle, ensure stable quality of the products and reduce the time and funds required.

Along with the higher level of automation in large-scale and mass production, there is an intensive transition to automatic systems of machines (automatic lines

performing a group of technological operations of complete processing of parts).

All-round mechanization of production in mechanical engineering is a characteristic feature not only of the industrially advanced countries. The manufacture of some products in any country, even a little-developed country, under present conditions may prove to be inexpedient without the use of automatic lines (for instance, the production of safety razor blades can be effective only on automatic lines). The manufacture of transistor receivers, particularly their mounting panels, cannot be organized unless there is circuit printing equipment just as it is obviously impossible to set up the effective manufacture of such products as electric bulbs without the use of automation.

Therefore, one must be critical of the view that all-round mechanization and automation is a prerogative of industrially advanced countries alone and that these methods are not good for the developing countries.

IV. SOME PRACTICAL ASPECTS OF THE ORGANIZATION OF MECHANICAL ENGINEERING IN DEVELOPING COUNTRIES

IV. 1. In the process of economic and industrial development of the developing countries the following stages in mechanical engineering can be distinguished:

Stage I. Acquisition in the developed countries of the equipment required for the development of the national economy and organization of maintenance and repair of equipment available in the country.

Stage II. Organization of production of products of mechanical engineering indispensable for the development of the national economy and satisfying the constant demand of the population.

Stage III. Expansion and organization of competitive methods and means of production of equipment that can be exported to other countries including the developed ones.

In considering these problems no decision should be taken before making a thorough technical and economic analysis of all aspects both from the tactical and strategical point of view.

IV. 2. Experience shows that some countries having no sufficient motives organise the production of mechanical engineering products in quantities exceeding the internal demand and incapable of competing on the world market because of high production expenditures or a low technological level, so that the capital investments in the organisation of production prove inexpedient.

The contrary situations occur more frequently. In order to develop one or another branch of the national economy it is always possible to obtain foreign equipment which may be more economical for a particular case

than domestic equipment. However, bearing in mind that these products are constantly required for the development of the national economy, it may be more expedient to organize national branches of mechanical engineering in the interests of the national economy. A complete solution of these problems, particularly for the developing countries will require the aid of the state or other more industrially advanced countries.

The Soviet Union, in pursuance of its policy of cooperation in the industrialization of developing countries, has in the last 10 years helped to build over 1500 enterprises on highly favourable terms.

IV. 3. In solving the problem of the organization of national mechanical engineering, it should be borne in mind that under present conditions not a single country, no matter how large and industrially developed, can produce the number of machines, instruments and mechanisms required for the development of the economy, so that it is forced to buy a considerable proportion of equipment in other countries.

The quantity and range of new machines, instruments and mechanisms is constantly and rapidly increasing.

Thus, in 1965 alone, Soviet industry created 3366 types of vital machines and equipment and 1577 types of instruments, apparatus and means of automation.

Table 13 summarizes the data on the development of nomenclature of new products in the various branches of mechanical engineering in the USSR.

Table 13

The Most Important Types of Machines and Equipment Created in 1950 - 1965

	1950	1958	1965
Total equipment including:	650	2051	3366
Machine tools	133	245	281
Press-forging equipment	51	99	106
Foundry equipment	8	19	59
Metallurgical and mining equipment	44	122	115
Equipment for heavy industry	35	135	141
Electrical-engineering equipment	48	212	537
Agricultural machines	53	127	115
Construction machines	47	165	188
Equipment for light industry	39	118	146
Equipment for food industry	I	105	158
Quantity of the most important types of instruments and apparatus	-	348	1517

IV. 4. Experience proves that in some countries it is economically expedient to limit organization of production of industrial equipment primarily to such types of machines, instruments and mechanisms that are of vital importance to the development of key branches of the economy, mainly based on available resources of raw materials. However, there are many examples when some countries, including developing countries, ensure employment of their population and increase their national income by importing raw materials for some products that compete successfully on the world market.

To ensure the necessary funds for the purchase of foreign equipment it is advisable to develop the national economy with a view to selling goods abroad for a similar sum of money. Traditional items of export may be successfully supplemented by exports of manufactured goods, including the products of mechanical engineering.

IV. 5. Soviet experience in developing mechanical engineering has shown that with the development of national mechanical engineering the share of imports of machines and equipment gradually decreased to a certain level, in recent years, it has become stabilized at about 33.5% of the total volume of imports.

Along with the development of mechanical engineering, the export of machines from the USSR to other countries has also been on the increase and at present

it accounts for about 20% of the total volume of exports, and shows a marked tendency towards further growth.

Trade with the socialist countries based on long-term agreements accounts for greatest share in the import and export of machines for Soviet industry. In the socialist countries there is an ever-growing tendency towards economically expedient inter-nation division of labour and specialization, which ensures the most effective conditions for the manufacture of machines and equipment. The experience gained by the socialist countries in rational cooperation in the field of mechanical engineering may prove useful for other countries.

