III. Cybernetics and the Humanitarian Sciences

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Cybernetics and Economics

One of the most important and promising fields of application of cybernetics is economics. Economics is of decisive importance in the life of society, as its basis. Economics applies to a group of the most complex subjects of cybernetic investigation. By virtue of this complexity the development of problems of application of cybernetics to economics has been begun quite recently, much later than in other areas. However, the current importance of the problem, its social significance have already given rise to a multitude of disputes and disagreements of theoretical and methodological character.

An obligatory premise for the application of cybernetics to any field and particularly to economics should be a profound quantitative analysis of the subject of investigation. Therefore, a problem of first importance is the determination of the characteristic features of economics which distinguish it from other fields of cybernetic investigation.

In engineering and linguistics, biology and medicine, the subject of cybernetic investigation and its character do not depend on the social order. In contrast to this, the nature of application of cybernetics to economics is to a considerable degree determined by the social order. The problems and area of application of cybernetics to economics are radically different in capitalism and socialism, and this difference is brought about by the specific characteristics of the capitalistic and socialistic methods of production, respectively.

In capitalism, with its private ownership of the means of production, a strict organization of production processes within the limits of separate enterprises and monopolies is combined with competition and an anarchy of production on the scale of the entire society. This serves as the framework and reduces the efficiency of application of cybernetics to capitalistic economics.

Being a science with a purposeful direction, cybernetics in capitalism can deal with the national economy as a single whole only on a very limited scale. Therefore, even a careful study of the relations on the basis of detailed information can in no case lead to efficient organization and control, to overcoming the turmoil in the national economy of a capitalistic country. Such an organization is unthinkable under conditions of capitalism because of its organic nature. In capitalism, cybernetics is applicable only to separate, although in a number of cases, large, parts of the national economy.

In analyzing cybernetic problems as applied to social processes and phenomena, the founder of this science, Norbert Wiener, points out

the absence of purposefulness in the development of a bourgeois society, and the inapplicability of the cybernetic approach to the control of society under capitalistic conditions because of this. Without disclosing his sympathies with the bourgeois, "amorphous" democracy, as he calls it, Wiener notes, however, that the absence of purposefulness is contrary to the principle of "efficiency" (Leningrad, 1). This admission by a bourgeois scientist is quite significant.

The development of the Soviet Union, the country which has conquered socialism, is of a purposeful nature: the Soviet aim is the building of a communist society. The efficiency of the socialistic system of economy has been proved by its worldwide-historical achievements: the mastery of space, the development of atomic energetics, and in a number of other fields of modern science and engineering.

The greatest advantage of socialism is the planned development of economics. Based on public ownership of the means of production, the socialistic economy of the Soviet Union is being developed according to a general plan and, because of this, can be regarded as a single system, to a certain degree, for the application of cybernetic methods.

The application of cybernetics to the national economy as a whole is far more complicated than to its separate parts. On the other hand, the effect of such application is incomparably greater. It is hard to overestimate. Actually, the greater the development of the national economy, the more complex and more varied the relations and interactions of its various parts, the greater the importance acquired by the analysis of these relations and by the control of the reproduction process. The English cybernetician, W. Ross Ashby, notes with good reason that if we are dealing with a village, meetings of its elders are adequate for its economic control. If the society consists of millions of people more complex methods of coordinating their actions are necessary (Leningrad, 2).

In a manner similar to what occurs in physics, biology and other fields, the application of cybernetics achieves it goal only when it is based on accurate knowledge and consideration of the objective laws of nature; the application of cybernetic methods to the national economy should be based on objective economic laws. For the last century, the discovery of the objective laws of social development has constituted the scientific service of representatives of working class interests, the interests of the leading class in modern society. Bourgeois economists and sociologists are, by virtue of their class limitations and apologetic tendencies, distorting the rules and regulations of social development, taking the groundwork from under the feet of scientific cybernetic investigations; moreover, they not uncommonly utilize cybernetics also for apologetic purposes.

Only socialism creates conditions for a truly scientific utilization of cybernetics in economic theory and practice on the basis of objective laws established by the Marxist-Leninist political economy. Under the conditions of socialism the economic development of society is

determined and directed by the government national economic plan. Hence, the main system for application of cybernetics in economics is the planning of the national economy.

The development of the national economic plan from the viewpoint of cybernetics can be regarded as a definition of the strategy of economic development. The plan constitutes the specific embodiment of the policies of the CP in the field of the national economy. Making up the plan should be based on adequately detailed and accurate information.

Providing such information is the function of registration and the national statistics. Hence, along with planning, the most important system for application of cybernetics in economics is the national statistics.

After the strategy of economic development has been worked out, the operational supervision of accomplishment of the plan and the realization of the strategy selected assume principal importance. Here, an important place belongs to the credit finance system, which should also become a system for large-scale application of cybernetics.

Among the systems which show the greatest promise for the application of cybernetics in economics the supply of technical material has a special place. Supply largely determines the planning of socialistic production. The organization and planning of continuous supply have quite a few difficulties inherent in them. The transmission and processing of large volumes of information in very short periods of time represent a condition for the efficient organization of supply. A tremendous army of white-collar workers, whose work is mechanized to the slightest degree, is occupied in the supply of technical material. Nevertheless, from all areas of economic work the supply operations are of the most formalized and monotonous character. Therefore, both with respect to significance for the national economy and its specific characteristics the supply of technical material can and should become the first system for the application of cybernetics. The systems for application of cybernetics in economics mentioned above by far do not exhaust the possible list of systems. These are the main systems, on which cybernetic investigations have already been begun and certain starting principles have been worked out.

The problem of application of cybernetics in economics has two sides: the application of computers for economic calculations and the application of cybernetic methods for studying, monitoring and control of economic processes.

Computers are constructed and act on the basis of cybernetics. The indisputable fact of their existence and their obvious efficiency in the field of engineering and the exact sciences have at the present time assured almost universal recognition of the so-called "technical cybernetics".

