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TRENDS IN AUTOMATION IN THE USSR

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S-E-C-R-E-T

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TRENDS IN AUTOMATION IN THE USSR

CIA/RR PR-161

(ORR Project 30.1089)

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FOREWORD

The purpose of this report is to present the conceptual and organizational framework of industrial automation in the USSR, with specific reference to the machine building sector of Soviet industry.

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TRENDS IN AUTOMATION IN THE USSR*

Summary

The Sixth Five Year Plan (1956-60) of the USSR calls for a significant expansion of mechanization and automation in the Soviet machine building, metallurgical, and other basic industries.** Previously automation had been directed primarily toward application to military programs. The broadening of the program for automation indicates that Soviet leaders are confident that now they can give greater attention to problems of the long-term technological development of industry as a whole without impairing military requirements.

Soviet leaders are relying on the program for automation to offer tangible benefits, such as increased production, savings in manpower and plant space, savings in materials, improved quality of products, and greater safety and convenience for workers. Moreover, automation is one of several measures expected to contribute to the increase of 50 percent in industrial productivity anticipated under the current Plan. If the goal is reached, Soviet leaders hope to achieve a base for a large-scale application of automation and other advanced technological processes which will enable the USSR to surpass the US in production per capita after 2 or 3 more Five Year Plans.

Soviet leaders have recognized the difficulties of implementing the program for automation and have taken well-conceived steps to assure its eventual success. Administrative machinery has been created to supervise and coordinate basic scientific research, technological development, and the introduction of automation into specific industries

* The estimates and conclusions contained in this report represent the best judgment of ORR as of 15 March 1957.

** In Soviet usage the term mechanization in the broadest sense refers simply to the use of machines to replace manual labor, whereas automation denotes the use of mechanical or electronic devices to replace human control of the processes of production. See I, p. 3, below, for a discussion of the distinction between mechanization and automation made by Soviet scientists and technicians.

and enterprises as well as the development and production of mechanisms and devices used in automation. Moreover, economic incentives specifically designed to stimulate technological progress are offered to industrial managers and technical and production personnel. The current policy in favor of replacing outdated equipment also tends to promote the introduction of technological innovations, including automation.

The processes of mass production used in the USSR which apparently have been considered most easily adaptable to automation include public utilities; component production; and continuous-flow production of solid materials, friable materials, and liquid and gaseous substances.* Soviet authorities on automation tend to base their plans for component production on the installation of cyclic automatic machines and for continuous-flow production on the use of feedback control (self-correcting mechanisms).

The program for automation gives emphasis to industries employing component production, particularly machine building plants which manufacture motor vehicles and agricultural machinery. The individual automatic machine tools represent the first stage of automation in these industries, and the automatic transfer line epitomizes the more advanced level. The truly automatic factory, in which automatic lines are integrated by means of electronic computers and feedback control, probably will not be achieved for many years either in the USSR or in the US.

Since World War II the USSR has developed a program for research on the automation of manufacturing processes in the machine building industries on a greater scale than has the US. The quality of Soviet research and technology in this field of automation equals that of the US, although the US leads the USSR in the range and the quantity of industrial applications. In the motor vehicle industry, for example, the USSR has perfected automatic lines for production of only a few components, such as the engine block and piston, whereas most of the major US automobile firms have perfected and installed lines for making practically every component by such means. With enforced standardization and centralized control of changes in the design of products, the USSR would be justified in automating component production to a greater extent than any US manufacturer would be.

* A leading Soviet scientist made these classifications of industrial processes according to common features and methods of production. See I, p. 3, below, for a discussion of the distinctions in the automation of these classifications.

Factories of the Soviet motor vehicle and agricultural machinery industries have 80 to 90 automatic and semiautomatic lines. These lines have increased production and are being utilized extensively for operational research, thus serving two purposes of equal importance.

The limited application of automatic lines to actual production is illustrated in the Soviet motor vehicle and tractor industries. Although almost every major motor vehicle plant is producing engine blocks on automatic lines, engine heads are manufactured with individual machine tools. In all major tractor plants, individual machine tools are still producing engine blocks, but automatic lines are used to manufacture engine heads.

If the plan to introduce 220 new automatic and semiautomatic lines into the machine building industry by 1960 is carried out, however, the USSR will be able to achieve automatic production of such mass-produced components as engine heads, blocks, and gear cases. In addition, the USSR should be able to introduce prototype lines for a limited number of other components.

I. Concepts of Automation.

A. General.

Automation is not a single, easily identified development but the result of industrial progress in technology. The Soviet usage of the term automation does not imply that automation is a new phenomenon separate from the broad advance of mechanization. The frequent Soviet references to automation as the highest degree of mechanization are logical because automation does replace human labor by machinery, the traditional definition of mechanization. The leading Soviet scientists and engineers emphasize, however, that whereas mechanization is commonly understood to mean the replacement of human labor by machinery, automation is understood to mean the next logical step, the replacement of human control of technological process by mechanical control. The Soviet concept of automation thus involves the use of any machine,

device, or the like which replaces man as the controlling mechanism in the process of production.*

Soviet writers, like others, use the term automation loosely. As a result, there is much confusion as to the exact meaning of automation as used in various popular publications, economic journals, and technical publications in the USSR. The confusion arises because the term automation has different meanings for different groups of Soviet writers and because automation differs in definition from industry to industry. For example, automation may refer to (1) any equipment or method designed to reduce the labor required in an operation, (2) highly mechanized assembly lines that use automatic machines and material-handling equipment, or (3) automatic process control that uses advanced types of electronic circuits and computers.

A leading Soviet scientist has classified definitions of automation from an industrial point of view into five types of processes according to common factors and methods of production, as follows: (1) component production, such as pistons, antifriction bearings, and cylinder blocks; (2) continuous-flow production of solid materials; (3) continuous-flow production of friable materials; (4) continuous-flow production of liquid and gaseous substances; and (5) public utilities. 2/ The essential difference among these types of automation is that they are based on two distinct principles. Automation of component production is based on cyclic action of automatic machines,**

* The Bol'shaya sovetskaya entsiklopediya (Great Soviet Encyclopedia) has defined "automation of production" as the application of instruments (pribory), devices (prisposobleniya), and machines (mashiny) which are designed to carry out the processes of production without the direct participation of the individual, but only under his supervision. The Committee of Technical Terminology of the Academy of Sciences, USSR, has explained automation as "a branch of science and technology ... which secures the freeing of individuals from direct participation in production processes, combined, in particular, with the fulfillment of the function of control and regulation, by means of establishing suitable connections between mechanisms (ustroistva) which carry out the production process." 1/ (For serially numbered source references, see Appendix C.)

** A cyclic automatic machine is understood to mean any machine which performs a preset cycle of operations repetitively with almost no human intervention. The function of the worker is limited to manual pushbutton starting and stopping, observing and adjusting the performance to correct any malfunction, and repairing and maintaining the machine.

whereas the other four types are guided by the principle of automation based on the concept of feedback control.

Further confusion arises when Soviet writers, by introducing additional concepts of automation, distinguish between complex mechanization and automation. The three stages of automation generally recognized by Soviet writers and technicians are as follows: (1) partial automation, in which some or all of the individual operations in a process are automatically controlled but in which the movement of the product from one operation to the next is directed manually; (2) complex automation, in which a number of automatic operations are linked together to form a series of integrated processes by means of material-handling and transfer mechanisms; and (3) full automation, in which integrated processes, departments, or even factories are made fully automatic and self-correcting by means of computers and devices for feedback control.* These governing devices compare the operations in progress with advanced programming instructions and make whatever corrections are necessary to achieve the desired results.

