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Cybernetics and Control of the National Economy

In the life of people, along with processes of receiving and utilizing energy and materials, a considerable part has always been played by processes of receiving, transmitting and utilizing information, which in a general case are customarily called "control processes". The significance of these processes at the present time has increased sharply in connection with the steady technical scientific progress, expansion of the scale of production and complexification of the economy.

Communism, the highest form of organization of society, simultaneously signifies a high level of development of productive forces and complete utilization of science and engineering. In the Draft Program of the CPSU, which represents a concrete scientifically grounded plan for building communism, the increase in public production and labor productivity on the basis of the rapid technical scientific progress and rise in the technical-cultural level of the working class is noted as a characteristic feature of a communistic society. In communism the highest level of planned organization of the entire social economy is achieved; the most effective and reasonable utilization of the material resources and labor resources are assured for satisfaction of the growing needs of society members. The main economic problem in the matter of building communism is the creation of a technical material basis, which means the following: complete electrification of the country and perfection of engineering, technology and organization of public production in industry and agriculture on the basis of this; comprehensive mechanization and automation of processes of production; extensive application of chemistry to the national economy; all-possible development of new, economically effective branches of production, new types of energy and materials; complete and efficient utilization of natural resources; organic combination of science with production and fast rates of technical scientific progress.

In the solution of these problems efficient organization of control processes in all their manifestations acquires importance, beginning with the control of separate technical assemblies and ending with control of the national economy of the country as a whole.

A vital question arises: how should efficient utilization of personnel and facilities, clear-cut coordinated work of the tremendous number of enterprises be assured in practice under conditions where there is a progressive increase in the rates and scales of production?

For with the development of science and engineering, with the increase in the forces of production there are increased requirements for speed and accuracy of control of technical processes, and a colossal increase in streams of economic information as well as in the requirements for speed and accuracy of its processing and for the quality of planning. We should strive to attain a situation in which a communistic society be as economical as possible. The main function of the communist government will be the control of economics; however, it cannot accomplish this on the basis of the tremendous control apparatus which utilizes manual labor of the employees.

The main advantages of the socialistic method of production over the capitalistic method are centralization of control, which is accomplished in the interests of the entire people, and planning of the management of the economy. These advantages, in principle, require an appropriate scientific system of organization and technical control facilities of the national economy for the purpose of realization under conditions of a progressively complexified economy.

For the purpose of attaining the optimum as a "whole" in the interests of the entire national economy a coordination of a large number of particular solutions, which frequently are opposite to the tendencies existent, consideration of the mutual influences of various technologically interrelated branches of the economy, of the natural conditions of various regions, without mentioning proper quantitative evaluation of political factors, prospects of development of socialistic countries and of the world economics, are essential. This latter factor is acquiring progressively greater significance and is substantially expanding the boundaries of search for optimum solutions.

Therefore, the continuous development of forces of production, complexity and interrelationship of various branches of the economy objectively require a radical change and improvement in methods and means of control in all units by means of a transition from manual forms of control to automated systems based on the utilization of scientific methods and electronic engineering.

In the Draft Program of the CPSU the need for organization of extensive application of cybernetics, electronic computers and controllers in various fields of the national economy, including planning, the area of accounting, statistics and control has been specially emphasized.

Optimization of Control -- The Main Task of Cybernetics

Cybernetics is the science of the methods of optimum (the best) control and construction of controlling systems.

Despite the exceptional variety of specific manifestations of control processes in living nature, engineering, economics, it turns out that fundamentally they are of a universal character and are accomplished according to a common plan.

Any control process is always associated with a certain organized system, which includes the controlling system proper and the executive organs [motor stages] which are being controlled, integrated by communication channels. Control is exercised on the basis of reception, transmission and processing of information under conditions of interaction of the given organized system with the environment, which is the source of fortuitous and regular interference.

The controlling system gives the motor stages command information over direct communication channels; it receives information from the motor stages about the actual condition of these stages and the execution of control commands over feedback channels. In addition, the controlling system receives information about the condition of the environment from special sensing or measuring elements.

On the basis of the information obtained the controlling system works out control commands which determine the actions of the motor stages and the future condition of the system being controlled.

The birth of cybernetics as a general theory of control processes was brought about by the requirements of practice for the creation of complex systems of automatic control of processes of production, complexification of control processes in economics, and is associated with the appearance of electronic computers, which are a powerful facility for automation of any information processing and control processes.