The situation is more complicated with the other aspect of application of cybernetics to economics, the cybernetic approach to the study of economic processes and phenomena. Some philosophers and sociologists

deny the applicability of cybernetics even to such a science as biology. It is no wonder that they have taken up arms against its application to the study of social processes to an even greater degree, particularly to economics. In the latter case, they are copied by various economists. The arguments against the utilization of the exact cybernetic methods in economics usually amount to the complexity of the economic processes, which are not supposed to submit to mathematical analysis, even with the application of computers.

In the United States such a viewpoint has been expressed most distinctly by Hildebrand, professor of political economy. Unfortunately, some Soviet economists adhere to this viewpoint also to different degrees. The position taken by these economists can be explained only by their lack of desire or inability to develop the science creatively. Marxist economists are well aware of the attention that Marx gave to the application of mathematical methods to economics, as well as, incidentally, to the other sciences.

On the basis of a profound qualitative analysis almost all economic processes can be formalized and expressed mathematically to one degree or another. This means that cybernetic methods can be applied to them. In the present day, during the era of development of computers and powerful information transmission facilities there is no reason to refrain from the application of mathematics and cybernetics to economic studies. At the present time in the Soviet Union you cannot find an economist who would come out against the application of computers to economics. However, unfortunately, there are quite a few economists who are for the application of computers but against the application of cybernetic methods to economics. Such economists apparently believe that the two aspects of application of cybernetics to economics mentioned are divided by a solid wall. What gives rise to confusion of this kind? The definite gap between the developmental level of electronic computing technique and the state of development of its methods of application to economics constitute the objective basis of it. With the current status of this method, computers cannot yet be utilized in economics to the full extent of their possibilities. Quite a few economists, however, are against (true enough, passively for the most part) the application of cybernetic methods to economics which have already been developed. Possibly, cybernetics will not obtain such a complete material expression in economics as in computers. However, even now the fruitfulness of cybernetics in the study of communications, monitoring and control of various very essential aspects of economic processes is beyond doubt. The material basis of this application of cybernetics exists in the form of electronic computers. However, the utilization of cybernetic machines for economic calculations by the previous methods, designed for manual calculation, is not very effective. Therefore, the one who speaks against the application of cybernetic methods to economics is objectively also against the utilization of computers in this most important field. This is absolutely intolerable.

As foreign experience has shown, even in a capitalistic economy, where the possibilities of utilization of cybernetics are incomparably poorer than under socialism, computers and the corresponding methods of transmission, storage and processing of information, methods and means of automation of control are being used on a very broad scale. In the United States, 80 per cent of all computers are engaged in economic calculations. The General Electric Company alone utilizes about 50 machines for this purpose.

Overcoming the lag in the field of application of cybernetics to economics is a most important task. Without mentioning the highest levels of application of cybernetics to economics, as monitoring and control, even at the initial levels-- transmission, storage and processing of information, not only computers but also methods of handling the information corresponding to their possibilities are required.

In work which has been begun in recent years on the application of cybernetics to economics, as in the case of any large scale new undertaking, there is no circumventing the conflict between the progressive and new with the backward and the outdated. However, in the Soviet Union, everything new and progressive meets with the greatest support by the CP and the people.

We should like to analyze the prospects of application of cybernetics to the following fields of economics: the system of registration and statistics; the system of planning of the national economy; in the supply of technical material; in the Gosbank USSR /State Bank/.

System of Registration and Statistics

For effective control and planning of the national economy, first it is necessary to be disposed of sufficiently complete, accurate and timely information, which can be provided by the accomplishment of registration and statistics in an appropriate way. As has been pointed out by N. S. Khrushchev: "successful solution of problems of building communism is inconceivable without a centralized system of registration and statistics in the national economy of the country..." (Report to the Seventh Session of the Supreme Council USSR, 1957).

Registration is the basis of efficient planning and operational control of the various enterprises and of the national economy of the country as a whole. At the present time, the collection and processing of economic information are accomplished to a considerable degree by hand. More than two million persons (Leningrad, 3) in the USSR are engaged in registration and statistics. For the purpose of obtaining information about the status of the national economy billions of document are processed every year.

The control of the national economy is a continuous process which requires the continuous inflow of timely information. However, processed and systematized information about the status of the national economy is obtained after a great delay, which reaches several months.

In the field of registration and statistics in the Soviet Union, mechanical calculating facilities have had a certain application-- various comptometers and analytical computers with which mechanized accounting factories, computing machine stations and computing machine bureaus are equipped. However, mechanical apparatuses do not solve the main problem of comprehensive mechanization and automation of the processing of economic information. They make it possible only to accelerate the accomplishment of the calculation operations and the simplest operations of sorting the data directly. At the same time, it is known that up to 90 per cent of all the operations encountered in registration-statistical operations are of formal-logical character and cannot be accomplished by means of these very simple facilities but rather require computers. The first areas of application of these computers to statistics will be censuses, inventories of equipment, inventories of basic appropriations, the processing of current and annual accounts, and others.

In view of the imperfection of computing techniques used in statistics at the present time, very rich economic information remains practically undeveloped and unutilized. Thus, for example, the data of 40,000 family budgets of laborers, white-collar workers and kolkhoz members are being worked up and used for planning absolutely inadequately. Nevertheless, a great deal of labor and money goes into making up and collecting these budgets. More complete workup of the budgets would give most valuable information about the purchasing power, its territorial structure, demands and paying capacities of the population. This situation can be corrected only on the basis of large scale automation of information processing within the system of national economic registration and statistics.

At the present time, provision has been made for the realization of large scale measures for automation of registration and statistics both at lower and medium levels (at enterprises and sovnarkhozes) and in the higher echelons (republic statistical administrations, Central Statistical Administration of the USSR). The direction of this very important work has been entrusted to the Central Statistical Administration of the USSR by the government. In the "Decree about the National Statistics", mention is made about this as being one of the basic functions of the Central Statistical Administration.