B. Component Production.

The greatest emphasis on automation of component production in Soviet industry has occurred in the machine building sector, principally in production of motor vehicles and agricultural machinery. Most of the many diverse processes of production that are peculiar to the machine building industry -- because of the very large number of different shapes, materials, and sizes of items produced by the industry -- lend themselves to the type of automation used in component production. The automatic fulfillment of a technological process of this type depends primarily on the control of a great variety of individual cyclic-action automatic machine tools which have the function of driving a perishable cutting tool that performs a distinct metal-cutting operation. At this crucial phase the feedback control necessary for full automation becomes difficult or impossible to achieve. Deviations of such parameters as temperature, pressures, and rates of flow, which are the major agents in performing the desired operations in industries employing continuous-flow production, lend themselves to correction through the application of feedback control. Deviations caused by the wear of the cutting tool in performing desired operations in component production, however, can be corrected only through replacement of this tool. Eventually,

* These stages of automation are discussed specifically with relation to component production in V, A, p. 23, below.

through the development and introduction of new and different methods of metalforming, the principle of integrated feedback control and computers may be applied effectively to component production, thus achieving full automation. Although the USSR is engaged in research toward this end, present emphasis is devoted to improving conventional types of high-speed-steel, carbide-tipped, and ceramic-tipped cutting tools by increasing their resistance to wear to a degree that permits economical and statistical control of quality in production. 3/

C. Continuous-Flow Production.

Automation of a technological process in those industries employing continuous-flow production is guided by the principle of automation based on the concept of feedback control. The automatic fulfillment of a technological process in continuous-flow production depends primarily on the control of a great variety of parameters such as temperatures, pressures, and rates of flow. Despite the diversity of industrial processes employed in continuous-flow production, the control apparatus required for their automation can be constructed to a large extent on a single plan based on feedback control.

This uniformity results from the general nature of the problems of checking and control. The functions of a system of automation in continuous-flow production, although not always apparent, are as follows: (1) sensing and checking -- that is, measuring the parameter to be regulated (for example, temperature), comparing the result with a predetermined value, and signaling in case of a discrepancy -- and (2) transforming the control signal into action on the process (for example, varying the supply of fuel), thus reducing the deviation in the parameter.

The achievement of a completely automatically controlled plant in the industries employing continuous-flow production is a goal for the future. In both the US and the USSR, however, the prospect of ultimately achieving such a plant is much better for those industries employing continuous-flow production than for those employing component production. Industries employing continuous-flow production, in fact, could not exist as they do today without automatic control in the most rudimentary sense of the phrase. The very nature of such industries as the chemical and steel industries demands devices for accurate control of every step in their entire technological process. Not until World War II, however, were great advances made, both in the US and in the USSR, in research and development involving servomechanisms and

electronic and communications instruments and devices capable of performing a sequence of logical, self-correcting operations.

The USSR appears to have kept up with the US in this field of research and development. In some special fields, such as that of theoretical nonlinear mechanics, however, many US scientists believe that the USSR has surpassed the US. 4/ A survey of Soviet applications of automation in the various industries employing continuous-flow production indicates that although the US leads the USSR in range and quantity of industrial applications, the quality of Soviet automation is equal to that of the US. 5/

II. Current Program.

The increased emphasis on automation in the Sixth Five Year Plan is a logical outgrowth of previous Soviet policies and of the general course of technological development in the USSR. Soviet leaders, who traditionally have extolled the advantages of improved technology, began in the late 1930's to promote advanced mechanization and automation in important sectors of industry. 6/

A. Former Limitations.

The scale of early Soviet efforts to promote advanced mechanization and automation was governed by rather severe economic and technical limitations. Before World War II there were general shortages of manufactured goods in the USSR. The immediate concern of Soviet planners, therefore, was a rapid increase in industrial production. Because labor and most raw materials were relatively abundant and capital equipment was scarce, the planners relied on conventional methods of production and equipment that provided a quick return from available resources. The planners were able to make only limited investments in advanced technological equipment. The decision to favor investments providing a quick increase in production stemmed also from the growing Soviet belief that war was imminent. 7/

Because of these pressures, mechanization and automation were applied only to key sectors of industry and were carried out on a piecemeal basis. Even in the favored sectors of industry, many plants continued to use equipment and methods that were backward by comparison with the best practice in the USSR and elsewhere because the additional production from these plants was badly needed.

Similar pressures have influenced Soviet industrial policy during much of the decade since World War II. During these years the USSR had to rebuild war-damaged industry, at the same time maintaining the military preparedness required by its cold war policies and by its indirect role in the Korean war. Programs for military production thus received priority. The primary emphasis in research and development involving automation was on applications to the military programs. Attention was focused on the research and development of analogue and digital computers for use in solving scientific and engineering problems arising in the design and development of a new aircraft, missile, or atomic weapon.

Progress in industrial automation was restricted largely to the machine building industries making items, such as bearings and pistons, which are widely used in both military and civilian production. 8/

B. Sixth Five Year Plan (1956-60).

Under the Sixth Five Year Plan (1956-60) the USSR is significantly expanding its efforts to mechanize and automate the processes of production. The Plan outlines a program for introducing mechanization and automation in the machine building, metallurgical, and other basic industries "on a large scale." Soviet leaders expect this program to contribute to a planned increase of 50 percent in industrial productivity. The section of the Plan dealing with mechanization and automation provides for a general increase of approximately 350 percent in production of instruments and means of automation, including an increase of 400 percent in production of instruments for the automatic control and regulation of technological processes. 9/

The Plan emphasizes partial and complex automation as the most immediate and practical goals for Soviet industry. Complex automation is given a degree of priority in the machine building, electric power, chemical, and petroleum industries, which have a state of technology sufficiently advanced to provide a basis for undertaking necessary research and development under the Sixth Five Year Plan. The Plan indicates, however, that full automation is extremely important as an ultimate objective. Soviet science has done extensive research in the theory of automatic control, data processing, and related fields. Soviet science has been instructed in directives for implementing the Plan to pay particular attention to the application of these theoretical findings to industrial processes.

Soviet planners realize that larger investments in capital equipment are required to achieve significant increases in industrial production. In working out the pattern of such investments, the planners faced problems of a different character from those in previous Plans. Obsolescence, for example, was becoming a problem in many industries, and the planners were beginning to realize that the cost of continuing to operate existing equipment might exceed the cost of replacing this equipment. 10/ Furthermore, the rate of annual additions to the industrial labor force was expected to decline.

In considering these problems, the government had to decide the proportions of investment which would be devoted to new conventional equipment and to automation. Automation would require high initial investments in developmental research and in equipment. On the other hand, conventional technology would require more new plants and substantially more labor. Furthermore, in order to transfer additional labor readily from agriculture to industry, larger investments in agricultural equipment would be required. Larger investments in urban housing services also would be needed to accommodate these new workers in industrial centers.

Soviet planners apparently chose to invest substantially in automation as well as in conventional technology 11/ and to invest more heavily in new equipment than in new plants. 12/

III. Policy Considerations.

A. General Short-Term and Long-Term Gains.

Automation generally requires a high initial investment and, in some instances, yields widespread benefits only over a long period of time. Soviet leaders seem to believe, however, that it will be possible to overcome technical obstacles and to obtain some returns under the present Five Year Plan.

The expected contribution of automation to long-range industrial development, however, holds the greatest appeal for Soviet leaders. Somewhat underrating the effect of automation on the productivity of technically advanced Western nations, Soviet leaders expect their program for automation and other technological improvements to provide a basis for ultimately surpassing capitalistic countries in industrial production per capita, although they concede that the attainment of this goal may require 2 or 3 Five Year Plans. 13/

Should the objectives of the present Soviet program be fully achieved, a number of basic industries would have made an appreciable start in automation by 1960. The USSR also would acquire invaluable experience in developing practical technology and equipment and in standardizing production of automatic devices. Soviet leaders probably consider that the new capacity and technical knowledge to be developed by 1960 under the program for automation are as significant as the additional production to be provided under the current Plan.