IV. 6. In the early stages of development of national mechanical engineering it is necessary to keep in mind that modern machines consist of a large number of complicated elements and units whose manufacture in a single country may, at frist, seem difficult. Such types of products include bearings, electric motors, electric apparatus, etc.

The experience of a number of developing countries proves that it is practicable, in the first stages of development, to buy these components in more developed countries with the subsequent specialised production of these products in large countries or their manufacture by cooperation between several countries.

IV. 7. A distinctive feature of mechanical engineering is also that its development calls for the creation and advancement of many types of related facilities producing various types of metals and other materials, paints, plastics, etc. It is economically profitable to produce a considerable portion of these products at specialized enterprises. Some parts and units may also be manufactured by cooperation between small shops employing a limited number of personnel.

The organisation of mechanical engineering output is determined, among other factors, by the level of specialization in the production of castings, pressings, etc., as well as fastenings, gear wheels, units, hardware, bearings, electric apparatus, etc.

IV. 8. An advanced national mechanical engineering industry presupposes close coordination on a nation-wide scale of all consumers and suppliers of raw materials, components, semifinished products within the country and the acquisition from other countries in economically practicable amounts of products that are not suitable for manufacture in the country.

IV. 9. The maintenance and development of the technical level of machines and their manufacturing methods calls for appropriate conditions. It is difficult to imagine now the path of mechanical engineering in the USSR, its first steps, the construction of the first plants, had all this not been preceded by the construc-

tion of experimental shops, plant laboratories, designing bureaus, research institutes. At that time many experts in the West regarded it as technical adventurism and unwarranted squandering of funds in a country with limited resources.

Today, the system of research institutes, powerful experimental shops and laboratories are the pride and backbone of engineering progress not only for Soviet industry but for many other countries.

In 1965 designing, research and exploratory development were conducted in the Soviet Union at 2393 bureaus with their own balance.

Industrial enterprises had 39,166 designing bureaus and departments, and 25,788 laboratories.

This experience should also be considered by the developing countries. Experimental research activities should be conducted concurrently with the organization of the corresponding branches of national mechanical engineering.

IV. 10. The development of mechanical engineering and wide application in the national economy of complex equipment calls for skilled labour.

The experience of the USSR and other countries shows that earlier ideas that with the improvement and development of technological equipment, the demand for skilled labour will fall have been refuted by industrial development.

The operation and maintenance of modern machines and equipment require highly-skilled personnel possessing the necessary technical knowledge enabling them to understand and service complex modern equipment.

This problem is of particular importance to the developing countries. The opinion expressed by some experts that in the developing countries only the simplest low-efficiency types of machines should be used because of lack of trained personnel is not corroborated either from an economical or social aspect.

The training of a highly skilled lathe or milling machine operator for all-purpose equipment obviously takes no less time and money than the training of a skilled machine fitter.

At the present time all countries, including the developing countries, use not only industrial equipment but also very complicated household equipment, such as radio and television sets, refrigerators, cars, air conditioners, etc., whose care and servicing calls for skilled technicians; therefore, it is practicable for the developing countries to train highly-skilled personnel not only for the operation of household equipment but also for industry.

This report gives but a general outline of Soviet experience gained in the development of mechanical engineering. Therefore, the brief conclusions and recommendations contained herein should not be regarded as universal and all-embracing.

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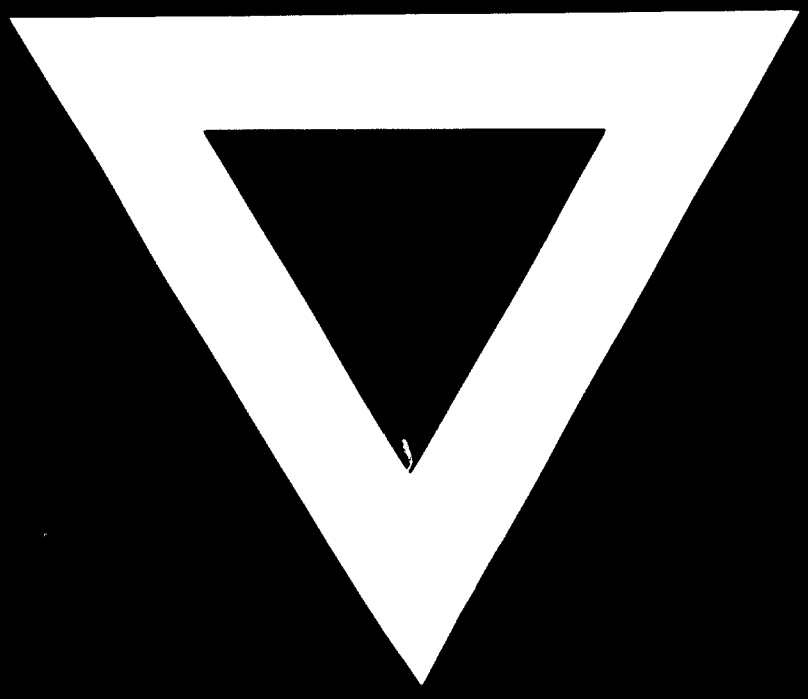

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