Along with computers the most important part in the matter of perfecting the national statistics should be played by the information theory-- the division of cybernetics which studies problems of the formation, storage, transmission and processing of information. Investigation of the content and volume of information and the determination of the best means of transmitting it by cybernetic methods will increase considerably the efficiency and effectiveness of national statistics.

The incorporation of cybernetic methods into such a complex field as economic statistics requires complete scientific preparation which should be based on the achievements of cybernetics and on the beneficial

experience of national statistics.

Specifically, the general principle of construction and organization of work of the Central Statistical Administration is proper. Figuratively speaking, this principle can be likened to a cone at the apex of which is a workup of the balance of the national economy. To varying degrees, the activity of the branch divisions and offices of the Central Statistical Administration are subordinate to the problem of making up the balance of the national economy, which in a general form characterizes the entire process of the expanded socialist reproduction. Naturally, these divisions, carrying out the statistical processes necessary for making up the national economic balance, do extensive work on a more detailed numerical treatment of affairs in the corresponding branches. However, thereby both with respect to the content of their activity and the periods of various workups they are under the organizing influence of work done on the national economic balance.

Naturally, given the multistage system of processing statistical data for making up the national economic balance, a considerable part of the information from the enterprises is lost. On the other hand, the balance-sheet of national accounts is made up in two broad forms and over long periods of time which essentially reducesits value for planning.

The automation of information processing essentially reduces these periods. Detailing of the balance-sheet of the national accounts necessary for planning can be provided by making up production and production distribution balance-sheets for groups of branches /of the Central Statistical Administration/.

The Central Statistical Administration USSR has made such a balance-sheet for 1959. The balance-sheets were made up in accordance with 157 product-branches in the actual *expression and 83 branches in the cost expression. Production and production distribution balance-sheets among the various groups of branches constitute a mathematical-economic model of the national economy, the prototype of which is constituted by schemata of social reproduction by Marx and Lenin. In this model the flow of production is shown, directed from some branches to others for productive consumption, as well as the influx of production for nonproductive consumption and accumulation. On the basis of this model and with the aid of mathematical methods and computers a number of very valuable economic studies and plans have been made.

Making up the detailed production and production distribution balance-sheets among the groups of branches for 1959 was accomplished by the Central Statistical Administration USSR as a simultaneous undertaking on the basis of a 20 per cent selective investigation of enterprises and structures. Now, the problem lies in making up similar and even more detailed balance-sheets methodically among the groups of branches, once every two-three years, and then every year. In addition, the production balance-sheets among groups of branches should be subordinate to the balance-sheets of the basic appropriations for production among

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the groups of branches. It is necessary not only to automate the collection and processing of information but also to determine its composition and manner of formation. Cybernetics can be of inestimable benefits in this work.

In studies on the application of cybernetic methods to statistics and particularly in making economic-mathematical models foreign work in making up tables of relations between branches of the national economy deserves some attention. As has been pointed out by the head of the TsSU SSSR /Central Statistical Administration USSR/, V. N. Starovskiy: "of definite methodological interest for the Soviet Union are the flowsheets made up in a number of countries showing the interrelationship between branches of the national economy and, particularly, branches of industry: sources of raw material and the materials of a given branch and the distribution of its production among other branches" (Leningrad, 4). In the United States, according to the data of the 1947 enumeration such flowsheets were made out for 500 product-branches. The mathematical workup of the flowsheets was made on a computer of the "Univac" type. Smaller flowsheets have been made out during the post-war years in many western European countries. However, the possibilities of utilizing these flowsheets in the capitalistic economics are small. The flowsheets cannot eliminate depressions and unemployment. It is not by chance that the government in the United States stopped financing operations for the investigation of relations between the branches, and the 1954 inventory was not worked up for these purposes either.

National Planning System

State planning is the most important link in the control of the national economy of the USSR. Rapid and steady growth of the complex and multicomponent national economy of the USSR requires the constant perfection of socialistic planning. The incorporation of computers into the practice of planning in the very near future will be a great contribution to the solution of this problem. The high speed of computers makes it possible to considerably accelerate the making out of plans, to increase the efficiency of administrative and planning organs. However, this by far does not exhaust the significance of computers for planning.

The incorporation of mechanical and electromechanical facilities into economic calculations-- adding machines, tabulating machines and others, does not lead to a change in their methods although it accelerates the calculations. The incorporation of computers creates qualitatively new possibilities for economic planning in a manner similar to what occurs in the exact sciences and engineering. Let us take a simple example. Mathematicians and artillerists were able even previously to make a fair calculation of the flight paths of shells and rockets. However, the length of time necessary for this calculation was

incomparable with the time in which the shell was to reach its target. On computers the flight path is calculated considerably more rapidly than the shell or rocket flies. This creates the possibility in principle of regulating flight on the basis of an exact calculation of its trajectory, which changes on account of various unforeseen newly occurring circumstances. Specifically, calculations on computers have been responsible for the striking accuracy of the launching, flights and return of Soviet space rockets.

Economic calculations made by the most careful and scrupulous methods may not be very effective if the length of time necessary for them is great and incommensurate with the planning period, because their results cannot be used in time. For this reason, it is rarely possible to calculate an adequate number of variants of the plan for the purpose of selecting that which is really the best one. The length of time necessary for the calculations interferes with the timely and complete correction of the plan during the course of its execution. Therefore, it was difficult in planning practice to utilize exact methods, which required a tremendous number of calculations, previously, before the appearance of computers. Such machines are hundreds of thousands of times better than the previous computing facilities because of their high speed. This changes the situation radically. The length of time necessary for planning calculations is markedly reduced even when the volume of them is increased by many times. The possibility arises of using exact methods. Therein lies the main effect of incorporation of computers into planning. In a speech at the July plenary meeting of the CC CPSU (1960), Academician A. N. Nesmeyanov declared: "the use of computing technique for economic records and planning can give a tremendous economic effect. This work should be done on a scale worthy of our country" (Leningrad, 5).