B. Specific Economic and Technological Advantages.

Leading Soviet administrators and technicians have stressed some of the specific economic benefits which they expect to derive from automation. Soviet analysis of the economic effects of automation is based only in part on actual industrial experience and rests to a large extent on theoretical estimates of future possibilities.

1. Increased Production.

Soviet studies comparing the output of production lines before and after automation usually have shown that automated lines bring a sharp increase in the number of units produced annually per worker and per square meter of production area.* 14/ Although the number of such studies is small, these findings, in addition to estimates of the technical capacity of innovations still in the planning stage, have caused Soviet economic and technical spokesmen to be optimistic.

2. More Advanced Technological Processes.

Some new technological processes, such as those involving atomic energy or certain chemical reactions, operate at high speeds, temperatures, or pressures that make it physically impossible for the human hand or eye to maintain direct control. 15/ In such cases, successful production requires electronic and telemechanical control.

3. Improved Quality of Product.

Automatic control of temperature, pressure, and other governing factors also is highly desirable to assure the necessary quality of products in certain processes of such industrial sectors

* For specific instances, see V, p. 23, below.

as petroleum, chemicals, and food processing. 16/ In other instances, automation can provide significant savings by improving the quality of production and reducing the rate of rejection. 17/ In the Khar'kov Tractor Plant, for example, the rate of rejection for engine heads allegedly declined by 75 percent after an automatic production line was installed. 18/

4. Savings in Manpower.

Because of the increasing shortage of labor, the USSR has shown considerable interest in the possibility that automation might provide sizable savings in manpower in such categories as production workers, quality-control staffs, and clerical employees. The small number of production workers required by those automatic lines for producing pistons and ball bearings, which are now in operation, has been highly publicized. Furthermore, there has been some discussion of the possibility of reducing clerical staffs by applying automatic techniques for processing data to payrolls, inventory records, and other administrative operations.

5. More Efficient Use of Plant Space.

Automation also can result in economies in plant space. The manufacturing cycle frequently can be carried out in a more compact layout, for example, so that there are direct savings in space and also in intraplant transportation of semifinished products and components. 19/ The most far-reaching gains of this kind, however, usually require fundamental changes in technological processes and in the designs of products.

6. Other Economic Considerations.

The principal motivation toward automation for both the US and the USSR can be summarized as a reduction in the cost of production by any one or any combination of the methods mentioned above. There are, however, relative differences in the two economies which also will influence the degree, scope, area, and/or necessity of industrial automation. At present, for example, the USSR is, for the first time, faced with an absolute shortage of manpower which threatens to impede the desired direction and rate of its rapidly expanding economy. In addition, the Soviet economy is faced with an inadequate supply of industrial and structural material, particularly steel and cement. Therefore, the economic criteria and motivations for automation

in the USSR at any given time may not be same as those for the US, because, among other differences, the relative scarcities of labor and capital are different in the two economies. In the US the present high cost of labor serves as an incentive to spur the introduction of automation, although some concern is being expressed about the adverse social and economic impacts of the technological displacement of labor resulting from automation. In the USSR the introduction of automation is viewed as a means of reducing the cost of labor even though labor is cheap relative to the US. Automation also is being relied upon by the USSR to release additional workers to ease an absolute labor shortage. The USSR views such labor displacement as an economic necessity and one of the important means of solving its increasingly tight labor supply. Furthermore, the USSR even may consider its practices of planned labor training and planned labor mobility as a panacea for some of the possible adverse economic and social problems resulting from automation.

7. Limitations and Necessary Characteristics of Automatic Transfer Lines.

From the point of view of the potential of industrial automation, the degree and scope of automation possible in those Soviet industries employing continuous-flow production is equal to that of the US. Regardless of the differences in economic systems, the technology of these industries in any industrially advanced nation demands a high degree of automation. In those industries employing component production, however, the USSR appears to be striving toward a fuller degree of automation than the US, as illustrated by the much publicized Soviet "automatic" piston plant.

A few of the basic characteristics and demands necessary for the economic utilization of an automatic transfer line are (a) mass quantity of output, (b) stability of design of components, (c) adjustment of both the tempo and the quality of the work of auxiliary shops to the demands of the lines, and (d) adequate supply of trained labor to operate and to service the lines.

After examining plans and reports on the Soviet "automatic" piston plant, US manufacturers of pistons indicated that no US firm could afford to invest so much in a plant that would become obsolete so soon, because the piston design is so diversified and so rapidly changing in the US. With enforced standardization and centralized control of changes in components and models, the USSR would be justified

economically in automating component production to a greater degree than any US manufacturer would be. 20/

There are two other limitations of automatic transfer lines that merit further comment. The first is the need to gear the rest of the factory to the production rate and specifications of the line. Consequently, the capacity of the automatic line represents, with proper allowance for the manufacture of spare parts and a certain amount of "auxiliary production" (often consumer goods in the USSR) the maximum capacity of the plant. Secondly, the machine tools in automatic lines cannot be converted so easily to other uses as can a "universal" machine tool. The USSR, however, is attempting to overcome this limitation and also to build more flexibility into lines by adopting the use of the unit-type machine tool* in automatic transfer lines.

C. Ideological Overtones.

In the USSR, as elsewhere, the phenomenon of automation has a visionary appeal that cannot be explained solely in terms of economic and technological considerations. The imagination of Soviet leaders seems to have been captured by the possibilities which automation offers for achieving the traditional ideological goals of easing the toil of workers, eliminating the distinction between mental and physical labor, and providing plenty for all. These ideological considerations probably do not exert a decisive influence on Soviet policy, but social betterment is regarded as an important byproduct of automation. In addition, the promise of a plentiful tomorrow -- to be achieved through automation -- is used to justify a continued emphasis on production of producer goods.

D. Investment and Obsolescence.

In the last few years, Soviet economists and industrial leaders have debated the proper criteria for appraising the economic effectiveness of capital investment in technological improvements, including automatic equipment and processes. In earlier discussions in the USSR the short-term reduction in direct costs of production was an important criterion. 21/ Recently, more attention has been paid to the long-term savings resulting from technological improvements, especially if introduced at several plants, 22/ and to other factors of cost such as

* See V, B, 2, p. 27, below.

savings in plant space and improvement in quality. The problem of working out a general formula of measurement still is receiving much attention from the central agencies concerned with planning and technological improvement. 23/

The changing appraisal of the criteria for investment has resulted in large part from a shift in the doctrinal approach toward obsolescence. Traditional Marxist-Leninist doctrine held that the obsolescence of capital equipment is peculiar to capitalist economies and cannot exist in a socialist society. This theory tended to justify the continued use of outmoded and inefficient machinery until it could no longer be kept in repair. Because it was held that there could be no obsolescence of fixed capital, depreciation could cover only the physical deterioration of fixed capital. 24/

In the last few years, however, Soviet economists and leaders generally have questioned critically this concept. In mid-1955 a leading writer on the subject even advocated its abandonment. He charged that "the denial of the obsolescence of equipment ... justified the actions of those directors of enterprises who are not concerned with whether or not the further use of a certain machine is profitable or unprofitable and who are not concerned with the improvement of equipment. The lower depreciation rates employed in several branches of industry do not stimulate the introduction of new technology." 25/ Apparently, it is difficult to overcome the inertia and caution of plant managers and other officials in handling obsolescence as well as other matters related to technological innovations. 26/

IV. Implementation of the Program.

During the past decade, Soviet scientists have made impressive progress in developing the theory of automatic control. Only since early 1954, however, have essential steps been taken to encourage widespread industrial automation. Soviet leaders have set up central administrative machinery to formulate general policies and procedures for promoting the solution of scientific, technological, and administrative problems involved in automating industrial operations.* These leaders also have prepared to expand production of standard instruments and equipment used in industrial automation.