Cybernetics takes up the development of methods of finding optimal solutions in complex situations and the study of similar phenomena in living nature. The process of finding solutions in a general case includes the evaluation of information about the situation, determination of the line of behavior (strategy), corresponding to the goal of the control, and the working out of a program, that is, a series of control commands which determine the specific actions of the motor stages. Generally, the group of processes associated with the finding of solutions is very broad. This concept combines all-possible information processing, beginning with elementary reactions of the reflex type characteristic of the simplest controlling systems of living nature and ending with processes of human creative thinking. At the present time, in cybernetics mathematical methods of finding optimal solutions, such as linear and dynamic programming as well as methods of theory of mass service, the theory of games and others which are utilized in the areas of economics and military control, in the planning and analysis

of results of scientific research, and others have been developed considerably.

One of the main achievements of cybernetics is the elaboration of a standard approach to the study of various processes involved in information processing and control by means of separating these processes into elementary acts, which, as a rule, represent alternative selections ("yes" or "no"). Methodical application of this approach makes it possible to describe successively all the more complicated processes of mental work from a formal viewpoint, which is the first requirement for subsequent automation of them by means of computers.

Cybernetics has established two universal principles for constructing control systems: the feedback principle and the principle of hierarchy (multistage nature) of control. Feedback from the motor stages to the control organs is essential for monitoring the operation of the system and for taking into consideration the influence of environmental factors.

The principle of hierarchy of control assures economy of the structure and stability of function of the system. It consists of the construction of a many-tiered system, in which direct control of motor stages is carried out by lower-level organs, which are monitored by second-level organs, which themselves are monitored by a third-level organ, and others.

These principles represent the basis of the processes of biological evolution and the basis of development, learning and acquisition of experience by living organisms during the process of living. The gradual elaboration of conditioned reflexes and the layering of them represents nothing other than an increase in the level of control in the animal's nervous system.

These principles of feedback and hierarchy of control are also utilized in the construction of complex control systems in engineering and organization of control processes in social life. Of special interest are the self-organizing systems which possess the property of going independently from arbitrary starting states to certain steady states which correspond to the nature of the environmental influences.

A characteristic method of investigation in cybernetics is the method of mathematical modelling of various control systems with the aid of electronic program-control general-purpose machines. This method, based on complete formalization of the processes being studied, makes it possible to take into consideration also the influence of various chance factors which occur under actual conditions.

It is possible to distinguish two main trends of utilization of cybernetics in the area of control of the national economy: the appli-

cation of cybernetic methods for the investigation of economic processes and for finding the optimum variants for solving economic-planning problems; the application of cybernetic technique for automation of processes of collecting and processing economic information and control.

Let us analyze in greater detail both these trends. We should like to note that they are closely connected with each other and should be developed in conjunction.

Modelling of Economic Processes

Practical application of cybernetic methods for the solution of economic problems includes, as a rule, the accomplishment of the two main stages of work: a) development of economic models (detailed mathematical descriptions) of the economic systems and processes being investigated; b) development and application of mathematical methods for the investigation of models constructed and for finding optimum solutions of economic-planning problems.

The most important type of economic model is constituted by the matrix flowsheets for expenditure and production output among groups of branches of industry which have been extensively utilized abroad and in the Soviet Union. These flowsheets show the interrelationship between various branches of the economy on the basis of consideration of direct and indirect expenditures for the output of various types of products in their actual* and cost expressions. This type of model can serve as the basis for scientific planning and an analysis of economic systems and can also be utilized in the organization of supply of technical material, investigation of problems of price formation, the effectiveness of investments of capital, and others. The development and mastery of methods of economic flowsheets and other models is a most important task. In order that the economic model constructed reflect the actual picture, considerable preliminary work by economists and mathematicians is necessary for the formalization and description of the system being investigated, the demonstration of direct connections and feedback relations, the main factors determining the functioning of the system. By applying engineering methods of investigation of systems of automatic regulation to economics it is possible to investigate the economic models developed in this way for stability, "speed of action", "accuracy" of operation. Naturally, for this purpose it is necessary to determine the appropriate criteria. The opposite problem may also be posed -- the problem of synthesis of economic systems which correspond to the requirements given. In contrast to engineering problems, in the synthesis of economic control systems

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of a socialistic society it is necessary to provide for efficient combination of purposeful directed planning with self-regulation of economic systems. Methods of modelling with the aid of computers make it possible to predict the development of economic processes and perform mathematical experiments in the field of economics. By the same token, economics is being converted into an exact experimental science.