Of the methods of planning calculations on computers already mastered and tested experimentally, we should like to discuss chiefly the methods for making up the balanced plan of production and distribution of production.

The methods of planning calculations should in all ways satisfy the requirements of objective economic laws of socialism, chiefly of the main economic law of planned development of the national economy. In accordance with the main economic laws of socialism, the direct aim of production in the USSR is satisfaction of the needs of society. Making the basic economic law concrete with respect to planning problems, Comrade N. S. Khrushchev stated the following: "Increased production in a socialistic society is planned in order to increase the total material benefits for the purpose of progressively more complete satisfaction of the needs of all members of society" (N. S. Khrushchev, Report to the Twenty-First Congress of the CPSU, Gospolitizdat, 1959, P. 74).

The needs of society are varied. Here we have included the needs for food, clothing, houses, books and others. Since the needs of society

are increasing continuously, it is necessary to increase production steadily for the purpose of satisfying them. Hence, among the social requirements are the needs for machines, metal, tractors, and other means of production utilized for expanding production. All these material benefits produce the income of society. They constitute the national income.

Therefore, the number of material benefits being planned, which go into consumption and accumulation, the volume and the structure of the national income should constitute determinative indices for making up the national economic plan. However, not all the products produced in the national economy go into the income of society; part of them remains constantly within the limits of production. Society cannot consume entirely the grain of a new harvest. It must concern itself with replacing the seeds used for sowing. In the same way, more coal is mined to replace coal which has been burned; worn-out machines are replaced by new ones; metal used up in machine construction is replaced by new metal. Therefore, along with the part of the product constituting the national income society produces a part of the product which constitutes the so-called "replacement fund". As K. Marx has shown, the national income and the replacement fund are in a certain quantitative interrelationship at a given level of technical development. The problem, therefore, reduces itself to determining the necessary production in all branches of the national economy in accordance with the national income planned. In order to solve this problem a tremendous number of calculations is needed. Actually, let us assume, that during the planning period it is intended to produce 10,000 airplanes. How are we to determine the degree of production of different types of products in various branches of the national economy, for example, the production of electrical power, necessary for this?

The consumption of electric power for the airplane does not constitute all of the electrical power which must be expended directly at the aircraft plant. Along with these direct expenditures of electric power, in the planning of its production it is essential to take into consideration the so-called "indirect expenditures": electric power for smelting aluminum which is to be used for the production of airplanes, electric power for the electric locomotive which transports the materials and fuel to the aircraft plant, electric power to be used in mines for the purpose of mining this fuel, etc.

Therefore, the full electric power expenditures for the production of airplanes are much greater than the direct expenditures at the aircraft plant. After listing the complete electric power expenditures for preparation of a single airplane, it is easy to determine how much electric power is required for 10,000 airplanes. This situation is similar with regard to plastic which is used for the production of airplanes, metal, wire, and other materials.

The figures for the complete expenditures are calculated by means of computers on the basis of data on direct expenditures. The results

of calculations of the complete expenditures of various products are printed by the machine for each of these products in the form of a table, which shows the scale on which various types of products have to be produced which are necessary for putting out units of the final products: a meter of fabric, a centner (50 kilograms) of flour, an automobile, machine, etc., which go into consumption and accumulation. The value of such information is obvious. Planning organs, making various decisions about the output of some type of product, will be accurately informed on the expenditures in various branches of the national economy with which this will be associated.

The table of complete expenditures serves as necessary material for making up the plan in accordance with the national income being outlined. After multiplying the figures for the complete expenditures by the volumes of final products, it is possible to obtain the planned flowsheet for the groups of branches of production or, in other words, a completely balanced plan of production and production distribution according to branches.

Making up the plan by the method proposed with the application of computers requires extensive economic research in the most varied directions. First of all, a careful workup of the indices of the national income intended-- the level and structure of consumption and accumulation-- is necessary. In this work, a significant place is taken by the determination of the proper norms of product consumption with respect to food, clothing, footwear, houses. The workup of the proper consumption standards is carried out at the Scientific Research Institute of Labor, the Institute of Nutrition of the Academy of Medical Sciences, the Scientific Research Institute of Trade and the Public Dining Room System, the Scientific Research Institute of Housing of the Academy of Construction and Architecture, and in some other institutions. On the basis of the proper standards, a number of sets of consumers' goods should be calculated, based on the current level of production, the level planned for the next few years, and the prospective level. In determining the prospective level of sets of consumers' goods, it is possible to use as a basis scientifically substantiated medical norms, and here the application of exact methods and computers is very effective (Leningrad, 13).

In connection with the determination of the structure of the accumulation, serious problems arise before scientific research institutes in the field of construction and before the leading planning and designing organizations. Calculation of the consumers of various types of products which go into the accumulation fund is facilitated substantially by the development of standard planning and designing. However, thereby a substantiated selection of standard plans and designs for construction during the planning period becomes more important.

A matter of first importance is the detailed workup of the indices of expenditures for production of materials-- direct expenditures. An account of the production balance among the various branches is the

starting point for such a workup. On the basis of this balance, the coefficients of production expenditures for the report period are obtained. For application to planning calculations, they should be modified in accordance with the tendencies of technical progress. If, for example, during the period being reported four tons of metal were used for the production of an excavator, and during the period being planned is intended to reduce this expenditure by 10 per cent through technical and construction improvements, the figure for direct expenditures for the planning period amounts to 3.6 tons.

The prospective indices of expenditures for production-- standards for the consumption of material produced-- were developed a long time ago in the Soviet Union. However, the group of products for which these standards have been determined should be expanded considerably. In the USSR at the present time, there is a large system of branch scientific research institutes which can make up economically substantiated standards for consumption of material for each type of production.

The determination of these standards with consideration of technical progress and the prospects of development in various branches creates a reliable basis for calculating tables of complete expenditures in the planning period.

Since thousands of different types of products are produced in the national economy, it is necessary to solve a system of thousands of equations, performing millions and even billions of calculation operations for this purpose, for the purpose of calculating the table of complete expenditures.