* See the accompanying chart, following p. 14.

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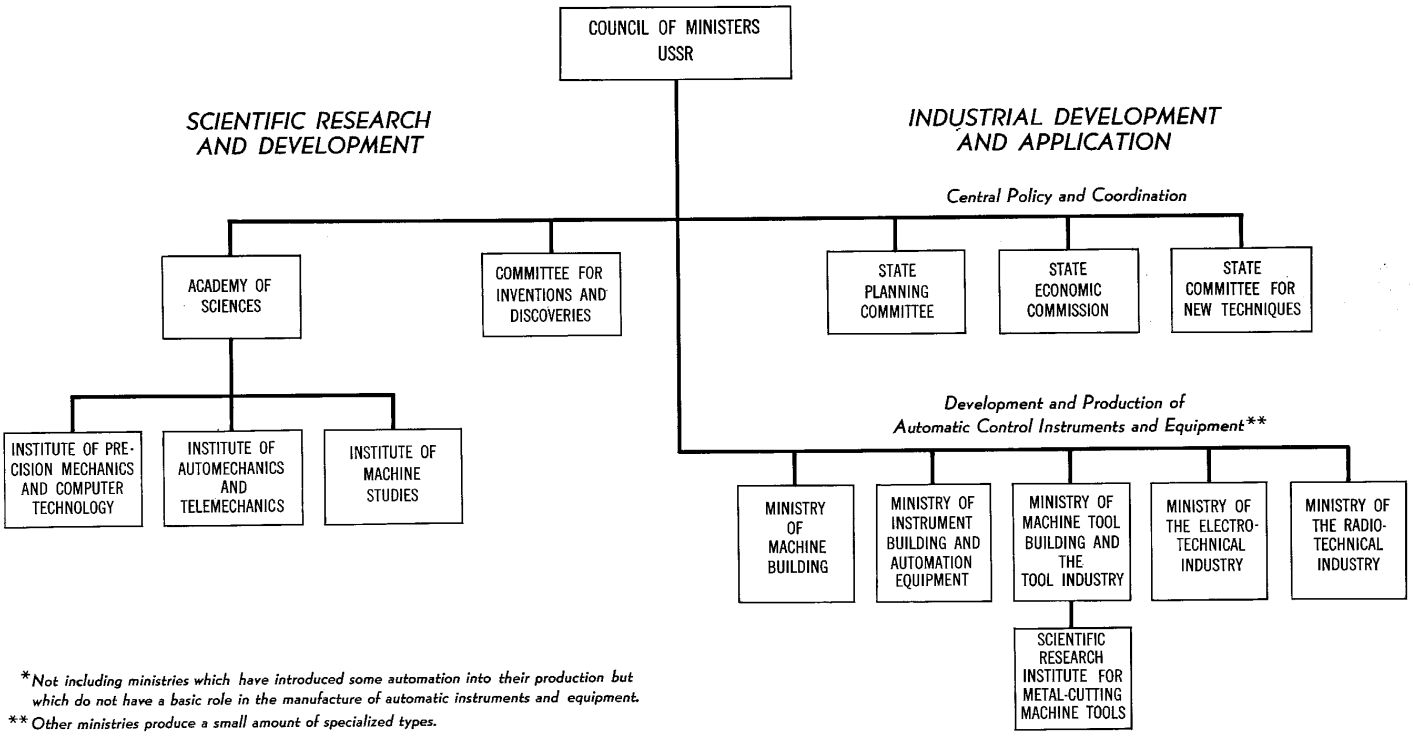
USSR

MANAGEMENT OF THE PROGRAM FOR INDUSTRIAL AUTOMATION*



*Not including ministries which have introduced some automation into their production but which do not have a basic role in the manufacture of automatic instruments and equipment.

**Other ministries produce a small amount of specialized types.

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A. Organizational Measures to Encourage Mechanization and Automation.

Soviet leaders have recognized that the success of their program for mechanization and automation under the Sixth Five Year Plan depends on the proper timing and coordination of scientific and technical activities. Bulganin pointed out in July 1955 that the USSR was failing to realize its full industrial potential largely because of the poor cooperation between science and industry, the failure to keep abreast of developments abroad, and the lack of initiative of industrial managers in adopting new techniques. 27/

A major shortcoming stressed by Bulganin and others was that responsibility for the industrial application of scientific discoveries was not sufficiently centralized. Before May 1955 the Academy of Sciences directed and coordinated general scientific research, 28/ but the individual ministries, which controlled the development and introduction of technology within their areas of responsibility for production, frequently showed considerable inertia. 29/ Nominally the State Planning Committee (Gosplan) was responsible for coordinating the efforts of the Academy and the various ministries and for bridging the gap between pure and applied science. The Scientific-Technical Council of Gosplan, which included representatives of both science and industry, reviewed the plans of both the Academy and the ministries.

Under this system, however, central coordination of industrial research and development was inadequate. The Academy of Sciences frequently failed to coordinate its research with the requirements of industry and devoted insufficient attention to technological research based on its scientific findings. 30/ Similar charges have been made against the universities and their research establishments. 31/

1. Improvements in Central Technological Administration.

On 25 May 1955 the State Planning Committee (Gosplan) was divided into two agencies: the State Planning Commission (also called Gosplan), to handle long-term planning, and a State Economic Commission (Gosekonomkomissiya), to handle current planning. 32/ This reorganization led to greater specialization in planning and was designed to focus greater attention on major problems of long-range economic and technological improvement, including problems relating to automation. At that time, Khrushchev stressed the need for long-term plans, covering 10 to 15 years, for a number of industries.

On 28 May 1955, Soviet leaders created the State Committee of the Council of Ministers for New Techniques (Gostekhnika)* under V.A. Malyshev, Deputy Chairman of the Council of Ministers and former Minister of Medium Machine Building. 34/ The mission of Gostekhnika is to promote the introduction of technological improvements in industry and to coordinate policies and activities in this field.**

Gostekhnika was directed specifically (a) to plan the complex mechanization and automation of the most important branches of industry and to obtain the prompt use of important inventions and discoveries; (b) to make recommendations on the general course of scientific and technological development in all branches of the economy and on "future work in the creation of new instruments, equipment, materials, and physiological processes"; (c) to initiate proposals for the cessation of production of outdated equipment; and (d) to organize the systematic collection and dissemination of information on both domestic and foreign developments in science and industrial technology.*** 35/ Gostekhnika also was directed to propose suitable incentives to encourage technological progress.

Gostekhnika was given requisite authority to enforce its policies, including the right to control the introduction into the national economy of scientific discoveries, new technology, and important inventions and to inspect "ministries and departments" on these matters. 36/ The latter organizations, however, were not relieved of the responsibility to adopt the most advanced techniques of production on their own initiative. 37/

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* A State Committee for Introduction of Advanced Techniques in the National Economy -- also called Gostekhnika -- had existed from 1948 to 1951. That Committee tended, however, to concentrate on problems of standards and specifications rather than on coordination of policy and was abolished in February 1951. Responsibility for inventions and for the introduction of technological improvements then reverted to the various industrial ministries. Subsequently, Soviet writers repeatedly criticized the ministries for lack of initiative in this field and viewed the abolition of the former Gostekhnika as a mistake. 33/

** The State Committee for Questions of Labor and Wages, which was created in May 1955, also reviews plans for the introduction of new machinery and techniques of production. Such reviews, however, are limited to the effects of these plans on requirements for labor.