Problems of synthesis of optimum economic systems are of practical significance only with public ownership of the means of production under the conditions of socialism and communism. The national economy of the country as a whole can be regarded as a complex cybernetic system, which includes a tremendous number of different interrelated control paths with different levels of subordination.

The modelling and investigation of such a system directly, for example, in the form of a unified detailed flowsheet of expenditures and production output represent an impossible task even with the utilization of modern computers, because thereby it would be necessary to take into consideration millions of indices and billions of data.

The investigation of this system can be carried out by two methods: a) by using the so-called "microapproach", where a study is made of the separate autonomous control paths, and an idea is gained about the behavior of the entire system as a whole from their properties; b) by using the so-called "macroapproach", where an investigation is made of the basic rules and regulations of the complex system as a whole, avoiding the use of secondary factors, that is, the main and determinative path of regulation of the system is delineated.

The national economy of the country can be represented by a conglomeration of a large number of models of different levels. Models at the lower levels describe the behavior of particular (branch or rayon) economic systems, while models at higher levels operate with generalized indices, which are obtained from lower-level models and determine the basic rules and regulations of the entire system as a whole.

The specific economic models should possess, to a certain degree, the property of autonomy; their connections with the general national economic plan should be reduced to the utilization of general planning assignments and restrictions based on resources as input and output data, while for the inner functions within the models use should be made chiefly of actual rather than cost forms of expression of expenditures and production output, which will make it possible to reduce to a minimum the relationship of the given specific model to the price system.

As one of the first works in the field of mathematical modelling of economic processes mention should be made of the work of

A. G. Aganbegyan, conducted at the State Committee on Labor and Wages, for the creation of a system of mathematical-economic models for prospective planning of the standard of living of families of laborers and white-collar workers. The system includes a reproduction of the population with respect to age, sex and other characteristics, distribution models of workers with respect to the wages and formation of monetary and total income, demand, expenditures and consumption of the families of workers. These models are interrelated and are related to models showing the production flowsheet and flowsheet of production distribution among groups of interrelated branches, the expenditure of labor, investments of capital and others by a feedback system which reflects the actual economic and natural relations. Such a system of models should make it possible in a substantiated way to plan such important measures for increase of the material welfare of the working class as the determination of the minimum wage and increase in wages, abolition of taxes, etc. In taking each measure it will be possible beforehand to evaluate its influence on direct and indirect incomes of families at different levels on the scale and possible changes in the demand and consumption of various families.

Work in this field is being conducted also at the Computing Center of the Gosekonomsovet, at the Institute of Electronic Control Machines of the Gosekonomsovet, at the Institute of Economics of the ArmSSR, at the Institute of Labor and in other places; essential practical results have already been obtained. However, these are only the first steps, and it is essential markedly to expand the work front both in the field of development of methods of modelling economic phenomena as well as in the field of practical utilization of the models obtained. This unitized means of building a complex model of the national economy of the country in the form of a multistage system of interrelated specific models depicts the main principle of economic supervision by the CP: the combination of centralization and decentralization; it makes it possible to investigate also the optimum limits of application of these forms of control of economics. In the Draft Program of the CPSU it is mentioned that centralized supervision of planning should be concentrated chiefly on the development and assurance of fulfillment of the most important indices of national economic plans with all-possible consideration of suggestions coming from below; coordination and linking of plans made up in the various localities; the diffusion of technical scientific achievements and progressive experience; the pursuance of a single national policy in the field of technical progress, and investments of capital; the arrangement of production; wages, prices, finances and the realization of a unified system of registration and statistics. By means of mathematical modelling it is possible to deter-

mine in every specific case the efficient boundaries of combination of centralization and decentralization with consideration, on the one hand, of the interrelationships between the times of transmission of information and the elaboration of solutions and, on the other hand, the ability of the given specific system to carry out a stable self-regulation.

It is clear that rigid centralized control is impossible if the total time for transmission of information to the center, elaboration of solutions at the center and sending instructions back to various localities is so great that in the given system irreversible changes can manage to occur in this time, and the instructions arrive too late. On the other hand, decentralized control is impossible if the given specific system does not possess within itself adequate information for stable functioning.

The practical nature of all the national economic plans is determined, to a considerable degree, by their relation to an experimental basis, particularly with the demand actually observed. Therefore, of importance here is the development of models of the population consumer demand through prospective planning as well as models of price-formation planning.