In the USSR, complete expenditure tables have been calculated for the first time at the Institute of Electronic Control Machines of the Academy of Sciences USSR using a high-speed M-2 computer in accordance with the data of the Scientific Research Economic Institute of the Gosplan USSR (now, the Gosekonomsovet /State Economics Council/). Afterwards, similar calculations were made in accordance with the data of the Gosplan of the Polish People's Republic, Laboratory for the Application of Mathematical Methods to Economics at the Siberian Department of the Academy of Sciences USSR, and according to the data of foreign statistics. Calculations of the complete expenditure tables were then made at the Computing Center of the Academy of Sciences USSR on a BESM computer and in other institutions.

Thereby, for the purpose of making out a comparatively small table for 20 branches of production on the M-2 computer about a quarter-million calculations were made. Such calculations, including the automatic printing of the table, take approximately 15 minutes. An experienced calculator would need a half-year, that is, several thousand times more time than the computer, with the use of an adding machine or an electromechanical calculating machine.

A characteristic of the complete expenditure tables calculated according to the material of the Laboratory for the Application of Mathematical Methods to Economics at the Siberian Department of the Academy

of Sciences USSR lies in the fact that they did not include the entire national economy but rather a separate sovnarkhoz (Mordovskiy). Such tables, when calculated for all sovnarkhozes and union republics according to a standard production nomenclature, would be most valuable material for making up a balanced plan not only for branches of production but also for territories. This would assist in better planning of interrayon relations, would aid in determining more efficiently the cooperative supplies, and would more completely satisfy the needs of the national economy and of the population in the various rayons and republics.

Workup of complete expenditure tables by rayons would make it possible correctly and in a scientifically sound manner to solve problems of specialization not only of industry but also of agriculture. Actually, in those rayons where the indices for complete labor and material resource expenditures for production of crops are the lowest, the development of this branch of agriculture should be forced. Conversely, the rayons where the complete expenditure for the production of meat, milk, eggs, and others is relatively low should be oriented to the development of animal husbandry. Being calculated for a single interrelated group of products and branches in all countries of the socialist camp, the complete expenditure tables will constitute effective coordination of the plans of development of the national economies of these countries. They will assist in determining which types of products should be produced in a given country and which should be imported from other countries; which branches of the national economy should be developed from the viewpoint of interests of the socialist camp as a whole and in which countries this should be done.

The balance and interrelationship of the indices is a necessary but not the only quality of a scientifically constructed plan. Another very important property is that it be the optimum one. The plan should provide for the production of the maximum number of products with the most economical expenditures of labor and material resources. In order to compare expenditures for production and its results, it is essential to express them in standard measurement units. This cannot be done directly in hours of human labor. In socialism goods production of a special kind occurs; a law of value exists and operates. Material and labor expenditures can be made commensurate only in a value expression, by means of monetary indices--- prices and wages. Therefore, prices should reflect the true costs of production, while wages should be paid according to the quantity and quality of the work. At the present time, public production costs are expressed very inaccurately in prices. The utilization of the mechanism of prices for redistribution of the national income associated with various collateral circumstances discounts and prohibitive rises, which have been superposed for a number of years, have led to excessive price deviations from the actual costs of production, to an unfounded variegation in profits (Leningrad, 6). Hence, the perfection of price formation assumes great importance.

The July (1960) plenary meeting of the CC CPSU acted to revise wholesale prices for tools and means of production in 1961-1962 so that they more accurately reflected expenditures for production and entrusted the Gosekonomsovet of the USSR with working out methods for establishing the new wholesale prices (Leningrad, 7).

Work on the revision of wholesale prices is associated with a large number of calculations. Actually, for example, let us say for the purpose of eliminating unprofitableness of the coal industry, the price of coal will be changed. This will entail a change in the price of coke, for the production of which coal is used, and, therefore, the prices for cast iron, steel, and rolled iron will change also. In turn, the prices for metals will have an essential influence on the cost of production in machine construction including the construction of mining machines. The change in prices for mining machines should again reflect on the price of coal, etc. A reduction of prices for liquid fuel, natural gas and many types of machines produced at the present time and an excessively high profit will also call for an appropriate change of prices for the entire chain of products associated with production of them. Therefore, a change in the prices of any product should reflect on the level of prices of many other types of production. The matter of taking the interrelationship of price changes into account has always presented planning workers with many difficulties. It would be impossible to calculate prices in several variants and assure sufficient accuracy in the linking-up of prices with one another.

The large number of calculations required for the coordination of prices can be accomplished on computers in many variants in a very short period of time and thereby with great accuracy. However, a fundamental perfection of price formation is possible only on the basis of calculating the actual public costs of production of the basic products of the national economy. For a number of years now, economists-- scientists and practical workers-- have been conducting discussions with respect to the principles of price formation. However, only very recently, by the methods of machine mathematics has it been possible to calculate price levels in accordance with each of the principles discussed: according to the schema of the so-called "averaged value" and according to the schema of production prices.

The application of computers to planning calculations on labor and wages uncover very broad possibilities. Some of these calculations has been entrusted by the State Committee on Problems of Labor and Wages of the Council of Ministers USSR to the Institute of Electronic Control Machines (Moscow) and have already been carried out. The calculations have made it possible to determine the change in family incomes of workers in accordance with the new wage scales in various branches of industry (Leningrad, 13).

The examples analyzed above, naturally, are far from exhausting the tasks of national economic planning in the solution of which cybernetic methods and electronic computers can be used effectively. There

is a number of other tasks in the field of planning investments, labor and wages, selection of the most expedient planning variants, and others, in the solution of which machine mathematics and exact methods should play a great part.

Supply of Technical Material

Considerable attention has always been given and is now being given to the supply of technical material as one of the most important links in socialist reproduction. At the present time, in the USSR sales and supply organs annually make up 10,500-12,000 flowsheets for materials in various types of production (Leningrad, 8).