*** Gostekhnika shares this responsibility with the Academy of Sciences and the industrial ministries.

Since its creation, Gostekhnika has been an administrative focal point of the program of mechanization and automation, directing ministerial research establishments to undertake certain general tasks and specific projects required by the program for automation. 38/ Gostekhnika also has publicized Soviet and foreign developments in industrial technology and equipment* 40/ and has investigated the advisability of ministerial programs to introduce automation in the different industries and to develop new equipment and processes. In September 1956, Gostekhnika and the Institute of Machine Studies of the Academy of Sciences jointly sponsored a conference on "the integral mechanization and automation of technological processes in machine building." This conference was attended by 850 "scientists, designers, engineers, and leading workers of machine building ministries" who reportedly made "many valuable practical proposals." 41/ Similar conferences have followed in other major industrial sectors.

2. Improvements in Technological Management.

In attacking the basic problem of the lack of initiative in the ministries, the Soviet leaders assigned definite responsibility for the development and introduction of automation and other technological improvements to specific ministerial officials and departments. The new post of Deputy Minister for New Techniques was established within the industrial ministries. 42/ In addition, scientific-technical councils at the ministerial and plant levels were revitalized. These councils are taking an active role in solving technical problems related to automation. 43/ The industrial ministries have also set up new research institutes, such as the Experimental Scientific Research Institute of Press and Forging Machine Building (Eksperimental'nyy

* The newspaper Promyshlenno-ekonomicheskaya gazeta is the organ of Gostekhnika for the dissemination of technical information. The Committee for Inventions and Discoveries (attached to the Council of Ministers) also publishes a monthly journal to disseminate information of this type which covers a broader area than industrial technology. This Committee, which was reactivated and given enhanced status in early 1956, is directed "to improve radically the leadership in the introduction of inventions and discoveries ... and to insure control over the fulfillment of the directives of the Party and Government on the further development of the rationalizing and invention movement." In October 1956 the Committee convened and participated in an all-union conference of "rationalizers, inventors, and innovators of production." 39/

Nauchno-Issledovatel'skiy Institut Kuznechno-Pressovogo Mashinostroyeniya -- ENIIKMASh)* at Voronezh 44/ and the All-Union Technological Planning Institute for the Development of Technology and the Organization of Production in the Electrical Engineering Industry (Vsesoyuznyy Proyektno-Tekhnologicheskiy Institut po Razrabotke Tekhnologii i Organizatsii Proizvodstva v Elektrotekhnicheskoy Promyshlennosti -- Orgelektroprom) at Khar'kov. 45/ Such institutes are charged with studying general problems of technology, including problems of automation, that are related to particular industrial branches or regions.** Finally, special automation divisions, design bureaus, and laboratories have been set up in many of the enterprises which are scheduled to undertake automation under the Sixth Five Year Plan. 46/

B. Organizational Measures to Expand Production of Automation Equipment.

Soviet leaders have attempted also to standardize and improve production of instruments and other devices used in automation. The Ministry of Machine Tool Building and the Tool Industry, although not administratively responsible, pioneered the development and organized production of such devices. The work of ENIMS has been particularly important.*** The ministries in charge of production, however, principally the Ministry of Machine and Instrument Building and the Ministries of the Radiotechnical Industry and of the Electrotechnical Industry, neglected their responsibilities in this field.

Because these ministries, particularly the Ministry of Machine and Instrument Building, failed to develop general-purpose devices for control which could be used to automate a variety of industrial processes, little progress was made in standardizing designs. 47/ Industries which undertook automation usually designed and produced their own equipment, and by 1955 more than 30 ministries thus were

* This Institute is under the Ministry of Machine Tool Building and the Tool Industry.

** The well-established central research groups, such as the Experimental Scientific Research Institute for Metal-Cutting Machine Tools (Eksperimental'nyy Nauchno-Issledovatel'skiy Institut Metallorezhushchikh Stankov -- ENIMS) of the Ministry of Machine Tool Building and the Tool Industry, rather than the new regional institutes probably will continue to bear primary responsibility for research and development.

*** The vital role of ENIMS is discussed in V, B, p. 25, below.

producing automatic equipment, with little or no coordination of their efforts. 48/ This lack of coordination resulted in high cost and low output because production was in small lots and frequently was carried out by enterprises which were not well equipped for the job. Soviet leaders recognized that correction of this situation was essential to the successful implementation of the program for automation. 49/

In an attempt to organize the design and production of standard devices for automatic control on a more specialized basis, the Ministry of Machine and Instrument Building was divided, on 22 January 1956, into an all-union Ministry of Machine Building and an all-union Ministry of Instrument Building and Automation Equipment. 50/

At least, for the time being, the Ministry of Instrument Building and Automation Equipment has jurisdiction only over instruments, computers, and other precision machinery formerly produced by the Main Administration of Instruments and the Main Administration of Precision Machinery of the old Ministry of Machine and Instrument Building. 51/ The new Ministry apparently will be primarily responsible for providing the increases of from 350 to 450 percent in production of instruments and precision machinery which are called for by the Sixth Five-Year Plan. 52/ The new Ministry will have jurisdiction over the 30 new instrument plants scheduled for construction, and statements by the Minister suggest that already the number may have been increased to 40. 53/

The plants of the new Ministry will not produce all of the devices used in automation. Electronic equipment, for example, is still the responsibility of the Ministries of the Radiotechnical Industry and of the Electrotechnical Industry. Under the Sixth Five Year Plan these Ministries were directed to increase production of electronic devices for automation and to expand their facilities for research. 54/ These Ministries are expected to coordinate their efforts with the Ministry of Instrument Building and Automation Equipment, which is regarded as the principal producer of general-purpose instruments and control devices. 55/ What specific powers the new Ministry has to enforce coordination is not clear as yet.

The new Ministry is expanding the research establishment taken over from the former Ministry. In August 1956 the Minister announced that several new research institutes and design bureaus are to be established in order to expedite the development of the new types of instruments and control components required by Soviet industry. 56/

Some of the new facilities for research are to be located in regional centers of industrial development, such as Tbilisi, where there is to be a scientific research institute for the construction of electric calculating machines. This institute will have its own experimental shops and design bureau. 57/ At Kutaisi the new Ministry is setting up a "specialized planning and construction bureau," 58/ presumably to assist enterprises in that area to plan the automation of their processes of production.

The new Ministry also is working closely with other ministries in solving the technical problems involved in automating specific types of industrial production, such as production in the petroleum, light, and food industries. 59/ Together with the Soviet-Hungarian Scientific and Technical Cooperation Commission, the new Ministry also sponsored a conference within the Sino-Soviet Bloc on problems of automation and the manufacture of instruments for control. This conference was attended by representatives of Bulgaria, Communist China, Czechoslovakia, East Germany, Hungary, Poland, and the USSR. 60/

The progress of the new Ministry in carrying out its responsibilities is rather difficult to assess as yet. The Ministry failed to achieve the scheduled output of computing machines during the first 6 months of 1956 even though it did fulfill its plan for gross output. 61/ The failure cited, however, related to production of only one item, and the over-all fulfillment related to only a short period of time.

C. Economic Incentives.

Soviet leaders also have attempted to overcome technological inertia in industry by providing stronger economic incentives to managers and workers. The economic rewards for innovation frequently have not been commensurate with the risk of temporarily not fulfilling the goals of the Plan.