The solution of problems associated with optimization of the main path of economic control of the national economy will give a standard approach to the most varied mathematical problems of the socialistic economics. By using the method of statistical tests(the Monte Carlo method) for modelling economic processes it is possible to take into consideration the influence of random factors corresponding to actual circumstances. Moreover, mathematical modelling of economic processes makes it possible to approach the structure and content of national economic plans from a new angle.

Usually, the plan is regarded as the conglomeration of certain quantitative indices corresponding to given types of production and the time at which they are to be supplied. This conglomeration should satisfy two requirements: internal coordination and the state of being the optimum.

It is essential to add a third requirement to these two requirements for the plan, the requirement of stability, that is, a lack of criticalness of the plan toward changes of its various indices. For the purpose of characterizing this property it is possible to introduce the values of the permissible limits of these changes into the plan structure by analogy with the system of technical allowances in industry. Possibly, for the purpose of assuring stability of the plan more complex probability characteristics will have to be used (dispersion, correlation factors, after-effect factors and others), the values of which will be determined by methods of mathematical modelling.

It should be emphasized that the use of mathematical modelling and of mathematical methods in economics generally makes it possible to obtain not only quantitative results but also to delve into new qualitative rules and regulations of economic processes. Similar to what occurs in engineering, physics and other sciences, mathematical investigation of one phenomenon or another gives results corresponding to the activity to the degree to which the initial mathematical description (mathematical model) reflects the basic properties of the phenomenon being studied. Therefore, the basis of successful application of mathematical methods to economics is the cooperative work of economists and mathematicians on the development of quite complete and accurate mathematical models.

On the basis of a quite complete system of economic models with the utilization of corresponding automation facilities it is possible to carry out continuous counterplanning and current administration with a high degree of efficiency. Continuous modelling of a balanced structure of the national economy of branches, rayons and republics should prevent the occurrence of any disproportions in the production process.

Optimal Planning

The principle of optimalness is the basic law of planning in a socialistic society, where there are actual possibilities for utilizing resources most fully and correctly and organizing the economy in the interests of the entire people.

In the Draft Program of the CPSU it is mentioned that the main attention in all elements of planning and direction of the economy should be concentrated on the most efficient and effective utilization of material, labor and financial resources, natural resources and the elimination of excessive expenditures with the aim of attaining the best results with the lowest cost in the interests of society.

The use of mathematical methods for solving economical problems should provide for obtaining the optimum variants of planning, distribution of efforts and facilities and, in the final analysis, the obtaining of a maximum economic effect with definite expenditures of time and resources.

An effective method of solving such problems which has obtained extensive practical application is the method of linear programming proposed in 1939 by the Soviet scientist Professor L. V. Kantorovich. Linear programming represents a mathematical method of finding the optimum (least or greatest) value of a certain magnitude which evaluates the quality of the process being investigated (for example, the output or general expenditure) and depends in a linear manner

on a large number of factors (raw material, materials, power, labor, etc.). Thereby, consideration is also given to possible restrictions in the change of factors and in the course of the process like, for example, the equality of the total expenditures of each of the factors to the resources of the specific factor, observance of certain proportions in the output of products, and others.

The values of production factors corresponding to the optimum plan, that is, to the optimum value characterizing the quality of the process, are determined.

The significance of the method lies not only in the fact that for a large group of economic problems it makes it possible to find the most advantageous solutions but also in the fact that it gives a uniform method of characterizing optimum plans, indicates method of evaluation and means of improving on existing ready-made plans, bringing them closer to the optimal, and also makes it possible in an operational manner to introduce additions and corrections into the plans in connection with the changes in the factors and conditions.

It should be noted that existing mathematical methods, although they make it possible to solve a large number of practical problems in the field of economics, possess a number of defects (a large volume of calculations even with the utilization of electronic computers, complexity of preparation work, the applicability only to narrow classes of problems and others). Therefore, the development of new effective methods of solving problems for the optimum is of great importance.

Apart from the linear programming indicated above, we can point to such divisions as dynamic programming, the theory of games, the theory of mass service, non-linear and whole-number programming as new divisions of mathematics which are finding application to economics.

For the purpose of solving problems of a combined nature associated with calendar planning, methods of a mathematical theory of schedules, the theory of columns as well as algebraic methods of minimization used in the theory of relay-contact circuits can be used.

Of great importance is the development of simplified methods of solving economic problems available to planners and operating administrative workers as well as in sections where there is not yet the corresponding electronic technical equipment. Among these methods are specific cases of the method of linear programming, graph-analytical methods and others.