In the national supply system, a multitude of experienced highly qualified specialists is working, a group of distinguished men who know their work well. Nevertheless, none of the divisions of planning or economic activity has been recently bringing forth such a number of reproaches or so much criticism as the supply of technical materials. This criticism is, as a rule, justified. Actually, difficulties in the supply occur, in the majority of cases, because of improper distribution of various materials in the national economy rather than because of an absolute shortage of them. This is evidenced, particularly, by the following composite data. According to the situation on 1 June 1959, in part of the sovnarkhoz enterprises the values for the reserves of materials were 3,200,000,000 rubles less than that provided for by the plan, whereas at other enterprises there were surpluses of almost 15,000,000,000 rubles (Leningrad, 9).

What is the reason for the difficulties and shortcomings of the supply of technical material? How can they be overcome?

The current level of development of the national economy, of its interrayon relations and relations between various branches, the existence of a tremendous number of producing enterprises, and particularly of consumers of each type of production, have complicated exceedingly the problems of supply of technical material. The time has come when a simple increase in personnel occupied in the supply or even an increase in its qualifications does not solve the problem. Such measures, as experience has shown, give a very minor effect for the supply of technical material, and in a number of cases this effect is simply negligible. Cybernetic methods and computers should be of aid here. In the supply of technical materials, the processing of a colossal number of documents is carried out: requisitions, bills of lading, as well as documents associated with the storehouse activity and transportation. The possibility of utilizing computers for automation of processing of those documents is based on the fact that processing of them is of a strictly formal, uniform and repetitive nature. The need for using computers first in supply of technical materials was noted, particularly, at the June (1959) plenary meeting of the CC CPSU (Leningrad, 10).

In capitalism, under conditions of private ownership, there is no

activity supplying the national economy, and this cannot be organized under a single leadership. This would contradict the very nature of capitalism. However, cybernetic methods and computers are utilized in the supply of large companies and are of quite some advantage there.

Foreign experience shows that the utilization of computers makes it possible to find the most advantageous routines of work, which gives a considerable saving. Simultaneously with this, there is a marked reduction in the control apparatus (in some cases, by 80-90 per cent). The automation of control of supply in the American army has become quite common; here, automated supply systems for the airforce, the corps of communication troops, armored troops and others have been created.

Undoubtedly, under conditions of socialism, the application of cybernetics to a unified national economic system of supply will assure a much greater effect.

The process of work of supply organs can be divided into the following three main parts: a) account of technical materiel; b) planning of supplies; c) operational control of supply.

All these problems can be solved successfully by means of computers. Accounting includes the processing of bills coming from contracting enterprises; receipts and accounting documents coming from consumers and storehouses as well as reports on the movement of technical materiel.

The account of materiel is made in computers in special large-capacity memory apparatuses usually constructed with the utilization of magnetic tapes. Aside from the record made on magnetic tapes, a record is also kept on primary documents-- punchcards and composite lists-- which are periodically given out by the computer in the form of printed documents. Keeping an automated record, just as in the case of the ordinary manual method, is based on a closed system of document turnover, in which the final changes in the record are made only on the basis of confirmation coming from the receiver and after a comparison of them with the report ofthe supplier.

The planning process of supply of technical material represents part of the general process of planning and includes a calculation of the needs for technical materiel, a determination of the inventory and making up of requisitions and plans of supply.

These problems are solved by computers automatically after putting in the necessary basic data. The process of operational control of supply includes monitoring of the levels of reserves in storehouses, the preparation of instructions to storehouses for shipment of equipment and supplies and requisitions for equipment of which there is a shortage in the instances mentioned above.

The main characteristic of problems of operational control of supply is the great variety of rules used for solution and frequent change of the sequence in which they are carried out. This requires the combination of machine methods of processing with the work of people who carry out various tasks which are most complicated in a logical respect.

The system of supply of technical material represents the best

prepared field of application of computers, where automation gives a rapid and perceptible result. As has been shown by preliminary investigations, the use of computers makes it possible to reduce the control apparatus of the supply system by two times and to reduce expenditures in the system of supply of technical material by approximately five times. However, the effect of incorporating cybernetics into the system of supply of technical materials is far from being exhausted by this. The main effect lies in a radical improvement in the quality of supply. The use of computers will make it possible to reduce the time needed for making up supply plans from three-four months to three days. While working out supply plans by hand is done on the basis of data for the first half-year or the seven-eight months of the year under review, with the use of machines it can be based on data for three-quarters of the year or even for 11 months. Naturally, such data more accurately depict the state of affairs in the sovnarkhozes and at the enterprises, their actual needs for raw materials, other materials and semifinished products during the period being planned. The high speed of electronic computers and the application of special mathematical methods assure the optimization of the schemata of the supply of technical materials. All this will lead to a more complete satisfaction of the needs of the national economy, better utilization of material values. The improvement of the supply of technical materials will considerably improve arrangements according to plan and the rhythm of socialist reproduction, will assure tremendous national economic efficacy.

Of the calculations which can be effectively accomplished in the supply of technical materials by means of computers at the present time calculations for the optimum supply system have already been mastered and tried out in practice. A certain idea about the calculation for the optimum plan of supply is given by the following brief, maximally simplified example.

Suppose there are three coal deposits and three sovnarkhozes. The mining of the coal, the needs of the sovnarkhozes, as well as the cost of the mining together with the delivery are shown below in Table I. The sum of the needs of all three sovnarkhozes is equal to the total coal production (14,000,000 tons).

It is necessary to find a system of supplying the sovnarkhozes with coal in which the total expenditure for supplying all the coal will be the least. It is difficult to do this offhand, without appropriate calculations. From the first glance, it may be shown that sovnarkhoz D should be supplied with coal from deposit A. For the expenditures for mining and delivery of coal in this case will be the least-- 46 rubles. As far as sovnarkhoz F is concerned, coal from deposits A and B should be unloaded at it, at first glance. Nevertheless, the optimum plan of carriage has the appearance which is shown in Table II.

