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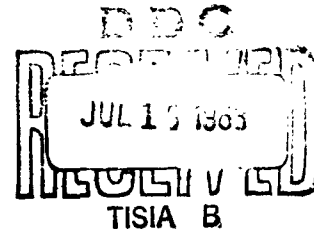
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**SOVIET CYBERNETICS TECHNOLOGY:
I. SOVIET CYBERNETICS, 1959 - 1962**

Edited by Willis H. Ware and Wade B. Holland



PREPARED FOR:

UNITED STATES AIR FORCE PROJECT RAND

The **RAND** *Corporation*
SANTA MONICA • CALIFORNIA

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PREFACE

This Memorandum is a collection of translations, with commentary and annotation, on the subject of cybernetics and cybernetics applications in the Soviet Union, taken from various sources during the period 1959-62. It is not the purpose of this Memorandum to present the detail of Soviet research projects, but rather to keep computer specialists who are interested in Soviet computing technology and cybernetics informed about Soviet publications and activities in these areas.

Particular attention is given to listing the articles carried in Soviet journals in the field, and to keeping abreast of the various conferences, seminars, and organizational activities in the cybernetics area. Translations of particular articles referenced are often available through the Office of Technical Services, Department of Commerce, Washington 25, D.C. All translations undertaken by The RAND Corporation are registered with the Office.

The series, Soviet Cybernetics Technology, is part of a continuing program of research in computer technology conducted by The RAND Corporation, under U.S. Air Force Project RAND.

SUMMARY

This Memorandum contains seven sets of translations in the area of Soviet cybernetics, together with commentary and analyses on the status of cybernetics in the Soviet Union and the directions in which Soviet cybernetics research is being pushed.

The three most recent volumes of Problems in Cybernetics, a collection of research reports published more or less annually, form the bulk of the Memorandum (Chaps. 3-5). For each volume, a listing of the contents is provided, together with a translation of articles contained in the final chapter of each volume, dealing with the conferences, seminars, and organizational activities during the period covered by the volume. Chapter 1, a translation of an excerpt from the book Philosophic Questions on Cybernetics, points out the growing pains of the new discipline and touches on the effort to reconcile cybernetics with other disciplines which may view its accomplishments and possibilities with skepticism. A detailed consideration of the controversy surrounding the subject is contained in the article in Chap. 2. This analysis was compiled by the (West) German Social-Democratic Party from Soviet and Eastern European sources.

Chapter 6 presents a typical general survey of cybernetics, written for the non-technician. It defines the principles of design, construction, and use of computers, and analyzes computer applications in national economic planning, the ferrous metal industry, and in transportation.

Finally, a brief item, translated from the Czech, presents two cybernetics research projects at the Computing Center of the Ukrainian Academy of Sciences.

FOREWORD

The translations in this Memorandum will be already familiar to some readers, as preliminary versions were distributed to a limited audience as they were completed. However, each translation has been carefully studied in the interim, and extensive work has been done to attain a greater degree of accuracy. As the volume of material published in the cybernetics field in the Soviet Union increases, so does our familiarity with its unique terminology increase. On the other hand, the lack of standard definitions, either in Russian or in English, continues to complicate the translation problem.

The series, Soviet Cybernetics Technology, dates back to the spring of 1959 when a U.S. technical delegation on electronic computers visited the Soviet Union as part of an exchange program. Among the eight members of the American delegation were Paul Armer and Willis H. Ware, from the Computer Sciences Department of The RAND Corporation. Upon their return, an extensive trip report and analysis of the Soviet state-of-the-art was produced.* In late 1961, the decision to establish a permanent series of publications on Soviet cybernetics and computer technology was made. Since that time twenty articles have been prepared in preliminary format, several of which are included in final form in the present Memorandum. Projected volumes in the series will cover such subjects as hardware, programming, and Soviet computer installations and personnel.

In a related project, work is progressing on the compilation of a Russian-English glossary of computer and cybernetics terminology, with the hope of eventual publication.

*Ware, W. H., (ed.), Soviet Computer Technology--1959, The RAND Corporation, RM-2541-PR, March 1, 1960. Reprinted in IRE Transactions on Electronic Computers, March 1960.

ACKNOWLEDGMENTS

The editors wish to express appreciation to the many who have helped make possible both this volume and the series, Soviet Cybernetics Technology. A. S. Kozak, Roger Levien, and Barbara Scott contributed significantly to the effort in translating from the Russian.

The cooperation of Horst Mendershausen in making the article in Chap. 2 available for publication in this volume is gratefully acknowledged, as is the work of Barbara J. Ernst who translated it from the German.