The most important planning-economic problems requiring the application of mathematical methods are the following:

1. The making up and analysis of tables of relationships

between branches in the national economy (in the actual *and cost expressions), which constitute the basis of the economic flowsheet models of the national economy analyzed above.

As is well known, there are definite interrelationships between various interdependent branches of production caused chiefly by technological requirements for the consumption of the same types of products in the production of other types of products. Knowing these requirements as well as data on the volumes of production of certain branches it is possible to calculate the optimum variants of relations between branches as well as the complete volume of public production with regard to branches with consideration of given volumes and the structure of the public and personal consumption and major construction.

The flowsheets among groups of branches made up by the Central Statistical Administration include about 200 branches of production of the most important types of products. On the basis of these flowsheets the coefficients of expenditures of labor, materials and energy can be obtained for the production of various types of products, which is very important for constructing a mathematical model of the national economy.

2. Calculation of the influence of change in prices and wage scale and development of a scientifically substantiated system of prices.

The problem of cost and prices of production of various types of products is of tremendous importance for the national economy; however, solution of it is exceedingly complex, requiring a tremendous volume of calculations, consideration of mutual relations and the dependency of prices on various products as well as knowledge of the actual cost of production of all products, including expenditures of work time and materials for the production of these products.

The existence of a scientifically substantiated price system makes it possible to evaluate the influence of changes in a number of factors on the prices of the products, including the prices of other products, the wage scale, utilization of substitutes, and others, that is, will give a basis for substantiated planning and an analysis of production.

3. Calculations of the effectiveness of investments of capital, which are of exceptional importance for the prospective planning of the country's economics.

The variety of possible technical solutions and lines of development in modern industry, the interrelatedness of various branches of the national economy, the interweaving of the problem of investments of capital with other economic problems make this problem exceedingly complex, requiring the processing of a tremendous

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quantity of data and complex calculations.

Complex solutions of the problem of investments of capital will contribute to the selection of the most advantageous and economic trends in capital works, which provide for maximum development of the productive forces of the country as a whole.

4. Calculations associated with the solution of various economic problems of the optimum: the loading of equipment, effectiveness of various types of production of products which can be substituted for one another, the carriage of cargo by different types of transport, the selection of places for locating enterprises and determination of their production scale, selection of variants of distribution of the production program according to enterprises, most efficient arrangement of enterprises and storehouses as well as selection of variants for the most expedient utilization of certain resources. The application of mathematical methods to the planning-economic work will contribute to providing the maximum effect in the utilization of existing personal and material resources.

Automation of Control of the National Economy -- The Most Important Element in the Matter of Building Communism

In the Draft Program of the CPSU it is mentioned that communism is the highest form of organization of social life, in which all the production units, all self-controlling associations should be tied harmoniously into a generally planned organizational economy, into a single rhythm of public work.

For the purpose of practical accomplishment of this organization of public life the most extensive incorporation of means of automation into the area of control of the national economy and chiefly incorporation of electronic computing technique and automated communication lines into the area of control of the national economy are of exceptional importance.

Most important is the fact that by means of electronic computers it is possible to analyze and solve such economic problems which previously it would have been inconceivable to pose because of the tremendous laboriousness of the calculations.

One of the main criteria for evaluating the expediency of incorporation of automation facilities along with increase in the efficiency and accuracy of control is an economy of public work obtained thereby. Labor economy in the area of control is of essential significance at least because expansion of the scale of production and complexification of the control system of the economy are continuously increasing the portion of public labor being expended in this area.

At the present time, in the state apparatus of the country several millions of persons, including a tremendous number of economists, planners, planners and designers, technologists, normalizers, skilled workmen and others, are occupied in the registration and administrative-control work service. These workers are occupied for a considerable part of the work time in carrying out registration and calculation operations, writing and formulating various documents, transmission and reception of information. These operations are carried out mainly by hand.

Defects in the application of facilities for mechanization of control work were covered, as a rule, in previous years by an increase in the census of administrative-control personnel. However, at the present time, in connection with the development and complexification of the national economy no increase in the staffs of control personnel will assure effective control of the economics. Moreover, even the application of antiquated facilities for mechanization of control work -- desk computers and analytic-computing machines which provide only for mechanization of counting and computing operations -- is perfectly inadequate.

A problem of first importance is the automation of information processing within the system of national economic registration and statistics, because complete, accurate and timely information are needed for solving problems of planning, supply of technical materials and operational control of the national economy. Automation of registration and statistics should be accomplished simultaneously in both the lower elements of the system (directly at enterprises) and in the higher ones, in the sovnarkhozes, republic and Central Statistical administrations.