1. Credit Policy.

Until recently, Soviet enterprises experienced difficulty in financing technological improvements undertaken on their own iniative. Budgetary allocations to enterprises for planned capital development tended to favor projects directly related to the fulfillment of current goals for production rather than to technological innovation. 62/ If, on the other hand, enterprises resorted to special loans from the State Bank (Gosbank) to finance automation or other improvements, they

faced very unfavorable credit terms. Special Gosbank loans for this purpose could be obtained for only 1 year and had to be repaid from savings realized from the proposed improvement during that year. 63/ Credit on such terms was of little help to enterprises in heavy industry, because innovations usually could not be completed and amortized within a single year.

In August 1954, however, the Central Committee of the Communist Party and the Council of Ministers jointly ordered Gosbank to undertake a broad re-examination of its policies. On 26 July 1955, Gosbank adopted more liberal credit terms for technological improvements initiated by individual enterprises. 64/ Under the new policy, enterprises in the metallurgical, coal, chemical, petroleum, and machine building industries may obtain loans for 3 years for any of the following purposes: (a) to acquire, manufacture, or install new equipment; (b) to modernize or replace equipment; (c) to set up automatic and continuous production* lines; (d) to introduce complex mechanization; (e) to mechanize auxiliary operations; (f) to equip and adapt work areas; or (g) to acquire specialized transportation equipment. Repayment of such loans does not begin until projects are completed and in operation, although repayment still must come from savings in costs of production.

The principal restriction on the amount of credit to be extended for any given project is the requirement that large loans must be approved by central banking and ministerial officials. 65/ The Gosbank Board of Directors must sanction loans for more than 1 million rubles, and responsible ministerial officials must endorse estimates for improvements that cost more than a specified amount (1 million rubles for most enterprises but 2 million rubles for a special list of large-scale enterprises). Directors of enterprises and appropriate local or regional Gosbank officials, however, arrange smaller loans on their own authority.

By providing more liberal credit, Soviet leaders hope to encourage the introduction of automation and other progressive techniques. There already has been some indication that enterprises are taking advantage of the new loan policy, 66/ although perhaps not on the scale anticipated. In some instances, however, there have been complaints that ministries are not properly supporting projects initiated by individual enterprises. 67/

* See V, A, 2, p. 24, below.

2. Bonuses.

Efforts also have been made to encourage technological progress by stimulating the interest and initiative of personnel engaged in design and production. In August 1956 the Soviet Council of Ministers liberalized regulations governing payments of bonuses to employees who design or participate in the introduction of new types of equipment. 68/ Scientists, designers, or engineers who design new or improved types of equipment or who develop new materials are entitled to bonuses of 5 to 30 percent of the total annual savings realized by using the innovations. Bonuses are provided also for technicians and workers who directly participate in manufacturing new equipment and putting it into operation.

3. Measures Under Consideration.

Malyshev, among others, has recognized that additional incentives are needed to insure the maximum technological progress in Soviet industry. He has pointed out that enterprises undertaking innovations face almost inevitable losses under existing policies. 69/ If an enterprise proposes improvements, anticipated reductions in the cost of production are included in its plan as an obligatory goal. 70/ Goals for production, however, usually are not adjusted to accommodate losses that may occur in the initial stages of introducing new equipment and processes. Any profits that ultimately may develop tend to accrue to the state rather than to the enterprise. The progressive enterprise therefore runs the risk of penalties for not fulfilling its goal but does not have the compensating prospect of a significant reward for success in the new venture.

Recent Soviet discussions have emphasized the importance of reducing the risks and increasing the rewards for enterprises that undertake technological improvements. Among the specific proposals suggested have been the following: (a) temporary losses incurred by enterprises while introducing new equipment or methods should be written off by the ministries 71/; (b) the prices set for the products of an enterprise should reflect its state of technological development*; and (c) planned costs of production should remain constant for longer periods so that enterprises would share more liberally in

* The discussions of policy on pricing assume that the products of the technically progressive plant will be more durable and of higher quality than those of the more backward factories in the field. It is proposed, therefore, that price differentials should reflect this fact accurately. Presumably, however, price manipulation would be a flexible, temporary expedient.

profits derived from technological improvements. 72/ Although no measures have been announced as yet, it is quite possible that the Soviet government may act to implement these suggestions as a part of its efforts to promote more rapid technological development in industry.

V. Trends in Component Production.

A. Stages of Automation.*

1. Mechanization and Partial Automation.

Because the development of automation of component production is based primarily on the principle of the cyclic automatic machine, one of the principal indicators reflecting the progress and degree of automation in the entire Soviet machine building sector is the technological development and production of the Soviet machine tool building industry.

Since World War II the USSR has developed a technology and a capacity for production of machine tools which are approximately equivalent to those of the US and is now carrying on research on a greater scale than the US in various fields related to machine tool building and its automation. 73/ Furthermore, centralized control of research institutes and plants in the USSR tends to produce results that can be disseminated throughout the industry more quickly than can the results of research by individual companies in the US.

The most important development that has facilitated automation in Soviet machine tool building since World War II has been Soviet emphasis on producing the more efficient and productive designs, such as automatic and semiautomatic, combination, unit-type, and electrohydrocopying and contouring machine tools. Not only do all of these tools increase productivity, but they are the types of cyclic automatic machines needed for the development of automation.

The need for increasing the availability of these more productive machine tools is constantly stressed by such Soviet authorities on automation as engineers and plant directors. One of the solutions has been to standardize machine tools, their components, and their accessories and thus profit by the savings of labor and materials which result from mass production.

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* The three stages discussed here are those briefly outlined in I, A, p. 3, above.

In conjunction with the development and standardization of the cyclic automatic machine tools, the Soviet efforts to bring into effect the automation of component production are directed simultaneously toward the development, standardization, and production of new precision instruments and devices for measurement and control. In the fields of measurement and control the USSR is producing almost every basic type of instrument and device that is known in the West. 74/

The stage of automation known in strict Soviet terminology as partial automation involves an integrated scheme comprising (a) cyclic automatic machine tools; (b) devices for measurement and control; and (c) the automatic feeding, loading, and unloading of the workpiece at any individual operation of a technological process.* In this stage of production, only one or possibly a few of the operations of a technological process are performed and controlled automatically, thus necessitating direct human intervention in other operations and in the over-all manual control of the entire technological sequence.

2. Complex Automation.

The second stage of automation of component production in Soviet industry is known as complex automation. Whereas the term partial automation is used in Soviet terminology to describe the principles of automation applied to separate or individual operations, the term complex automation refers to the application of automation to a connected series of required operations which comprise a definite technological process. The distinguishing feature of this integrated system of automation is the reorganization of a technological process into a scheme for automatic, continuous production that insures coordinated functioning of all production and auxiliary operations.

More specifically, continuous production is characterized by a fixed rhythmic rate of work in all operations and steps in the manufacturing process in accordance with an integrated over-all plan and a uniform but selected output of finished products. In order to insure proper coordination of the various operations, the machinery and equipment are arranged in accordance with the sequence of the manufacturing procedures, and each work station is allocated specific

* In Soviet writing, however, the word automation alone is often used to indicate the concept described here as partial automation.

operations. The various operations are adjusted so that the time required for performing each operation bears a definite relation to the time needed for every other operation.

Such an over-all, automatically controlled system of production, in which all the phases of a technological process are automatically performed and controlled, frees manpower from direct participation in the process of production. The function of the worker is reduced to adjusting and regulating machines, observing their functioning, and changing tools. When applied to component production, complex automation forms the basis for the semiautomatic and automatic transfer lines, automatic shops, and automatic factories, each of which represents a progressive degree of the automatic integration and control of the processes needed to manufacture a finished product.