According to this system, coal should be supplied to sovnarkhoz D from deposits B and C, amounting respectively to 1,000,000 and 3,000,000 tons; coal should be brought in a quantity of 4,000,000 tons to

Table I

(1) Месторождения	(2) Совнархозы	D	E	F
	(3) Добыча млн. т	(4) Потребность, млн. т		
		4	4	6
A	2	46	73	57
B	5	50	59	71
C	7	64	86	82

(5) Затраты на добычу и доставку 1 т угля, руб.

1. deposits; 2. sovnarkhozes; 3. production, millions of tons; 4. need, millions of tons; 5. expenditures for mining and delivery of one ton of coal, rubles.

Table II

(1) Месторождения	(2) Совнархозы	D	E	F
	(3) Добыча	(4) Потребность		
		4	4	6
A	2			2
B	5	1	4	
C	7	3		4

1. deposits; 2. sovnarkhozes; 3. production; 4. needs.

sovnarkhoz E from deposit B; finally, coal should be brought from deposits A and C, amounting respectively, to 3,000,000 and 4,000,000 tons, to sovnarkhoz F.

Calculation of optimum supply has been made in four successive approximations (iterations).

(1) Месторождения	(2) Совнархозы	D	E	F	D	E	F	D	E	F	D	E	F
	(3) Добыча	(4) Потребность											
		4	4	6	4	4	6	4	4	6	4	4	6
A	2	46	73	56	50	77	60	64	91	74	72	99	82
B	5	50	59	71	59	59	71	64	73	85	64	73	85
C	7	64	86	82	64	86	82	64	86	82	64	86	82
A	2	2		0	0		2	0		2			2
B	5		4		1	4		0	4		1	4	
C	7							4			3		4

1. deposits; 2. sovnarkhozes; 3. production; 4. needs.

At each iteration supplies come from three deposits which can satisfy the requirements of the sovnarkhozes for the lowest prices (such

prices have been noted in bold type). At the first and second iterations these are deposits A and B. The prices of coal from deposits where it is inadequate for satisfying all the needs of the corresponding sovnarkhozes are increased successively. Hence, at the third iteration supply from a relatively poorer deposit, C becomes advantageous. At the fourth iteration, a schema is obtained which provides for complete utilization of the deposit and complete satisfaction of the requirements of sovnarkhozes, assuring the lowest expenditures for coal supply.

In contrast to the example presented, in the planning practice of the supply of technical material one has frequently to deal with scores and hundreds of suppliers and consumers rather than three suppliers and three consumers. The problem in this case is solved by a few score and even hundreds of iterations rather than by four. Thereby, millions of calculation operations are required. Thus, for example, for calculating the optimum plan of coal supply from 30 deposits to 98 sovnarkhozes, carried out at the Institute of Electronic Control Machines, about 8,000,000 calculations were made. The calculations took about one hour. It would require five years for an experienced calculator to do this with an electromechanical adding machine. In planning organs scores of workers assign consumers to suppliers for several months. Thereby, the supply plan obtained is not the optimum one. The plan of coal carriage, calculated on an electronic computer, has proved to be approximately five per cent, or a few score million rubles, more economical than that existing at present (Leningrad, 11). Even better results can be given by calculations of the optimum fuel-power balance on a computer.

Similar calculations are being made at the Institute of Electronic Control Machines in cooperation with the Institute of Economics of Construction of the Gosstroy USSR for carriage of cement and disposition of the cement industry.

The computing center of the Academy of Sciences USSR in cooperation with the Institute of Complex Transportation Problems has made practical computing machine calculations of optimum sand carriage plans and similar plans for other building materials, optimum runs of empty cars, and others. Sand carriage at 209 structures in Moscow, from eight wharves, calculated on a "Strela" computer proved to be more economical than calculations actually made in 1958 to the extent of 11.4 per cent or 2,000,000 rubles a year (Leningrad, 12).

Calculation of the optimum carriage plans is also being made at the Gor'kiy Sovnarkhoz and in a number of other scientific and economic institutions and organizations.

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Calculations of optimum carriages, as a number of other problems of the optimum, are carried out on a computer by methods of linear programming. These methods serve for the solution of problems with

linear functions. Linear functions are expressed by equations for the calculation of complete expenditures. Functions of this kind provide an abstract characterization of actual economics to a considerable degree. The majority of functions in economics, strictly speaking, is nonlinear. However, in many cases, such a nonlinearity can be overlooked, and then such an abstraction becomes very fruitful. It makes it possible, without overlooking the main problem, to solve many important planning problems. In 1939, for the purpose of solving extreme problems in the field of economics, L. V. Kantorovich, Corresponding Member of the Academy of Sciences USSR, proposed the so-called "resolving factors method". By means of this method, a number of problems of a production nature have been solved. However, at that time, mathematical methods had not obtained large-scale application to economics. In the postwar years, in the United States, the theory of linear programming was created. This theory for solving extreme problems with linear functions was used originally also on a very limited scale. The large volume of calculations necessary for practical realization of it created obstacles.

With the appearance of computers, these difficulties were surmounted to a considerable degree, and methods of linear programming began to be utilized on a broad scale in economic practice. Among the merits of methods of linear programming are the clear-cut and well formalized algorithms which make it possible to successfully utilize computers. Methods of linear programming were developed to a considerable degree in the works of the Hungarian mathematician Kreko as well as in the works of Soviet mathematicians-scientists and economists, L. V. Kantorovich, G. Sh. Rubinshteyn, A. L. Brudno, Yu. A. Oleynik, A. L. Lur'ye, I. Ya. Birman and others.