Specifically in this field, creation of a standardized system of collection and processing information on a nation-wide scale rather than separate computing centers for processing the data is important.

Above, we have dwelled on the importance of application of mathematical methods to the area of planning, which in its turn requires the most extensive incorporation of electronic computers in this field. The problem of making up the most effective plan, which assures the attainment of the best results with the least expenditures of material and labor resources, is responsible for the need for working out a large number of variants of the plan and selection of the best from them. Difficulties of planning are caused not only by the complexity and large volume of work but also by the very limited period in which it is to be accomplished.

The problem of operational control of economics, where in conjunction with unforeseen circumstances occurring in the process of realization of the plans it is necessary to make corrections and addi-

tions in various planning figures and assignments is particularly poignant. This requires a rapid and quite accurate evaluation of the influence of changes to be made on other interrelated divisions of the plan and the indices of various branches and separate enterprises. Only by means of computers is the realization of such recalculations of planning indices and introduction of the necessary additions and corrections possible in a very short time.

One of the most specific and best-prepared fields of application of electronic computers, where automation gives the most rapid and perceptible economic effect is the system of supply of technical materials.

Work is being done on the supply of technical materials in sovnarkhozes, republic and union organs and at various enterprises by hundreds of thousands of persons. The supply service requires the processing of a colossal quantity of documents: requisitions, bills of lading as well as documents associated with the storehouse service and transportation.

Difficulties in supply are far from always being caused by an absence or shortage of objects of consumption. Very many of them are caused by the bulkiness and unwieldiness of the supply system organization.

The automation of data processing within the supply system is facilitated by the fact that this work, despite its tremendous volume, is of a formal nature and submits to comparatively simple algorithmization.

Efficient organization and automation of the supply service will lead to a much more complete satisfaction of needs, better utilization of material values and a marked reduction in the apparatus of the supply system. In addition, the absence of delays in supply will reduce the occurrence of bottlenecks and will facilitate the smooth running of the production tempo.

Of greatest importance is the automation of processes for collection and processing of information within the system of the Gosbank USSR.

The state bank represents a centralized system for collection and processing of information about the circulation of money in the country, including a number of interrelated installations with various subordination levels. The institutions of the Gosbank are associated with enterprises and institutions of the national economy of the country from which they receive information. The characteristics of work of the Gosbank as an information system are the tremendous and progressively increasing volume of information being processed, the periodicity and rigid periods of processing of it.

Automation of the banking finance system on the basis of incorporation of computing technique will make it possible considerably to increase the rate and accuracy of data processing, the effectiveness of utilization of existing facilities, and, most important, will provide for more accurate and efficient control of the functioning of separate enterprises as well as of the entire national economy.

One of the problems of first importance in the matter of automation of control of the national economy is automation of control of transportation. In the Soviet Union there is the largest transportation system in the world with a single centralized control. In connection with the great intensity of the work very great requirements are made on the system of transportation control.

The existing system for the collection and processing of information about the movement of traffic is cumbersome and laborious. Therefore, despite the great work invested in making up the plans of operation (24-hour and shift), in many cases there are quickly deviations from them, and frequently they are not utilized for control of the work.

The use of high-speed machines for this in combination with automatic communications will make it possible to solve this very difficult problem in a fundamental way.

The automation of control of transportation will make it possible to assure maximum effectiveness of utilization of transport facilities, eliminate excessive and empty runs, will assure maximum rhythm in the work of transportation and a reduction in the size of the control apparatus.

Abroad, computers are utilized extensively in the area of economics: for calculation of wages, registration of reserves, making up bills of lading, reports, making up graphs of loading of products and utilization of labor power and others. In mercantile enterprises computers are used for the registration of goods ordered, sold and on hand, for analysis of the needs and possibilities of satisfaction of them, planning the goods supply in accordance with the demand.

The automation of control of supply in the American Army has obtained extensive application, where automated supply systems have been created for the Air Force, communication corps, armored troops and others.

Foreign experience shows that the utilization of computers will lead to finding the most advantageous routines of operation, which will give a considerable saving. Simultaneously with this, a marked reduction of the control apparatus is occurring (in some cases, by 80-90 percent).

Taking into consideration the fact that under conditions of

socialism the creation of a comprehensive automated system of control of the country's economy is entirely possible, it may be foreseen that the effect of such automation will be much greater than from the automation of various divisions of economics being used in capitalistic countries.

The extensive development and application of cybernetic methods and computers to the area of control of economics will contribute to the further powerful development of the national economy of the Soviet Union and successful advance of it toward communism.