3. Full Automation.

The Soviet concept of full automation, the third and final stage of automation, envisages an entire self-correcting technological process which is controlled automatically by an integrated system of servomechanism devices and digital computers. When applied to component production, full automation implies not only control by integrated computers of all the automatic production lines necessary in any one technological process but also automatic lines featuring methods of metalworking susceptible to integrated feedback control. Because the integration of complete feedback control is difficult or impossible to achieve with present methods of metalforming, however, the realization of a truly automatic factory for component production is a goal for the distant future.

B. Trends in Automation.

1. History.

The foundations for the present progress toward automation of component production in Soviet industry were laid in 1933 with the creation of ENIMS,* the centralized research institute for the machine building industries. The aim of ENIMS was to undertake a program of research and development involving techniques of production and types of machine tools that would yield increased productivity and decreased costs of production by maximizing the output of the machines and by minimizing the expenditure of human and mechanical labor. The logical initial phase of the development of this program was to concentrate

* See IV, B, p. 18, above.

on research on the cyclic automatic and semiautomatic machine tools that the West already was applying successfully to mass production. Before World War II, therefore, one of the basic trends toward the partial automation of machine building in the USSR -- as it had been in the US -- was the policy of replacing the universal machine tool by automatic, semiautomatic, and combination machine tools.

In addition, work in the field of automation of component production was conducted in the direction of developing automatic and semiautomatic transfer lines, the first of which was installed between 1938 and 1940 for production of caterpillar tread rollers at the Stalingrad Tractor Plant. 75/ This line, an example of complex automation, consisted of universal machine tools which were converted (automatized) and arranged to carry out their operation of machining in a technological sequence and which were connected by a conveyor that moved the workpiece from one machine to another.

During the period 1941-44 the Soviet machine tool industry concentrated on developing similar semiautomatic transfer lines for the defense industry, and the application of these lines is reported as having made possible the mass production of the KV and T-34 tanks. 76/ During this same period the introduction of about 80 unit-type automatic and semiautomatic machine tools into Soviet aircraft factories is reported to have replaced approximately 900 universal machine tools and freed approximately 1,600 workers. 77/

This trend toward partial and complex automation of component production continued after World War II with increased emphasis on the development of automatic and semiautomatic transfer lines featuring new and improved methods of machining, assembly, inspection, and devices for measurement and control based on achievements in research on electronic and communications equipment. The USSR has introduced such lines, primarily into the motor vehicle and the agricultural machinery industries, for mass production of the following items: engine blocks, engine heads, piston rings, piston pins, gear cases, bolts, nuts, bearings, plow shares, rake teeth, and hook-linked drive chains for combines. Soviet sources suggest that, as of the beginning of 1956, 80 to 90 automatic and semiautomatic transfer lines had been introduced into the motor vehicle and agricultural machinery industries. 78/

A survey of the industrial applications of these lines demonstrates that they are actually in operation in some factories

under conditions of production and are responsible for substantial increases in production. Equally important, these lines represent the advanced stage of the systematic Soviet program of research and development involving automation of component production and are utilized extensively for operational research.

2. Research and Development Since World War II.

Perhaps one of the most important developments in the automation of the Soviet machine tool industry, as characterized by the automatic transfer line, has been the concentration on research and development in the standardization of machine tool components since World War II. Standardization was undertaken in an effort (a) to decrease the time required for building an automatic machine tool, (b) to increase the flexibility of the machine tool, and (c) to profit from the savings in labor and materials which result from mass production. Some of the basic components which became standardized were power heads, spindle casings, mountings, beds, and transmissions. In addition, the industry standardized auxiliary units such as control panels; automatic feeding mechanisms; automatic transfer equipment; hydraulic pumps; and mechanisms for the automatic loading, clamping, positioning, and unloading of piece parts.

Machine tools, consisting of these individual standard units, are assembled into various combinations, depending on the nature of the machining operations to be performed. Although such machine tools are commonly referred to as unit-type machine tools (agregatnyye stanki), they are either combination, automatic, or semiautomatic machine tools or components of automatic transfer lines. 79/

When the specific machining operation, for which a unit-type machine tool was assembled, is modified or changed completely, the machine unit can be dismantled and reassembled into new combinations in accordance with the specifications for the next application. For this reason the unit-type machine tools have received wide application in Soviet automatic lines since World War II and have replaced the more costly, less flexible, and less productive custom-built combination machine tools used in earlier lines. The USSR claims that the practice of assembling machine tools from standard units has reduced by one-third the time required to plan a modern machine tool. 80/

The integration of a series of these unit-type machine tools with automatic transfer equipment; with automatic auxiliary

mechanisms; with automatic devices for inspection, sorting, measurement, assembly, control, and regulation; and with a continuous method of production results in an example of complex automation known as an automatic transfer line. The piece part to be machined is placed in the transfer equipment at the beginning of the line and emerges at the other end machined to the required specifications. There is little or no participation by the operators, whose functions are reduced to changing cutting tools and monitoring the control panel which indicates the progress and continued accuracy of the operations.

Since World War II the USSR has made great progress in extending the scope of the automatic transfer lines to include a variety of operations. The first lines were developed and built to perform simultaneously the machining operations, such as grinding, drilling, reaming, and milling, of all surfaces and holes in the production of engine blocks and heads. Later lines that were developed systematically by ENIMS include many of the other operations, such as casting, thermal treatment, inspection, and assembly, involved in component production.

One of the most striking examples of such research and development by ENIMS was the creation in 1951 of a so-called "automatic" piston factory, which produces pistons, without any handling operations, from the smelting of an aluminum ingot to the wrapping of the finished product.* This plant is operated by less than one-quarter of the number of operators and tool setters required for nonautomatic production. 81/ The "automatic" piston factory, antifriction bearing lines, and all the other automatic transfer lines developed since World War II may be regarded as experimental and as prototypes of future developments in the automation of component production. More than 400 operational and theoretical studies of the piston factory alone were made during the designing and early operational stages. 82/ Presumably, Soviet planners chose the piston as the item to be produced in this model "automatic" factory because (a) the piston is a standardized product used in vast quantities and the automation of its production would indicate the degree of automation possible under the Soviet policy of standardization and because (b) the vast number of operations necessary for the complete manufacture of the piston are common to most of the other items manufactured by component production.

In addition to almost every type of machining operation involved in component production, this piston factory also includes automatic

* See 3, p. 32, below, for the qualifications of a truly automatic factory.

casting, thermal treatments, measurement, calibration, sorting, testing, wrapping, and packaging, as well as mechanized bins for storing the piece part while it is being processed. 83/

On the basis of the operational and theoretical research conducted in connection with the piston factory, the USSR has developed the fundamentals necessary for a systematic and scientific approach to building future automatic lines. The extensive research carried out by ENIMS enabled the USSR to devise mathematical methods for determining the laws of probability governing the functioning of lines for automatic machining and flow of production. Sufficiently simple and reliable methods have been devised for the calculation of such factors as the probability of an erratic failure of a line and its components and the time subsequently necessary for the re-establishment of normal operations. In addition, mathematical methods -- all of which are calculated to obtain the optimum operating conditions of an automatic line -- have been devised to determine the proper number of work stations, sections of machining lines, and bunkers for in-process storage of a piece part. 84/

The method of introducing into Soviet industry the automatic transfer lines for machining of engine blocks and heads also reflects the integrated, systematic, and organized industrywide pattern of the Soviet program for research and development involving automation.