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Chapter 1

"PHILOSOPHIC QUESTIONS ON CYBERNETICS"*

EDITORS' INTRODUCTION

The science of cybernetics is subject to much debate and controversy in the Soviet Union today, as its adherents and its skeptics present their cases for and against the discipline itself and its implications. A detailed study of this phenomenon would perhaps show that the controversy is little different than the similar concern in our society over the possibilities of man being supplanted by mechanical "super brains," or, more precisely, the opposition to automation.

The Soviet debate is not, however, being carried on through the technical and scientific journals, and only hints of its magnitude, and even its very existence, can be gleaned from them. It is in the popular press that we learn of the opposition to cybernetics. An analysis, based on articles appearing principally in the Literary Gazette, and carried recently in a monthly publication of the Eastern Department of the (West) German Social-Democratic Party,** paints a picture in which "this science has almost induced a psychosis" in the Soviet Union. The report goes on to state that the difference of opinion is emotionally based, rather than technical, as men of literature and science debate the merits of cybernetics.

Even within scientific and technical circles, however, it is obvious that there are wide divergences of opinion. An attempt to ameliorate these differences was initiated during the latter part of the 1950s, with the establishment

* Filosofskie Voprosy Kibernetiki, V. A. Il'in, V. N. Kolbanovskii, E. Kol'man, Eds., The Socio-Economic Literature Publishing House (Sotsekgiz), Moscow, 1961, 392 pp.

** See Chap. 2.

of a series of discussions on the problems of cybernetics and the publication of a number of the papers presented during the discussions. A selected group of these reports has been assembled in the volume, Philosophic Questions on Cybernetics, published in 1961. Cybernetics is defined in the Preface to the collection, and an outline of the methodology and applications of cybernetics studies is presented. A perusal of the Table of Contents reveals that the articles are concerned with the place of cybernetics in the scientific community, its history and background, and general discussions of present day and future applications. A recurrent theme throughout the articles is that cybernetics is not aimed at degrading man, nor is the study incompatible with the Communist social order. Quotes from Marx, Engels, and Lenin are cited to show that cybernetics is not a revolutionary new study; rather, it traces its origins as far back as the Greeks, from whence the name comes.

The following two sections contain a translation of the Preface to the book, and a list of the articles carried in the book.

Preface to "Philosophic Questions on Cybernetics"*

The past decade has been marked by significant scientific and technical progress in designing and building automatic machines and remote control devices, and in radio engineering and electronics in the various branches of industry, transportation, and agriculture. The introduction of digital computing machines, automated assembly lines, automated factories, and the rapid development of automated industries has led to the rise and growth of a new field of knowledge--cybernetics.

Cybernetics approaches various systems of control from a unified position, leading to a common definition of that which is inherent in each of them. Such a method in science is not new. In its time, cybernetics has developed a series of theories and scientific disciplines which, in various fields of knowledge, leads to studies of general laws of nature for each one's various ranges of the occurrences of validities (the theory of oscillations, the theory of automated adjustment, the theory of statistical processes, and so on).

There are many possibilities for cybernetics which, at the present time, has become one of the most popular sciences, attracting the attention of specialists in many branches of knowledge--mathematicians, physicists, chemists, biologists, medical men, psychologists, linguists, astronomers, technicians, sociologists, economists. The rapid development of cybernetics was caused not only by its theoretical theses, but also by its strong practical achievements, especially in the area of the development of logical computational and self-adjusting machines and automatic devices.

*The items in this chapter have been translated from the Russian by Wade B. Holland, from the book, Philosophic Questions on Cybernetics.

The manifestly significant achievements of cybernetics in practical application of theoretical foundations parallel methodological vagueness and casualness on several important fronts. The application of the method of cybernetics is especially suited to the various sciences whose specifics have not been calculated, including the specifics of the various forms of the movement of matter.

In the activity and functioning of all organic, social, and technological systems of control, there are general natural laws and common traits relevant to the system's information retrieval processes, its coding and operating processes, and its retention and transmission of information from one part of the system to another. However, functional activity in each system of control works differently in accordance with the system's requirements. An automated machine is devised and constructed to its most minute detail by a man. Such a machine enjoys only those possibilities for calculating "activity" which he gives it. The alteration of the working program of the machine is effected only within given limits, which are tailored to the specifications of that particular type of machine.

The vital activities of an organism proceed in a significantly more complicated manner. Control of the vital activity of an organism--the process of its adaptation to a constantly changing external environment--is incomparably more complex than that of an automated device, although (as with a machine) the organism also receives information from external sources, interprets it, and responds to the change in its environment. The character of the possible reactions of an organism is incomparably more varied, and, for example, afferentation,* which exists as the basis of

*Translator's Note--Evidently a coined word: the noun form of afferent.

self-control, is by far more complicated than the reverse system of communications in machines.