A Single State System of Computing Centers

As the experience of utilization of electronic computers in the field of scientific and technical calculations has shown, the effective application of these machines is possible only in adequately large computing centers which possess the necessary cadres of specialists and monitoring apparatus.

It should be noted that in recent years, in the development of computing technique, there has been a clearly-defined tendency toward the creation of powerful computing multipurpose complexes, directly connected with a large number of subscribers by means of communication channels. Such computing centers can obtain information from the subscribers and given them the results entirely automatically. Examples of such combinations with a speed of more than one million operations a second are the Stretch, Atlas, TsBM-1604, L-3060 and other systems. In equipping the computing centers with such complexes as well as with such very productive computers as the Larc, IBM-7090, Pilot (United States) and others the structure and nature of their operation are essentially chains; from institutions of the manufacturing type with manual reception and issuance of various problems they are converted into complex automatic (and even self-organizing) systems for processing information which are equally well adapted for the accomplishment of complex calculations as for the processing of data or the control of actual systems. The computing complexes of such centers possess the property simultaneously of solving various problems, automatically selecting the optimum sequence of accomplishment of a given volume of calculation operations, carrying out the preparation and automatic programming of problems and distribution of the time of the solution, as well as automatically monitoring their own work and eliminating faults.

It has been determined that the operation of such powerful centralized information-processing systems is economically considerably more advantageous than the incorporation and utilization of a large

number of small machines in various institutions. The major computing centers spend a large part of the time for the processing of data: statistical processing of economic information, processing of correspondence, calculations of wages and other financial calculations, the management of technical material accounts, the accomplishment of planning calculations and others. These problems are very stable with respect to their content and methods of solution and are distinguished by the periodicity with which they come in.

A characteristic of the processing of these data is the need for constant storage of considerable volumes of accounting information in the machines as well as the considerable importance of operations for input and output of data by comparison with calculation operations.

The composition of those requesting such problems to be solved is more or less constant and is determined basically by the branch and territorial principles. The computing centers occupied in data processing to a certain degree are automated offices connected by communication channels with the enterprises and institutions being serviced. An example of such a center is the Center of Automatic Data Processing of the Sylvania Company (United States), which is associated with different institutions, enterprises and affiliates in various states, over communication channels with a total extent of more than 50,000 kilometers.

Under conditions of the large computing centers, where simultaneously several machines with the same purpose are concentrated, it is easiest to provide for interchange in work, the necessary routine of preventive and maintenance operations and, by the same token, reliability and continuity are provided in the functioning of computing complexes, which is particularly important under conditions of utilization of these complexes for the control of various branches of the national economy.

Therefore, the incorporation of computers into the control of the national economy should be planned from the very beginning is the form of creation of large computing centers designed for complex servicing of a number of enterprises and institutions. Therefore, a single national territorial system of information-calculation centers with a single centralized control should be created. These calculation-information centers should be created for comprehensive servicing of the needs of the sovnarkhozes, offices and departments of the Gosbank, the organs of the Central Statistical Administration, organs of the Gosplan and other institutions. The accomplishment of the following functions should be entrusted to these centers also: a) the accomplishment of laborious calculations for institutions which do not have their own computers as well as the direction and rendering of technical aid to

local institutions which have their own computers; b) the incorporation of scientific methods and organizational forms of control and automation facilities at enterprises and institutions of a given rayon, for which the information-computing centers should be made up of appropriate scientific groups for the investigation of operations and analysis of the work of the institution.

At the first stage these centers can be created as autonomous institutions in which bringing the basic data for processing and receiving the results of the computations will be accomplished mainly by hand.

Subsequently, these computing-information centers should be gradually connected by automatic communication lines with various institutions and enterprises of a given rayon.

Gradually, reliable automatic communication of the centers with one another according to a definite structure should be established.

For the purpose of making up a single automated system of control of the national economy a careful study from the qualitative and quantitative aspects is needed for the streams of information controlling economic processes and determination of the necessary and adequate level of this information at each individual stage of socialist production. A single system of circulation of economic information should be worked out, beginning with a working diagram of the article and ending with composite economic indices for the sovnarkhozes, republics, and Soviet Union. Thereby, the problem of the optimum level of aggregation of information at the divisions of shops -- enterprise -- sovnarkhoz -- republic -- planning organs of the Soviet Union -- should be solved. Using methods of the information theory it is necessary to work out an efficient system of coding economic information and records so that at every division of planning and operation of control of the economy the optimum functioning of the man-machine system be assured. The utilization of methods and technical facilities of cybernetics makes it possible to create a single system which combines planning-economic, operational-production, technological, bookkeeping, financial information in accordance with the supply of technical material and others. However, the creation of a single system of data processing does not mean complete centralization of all functions of economic control. On the basis of a single system of collection and processing of information coordinated planning solutions of planning-economic and administrative supervision can be worked out successfully by various functionally specialized organs.