The engine blocks and heads, which require many separate machining operations, are basic, mass-produced, and highly standardized products in both the motor vehicle and the tractor industries. It was logical, therefore, that the USSR should have chosen the manufacture of these two products for their first attempts after World War II to develop methods for the automation of component production. Unlike the US, where the automation of component production has been conducted almost exclusively by individual firms competing in the automotive field, the USSR appears to have divided the costs, risks, operational research, and immediate benefits of such automation between the automobile and the agricultural machinery industries. The research and development involving the automatic machining of engine blocks is conducted in the motor vehicle industry, and the development of improved automatic processes for machining engine heads is carried out in the tractor industry. 85/

This approach has made possible a constant improvement in the design and operation of the succeeding automatic transfer lines

as they gradually are perfected and introduced into the various plants of these industries. For example, the introduction in 1950 of a line for the DT-54 diesel engine head at the Khar'kov Tractor Plant resulted in production of 10,790 units per worker per year. In 1955 at the Krasnodar Plant "October" the introduction of a similar but improved line for the DT-54 engine head, attended by the same number of workers, reportedly resulted in production of 18,000 units per worker per year. Not only did the productivity of labor increase by 66 percent, but the cost of production per engine head is reported to have decreased by 22 percent. 86/

The economic effectiveness of another automatic transfer line, engaged in the manufacture of nuts 12 millimeters in diameter at the Kirovograd Plant for Agricultural Machine Building, resulted in gains in productivity and savings in cost. Compared with nonautomatic installations, this automatic line has increased production by 67 percent, reduced the number of workers by 83 percent, increased the productivity of labor nearly 1,100 percent, and reduced the cost of production per item by 33 percent. 87/

Soviet writers have repeatedly used the automatic transfer line at the Khar'kov Tractor Plant to illustrate the sizable increase in production after automation. The installation of this line is credited with increasing production of DT-54 tractor engine heads at the plant from 24,000 to 65,000 units per year and with reducing the number of production workers from 23 to 6. 88/

Another example of economic benefits that the USSR expects to derive from automation is illustrated in the following comparison of factors before and after the installation of an automatic transfer line for the machining of the DT-65 tractor engine head at the Khar'kov Tractor Plant 89/:

	Before Automation	After Automation
Annual production per worker (units)	825	7,190
Annual production per production worker (units)	1,040	10,790
Annual production per square meter of production area (units)	69	161
Production cost per item (rubles)	201	151

On the basis of such expected and desired economic benefits, the USSR appears to have come to the conclusion that the high costs of the program for automation should not be a deterrent to the further development and application of automatic lines. Responsible Soviet authorities do not expect to write off the costs of the first few lines from the gains in production but realize that the initial high costs of research and development are inevitable and can be recovered only after a number of lines have been built on the basis of the knowledge and experience gained from the original experimental lines. 90/ The exact number of lines required to pay off the initial costs of research and development, of course, will vary with (a) the nature of the product, (b) the scale of production, (c) the costs of development, and (d) the net savings compared with alternative methods of production.

Although the quality of the automatic lines in the USSR appears to be equal to that in the US, the USSR is still behind the US in the quantity of lines in actual operation and in the range of their application. In the motor vehicle field, for example, the USSR has perfected lines for only a few components, such as the block and piston lines, whereas most of the major US firms making automobiles use lines for practically every component necessary to the complete manufacture of the automobile.

The limited Soviet application of automatic transfer lines is illustrated by the fact that only one plant, the Moscow Motor Vehicle Plant imeni Likhachev, formerly Stalin (ZIS), has an automatic line for production of gear cases. 91/ Furthermore, a survey of the industrial application of automatic transfer lines in Soviet industry reveals that although the automatic lines are used to produce engine blocks in every major motor vehicle plant, these same plants still are producing truck and automobile engine heads on individual machine tools. The reverse situation exists in the tractor industry. Although all major tractor plants still are producing engine blocks on individual machine tools, these same plants are using automatic lines for production of tractor engine heads.

It is logical to assume, therefore, that the greater portion of the 220 new automatic and semiautomatic transfer lines which are to be introduced into the Soviet machine building industry by 1960 92/ will insure the completely automatic production of such components as engine blocks, heads, and gear cases in the motor vehicle and the agricultural machinery industries. The remaining portion of this planned figure probably will include newly developed lines for

the mass production of other components such as crankshafts, connecting rods, rear axle housings, tractor moldboards, and motor vehicle springs.

3. Computer and Feedback Control.

The truly automatic factory, which features the integration of computer and feedback control into the automation of component production, as characterized by automatic lines, probably will not be achieved for many years to come. Both the US and the USSR, however, are advanced in the theory of limited control of machine tools by electronic digital computer methods and have produced experimental and prototype models that are intended to be used primarily for the production of intricate piece parts. 93/ None of these machine tools is likely to be used for purposes of mass production, except in cases of parts of very complicated and irregular shapes which must be produced within the limits of a repetitive accuracy that cannot be achieved by using conventional, manually controlled machine tools. Apart from a few exceptions, there is no need in mass production for one universal machine tool that can make parts of any desired shape; the need is for groups of specialized machine tools that can produce thousands of identical components at a minimum cost. The electronically controlled machine tools probably will be applied to production in small quantities of such intricate parts as dies and cams. The USSR also intends to apply such machine tools in the aircraft and turbine building industries to the manufacture of piece parts having intricate, three-dimensional curves. 94/

APPENDIX A

METHODOLOGY

The published directives for the implementation of the Sixth Five Year Plan were taken as the focal point for the analysis of the broad objectives of the Soviet program for industrial automation. The detailed objectives and nature of the program were determined primarily from a study of the published speeches of Soviet leaders and the writings of Soviet scientists, technologists, and economists in journals and monographs. Analogical analysis was made of similar discussions in the US and the UK. Supplementary insight was provided by the observations of foreign scientists and industrial specialists who have visited central institutes for research and development and key factories in the USSR.

The central management of the entire program was examined broadly from the top levels of plant management to the ministerial levels. A general survey was made of the main types of automation as applied to industrial categories, with special attention to component production primarily as carried on in the machine building industry. A detailed analysis of other industrial sectors was not included in this report.

APPENDIX B

GAPS IN INTELLIGENCE

Although Soviet leaders and technical specialists have devoted much discussion to the general concepts and objectives of automation, they have not differentiated sharply between automation and other forms of technological improvement in referring to the role of automation in the Sixth Five Year Plan, nor have they indicated the precise role of automation in individual industrial sectors. Evidently much of the Soviet work in the field of automation is experimental, and Soviet technical specialists have not worked out exact criteria for evaluating the economic effectiveness of automation and other technological improvements. It is not now possible, therefore, to measure precisely the quantitative scope or effect of the program within the Soviet economy.

Information is lacking on such points as the following:

1. The quantity of a specific item produced or the amount of a specific type of work performed by means of automatic equipment compared with the total number of such goods produced or such work performed.

2. The amount spent on automation as a percentage of the total capital expenditure, either throughout the entire Soviet economy or within particular industries.

3. The period of time required for recovery of the amount spent on automation.

4. Reductions in the cost of production per unit achieved through automation.

5. The total number of units produced per worker per man-hour compared with existing methods of production.

Such information would provide the basis for an evaluation of the extent and economic effectiveness of industrial automation in the USSR.

APPENDIX C

SOURCE REFERENCES

Evaluations, following the classification entry and designated "Eval.," have the following significance:

Source of Information	Information
Doc. - Documentary	1 - Confirmed by other sources
A - Completely reliable	2 - Probably true
B - Usually reliable	3 - Possibly true
C - Fairly reliable	4 - Doubtful
D - Not usually reliable	5 - Probably false
E - Not reliable	6 - Cannot be judged
F - Cannot be judged	

"Documentary" refers to original documents of foreign governments and organizations; copies or translations of such documents by a staff officer; or information extracted from such documents by a staff officer, all of which may carry the field evaluation "Documentary."

Evaluations not otherwise designated are those appearing on the cited document; those designated "RR" are by the author of this report. No "RR" evaluation is given when the author agrees with the evaluation on the cited document.

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