Problems with linear functions or problems which permit linearization of functions, naturally, do not exhaust the entire multitude of economic problems. Even larger is the class of problems dealing with the search for the optimum variant-- problems with markedly nonlinear functions. In this group are chiefly problems of selecting the most effective variants of investments. The problem of determining production prices with a profit proportional to production funds is also a nonlinear one. Methods of solving the problem of investments have already been worked out partially abroad; however, this has been done with a very limited number of variables, inadequate for practical utilization. Methods and algorithms for calculation of production prices on computers on the basis of information expressed in a full-scale-material way have been worked out by us in cooperation with A. S. Kronrod, Doctor of Physical-Mathematical Sciences. In the calculation made by the algorithm found not only the prices of various products are determined but an actual evaluation is given of the basic appropriations, and the norm of investment efficiency is calculated. In addition, we worked out and used in practical calculations methods for calculating production prices on the basis of information expressed in a cost respect (Leningrad, 13).

As a whole, however, methods of solving problems with nonlinear functions as well as problems of dynamic programming remain to be worked out.

In the USSR and abroad research is being done in the field of dynamic programming and the theory of games as applied to the needs of economics. Further development of this field will be an important condition for large-scale application of cybernetics to economics.

The Gosbank System of the USSR

V. I. Lenin considered the banking system the most important public accounting tool. The backbone of the banking system in the USSR is the Gosbank /State Bank/.

The State Bank of the USSR collects and processes information about circulation of money and represents a centralized system of interrelated objects with common control. In turn each of these objects is associated with a considerable number of different enterprises, organizations and other economic organs which give information to the Gosbank institutions and receive appropriately processed information from it. This information is reprocessed not only at places to which it originally comes but also in the center of the banking system, which is associated with peripheral installations by two-way communication channels.

The State Bank of the USSR services hundreds of thousands of enterprises, organizations and institutions, including tens of thousands of kolkhoz members. More than 80,000 persons are engaged in technical work associated with computations and calculations in the Gosbank. In all the institutions of the Gosbank, every year an average of 3,300,000 different banking operations are carried out every day, and more than 1,000,000,000 operations per year. The total number of personal accounts in the Gosbank institutions exceeds 3,500,000. Of these approximately 80 per cent are involved in operations daily, which amounts to more than 2,000,000 entries in personal accounts per workday.

In recent years, considerable attention has been given to problems of mechanization of information processing within the Gosbank system in conjunction with the continuous increase in the volume of banking operations. However, the desk comptometers and the analytical accounting machines cannot solve the problems because of their low output and their lack of adaptability to the specific characteristics of banking operations. This fact has brought about an expansion of the number of institutions in large industrial centers and an increase in the staff of workers in these institutions.

At the existing rates of increase in document turnover, a situation will be created in the next few years in which without a qualitative change in the mechanization level the information processing will become impossible within the established time. An increase in the number of institutions and in the staffs will no longer give any substantial result.

Foreign banks, which also have run up against difficulties associated with increase in the volume of documents being processed, make extensive use of computers for the mechanization of operational bookkeeping. In the banking system of the United States and western Europe, special communication channels have been created on the basis of cybernetics which along with computers form integrated automated processing systems which transmit and store information. It is characteristic that the punchcards utilized for recording the initial information are even now official monetary documents. Extensive use is also being made of various forms of checks with magnetic recording of the data, which are official documents, and at the same time, assure the possibility of direct input of information into the machine.

The structural interrelationship of various elements in the system as well as the nature of movement of streams of information along communication channels between them permits us to put the question not only of the incorporation of various machines into the Gosbank system, but also of creating an automated system for transmission and processing of all banking and similar information.

Specifically, for large offices and city administrations, to which a considerable number of institutions with large volumes of processed information are subordinate, the most effective form of mechanization is that of setting up computers in them with long-distance input of the basic data into the machines directly from the institutions being serviced.

For the purpose of working out and incorporating computers into the Gosbank system, the unification and standardization of payment-calculation documents and the development of methods and an apparatus for putting data into the machines directly from the initial document are required, which will essentially increase the effectiveness of utilization of the machines.

Automation of a banking-finance system on the basis of the incorporation of computing technique will considerably increase the efficiency of utilization of existing facilities and will assure a marked reduction in the staffs of employees.

The problems and methods of application of cybernetics to economics analyzed above pertain chiefly to the operation of central economic organs. These problems and methods to a considerable degree are applicable also to economic organs of the union republics, to sovnarkhozes, large enterprises, and others. At the same time, sovnarkhozes and enterprises have their own specific problems, like for example, problems on optimum distribution of orders among the enterprises, maximum loads on equipment, economic utilization of raw materials, and others. In the solution of these problems, mathematical methods and computers can also find the most extensive utilization.

The application of cybernetics to a socialist national economy can be accomplished on the largest and all-inclusive scale. A major step in this direction is the creation of the Computing Center of the

Gosekonomsovet USSR. In this Center, in time, the main calculations for making up the national economic plans will be carried out on computers. In the future, it is intended to create such centers in the Gosplans of the RSFSR, Ukraine and other union republics. A large system of computing centers should be organized in the sovnarkhozes and at large enterprises. The calculating machine stations of oblast statistical offices of the TsSU can serve as the initial basis for such a system. Such stations exist in almost every administrative economic rayon. At the present time, they have been equipped chiefly with comptometers and punch card computers. Equipping them with computers incomparably increases efficiency and permits such stations to satisfy the requirements not only of statistical but also of local planning and administrative organs.

In this connection, foreign experience is of some interest. In the largest cities of the United States at present there are computing centers which on a commercial basis carry out economic calculations for large companies. About 1,500 large computers are concentrated in these centers. On orders of large companies to these computing centers calculations are made on wages, and the best distribution of orders and most profitable investment of capital are determined. Abroad, for economic calculations chiefly universal computers are used with additional sets of external apparatus.

The highly developed industry of the USSR has every possibility of providing for the requirements of the national economy with both universal and specialized computers for economic calculations. At the present time, there are in existence such machines as the Ural-4, a universal machine with external apparatus built up and adapted for economic calculations. Apparently, it is advisable to re-equip a certain portion of the machines of other types with such apparatuses. Specialized machines for economic calculations are being built and constructed.

The use of computers and cybernetic methods in socialistic economics is an important element in the world competition between socialism and capitalism. It is essential in this field also to provide Soviet science and engineering with leading positions.

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