The system of centers connected by communication channels in the future will form a single automated system of control of the national economy of the country.

An important advantage of the single system of centers lies also in the fact that this system makes it possible to solve the problem of mass incorporation of computing technique into the national economy with considerably lesser expenditure of facilities and time than the decentralized practice of machine utilization.

With the creation of a single system of nation-wide computing centers it is possible radically to solve such important problems as standardization of the computing machines produced. For this purpose it is necessary to select the most powerful type of multipurpose computer, which will be the basic machine for these centers.

Future requisitioners of the computing centers should be provided beforehand with all data necessary for the programming as well as sets of input and output apparatuses. This will make it possible beforehand to organize extensive preparation and programming of the problems.

It should be kept in mind that the formulation and initial preparation of such economic problems as planning of production and supply, calculation of cost, processing of accounting data for solution by computing machines is a very laborious and complex problem which requires considerable and combined work of appropriate specialists and program-mathematicians. In order that such problems be solved on machines frequently one has to change the work organization of corresponding institutions and the order of processing the documents; a single form of documents and standardization of processing methods for them are required. As experience has shown, on the average, one-and-a-half-two years go into the study and preparation of such problems. However, this time expenditure is paid up with a surplus, because subsequently all problems of the given type are solved very quickly on the machine.

With complete automation of administrative-control work an exchange of telephone, telegraph or television transmissions with automatic recording and processing of incoming information by means of computers and storage of them in memory apparatus will occur in place of the cumbersome and prolonged correspondence between institutions.

It is necessary carefully to develop standard projects of information-computing centers, which should be created with consideration of the recent achievements in organizational technique as fully automated complexes designed for processing various kinds of information and solving problems of control in certain territorial rayons. Specifically, it is necessary to provide for a special construction of buildings which satisfy the specific characteristics of the work, make extensive use of various auxiliary information facilities, office work

(apparatuses for multiplication, storage, search and transportation of documents, systems of tape recording, facilities for inside and outside communication and signalling, television technique and others).

In various enterprises and institutions, in accordance with the scale and character of their work, there may also be computing machines with automatic apparatuses for input and output of data or simplified apparatuses and devices simply for the reception and transmission of information.

The Soviet Union has every possibility for complete utilization of all the achievements of science and engineering, and one of these possibilities, which is not available to the capitalistic order is the creation of a single automated system for control in the country. This problem is fully practical. It can be solved gradually, by stages; solution of it will provide for great prosperity of the Soviet Union in all areas.

Specifically at the present time scientific and engineering achievements are making possible the complete realization of the great predictions of Lenin for the first time, to the effect that "communism is a Soviet regime plus electrification of the entire country".

The Leninist formula discloses the combination of tremendous political advantages of the socialistic system with a high level of engineering; in practice it will be embodied in the form of a single automated system of control of the national economy.

This system will make it possible more completely to realize the basic economic advantages of the Soviet order: centralization of control and planning of economy. By the same token complete harmony will be provided between political and economic foundations of the Soviet Government and the technical facilities for control of the country's economics.

An analysis of the situation shows the complete reality of developing operations, at the present time, on the creation of a system of automated control of the national economy and the presence of material premises necessary for this. Certain scientific institutes and institutions are even now working partly on various problems of automation of control of the economics; however, coordination and the labor in this field are perfectly inadequate.

The expansion of the front of scientific research, experimental development and, mainly, decisive incorporation of new methods and means of automation of control work into practice are needed. Undoubtedly, the creation of an automated system of control of the national economy requires considerable expenditures and considerable work for the preparation of cadres, the construction of machines, the development of communications and the accomplishment of theoretical

research work. However, it is exceedingly important that all the work be accomplished gradually, by stages; thereby, the volume of the initial investments will be comparatively small, and future development and incorporation of automation facilities should proceed through the saving obtained. With corresponding concentration of personnel and proper selection of the first areas to be automated various automated control centers can be put into operation in a short time, which should immediately give an essential saving and serve as the basis for extensive application of cybernetics to the area of control of the national economy.