The processes of control in human society are even more complicated. Therefore, natural laws inherent to a system of control in technology may be attributed to organisms and, to an even greater degree, to human society only with considerable organization and reservation.

The presence of opposing points of view has led to the organization of an exchange of opinions on philosophic questions in cybernetics, under the Chair of Philosophy of the Academy of Social Sciences of the Central Committee of the CPSU,* and the Institute of Automation and Telemechanics of the Academy of Sciences of the USSR. Participation of philosophers, mathematicians, physicists, engineers, psychologists, and physiologists has been encouraged in the discussions. Also, the journal, Questions of Philosophy, has presented analyses of the given problems. The discussions took place during 1958 and 1959. The discussions reflect the general theoretical and the special approaches of the various participants to the problems of a new science. At first, the differences between those supporting cybernetics without reservation and the scholars critically regarding its methodological positions were quite marked. During the progress of the discussions, there appeared rapprochement in points of view, and mutual understanding between the participants was reached.

The editorial board established rules for preserving the essence of the articles as they were presented by the authors, with the exception of necessary editorial corrections.

In bringing to the attention of the reader articles on philosophic questions in cybernetics, written mainly to facilitate exchange of opinions, we hope that the reader

*Translator's Note--Communist Party of the Soviet Union.

will find for himself material which will allow him to better orient himself in this new branch of knowledge.

List of Articles

- "On Cybernetics and the Sphere of its Application"
S. M. Shalyutin, Candidate in the Philosophical Sciences
On the Objectives of Cybernetics
The Significance of Cybernetics
Thinking and the Computing Processes in Machines
- "On Philosophic and Social Problems of Cybernetics"
E. Kol'man, Doctor of Philosophical Sciences
- "On the Possibilities of Cybernetics in Studying Characteristics of the Reflection of Matter"
B. S. Ukraintsev, Candidate in the Philosophical Sciences
- "Problems of Control in Cybernetics"
A. I. Berg, Academician
From Lenin to the Present
From Mechanization to Cybernetics
On Several Philosophical Problems of Cybernetics
- "The History of the Development of Cybernetics"
A. V. Khramoi, Candidate in the Technical Sciences
- "Several Scientific Questions on Systems of Control"
V. A. Il'in, Doctor of Technical Sciences
- "On Several Cybernetic Arguments"
V. N. Kolbanovski, Professor
- "Physiology and Cybernetics"
P. K. Anokhin, Member of the Academy of Medical Sciences, USSR
Several Principles Peculiar to Cybernetics
General Principles of Cybernetics and their Development
The Afferentation Function of an Organism in Cybernetics
The Processes of Self-Adjustment in an Organism and Cybernetics
Cybernetics and the Reflex Theory
Conventional Reflex in Cybernetics
- "Dialectics of the Nature of Life and Contemporary Cybernetics"
Yu. P. Frolov, Doctor of Medical Sciences

"Cybernetics and Labor"

V. N. Tipukhin, Candidate in the Philosophical Sciences

"The Role of Analogy in Cybernetics"

A. A. Fel'dbaum, Doctor of Technical Sciences

Appendices

The Congress on Cybernetics in Namur (Belgium) (A Short Survey) [1956]

V. A. Il'in, Doctor of Technical Sciences

The General Meetings

On the Second International Congress on Cybernetics

(From material from the report of the Academy of Sciences of the USSR Delegation) [1958]

I. Ya. Aksenov, Candidate in the Technical Sciences

Bibliography

A. V. Khramoi, Candidate in the Technical Sciences

Chapter 2

"CAN 'KYBERNETES' BE KHRUSHCHEV'S FELLOW PARTY MEMBER?"*

EDITORS' INTRODUCTION

The Monthly Report of Developments in the Soviet Union is a mimeographed publication of the (West) German Social-Democratic Party, in Bonn. The article here translated was carried in the edition of June 1962. The journal specializes in analyzing political developments in the Soviet Union and Eastern European countries, for which a program of continuous scrutiny of Soviet bloc publications is maintained.

The bulk of the issues raised in the article were gleaned from reports in the popular press and general-consumption magazines. Many of the quotes are in a much sharper tone, indicating a more deep-seated controversy, than is discernible from the article in the preceding Chapter. This points out, again, the fact that the issue is more "out in the open" in the popular press than in the technical journals of the cyberneticists.

Towards the end of the present article, a number of generalizations are made concerning the state-of-the-art in the Soviet Union and the political overtones of the cybernetics debate. These are apparently conclusions drawn by the author of the article, who is not identified. It should be emphasized that they represent the opinion of a Western analyst, and are not quotes from Soviet sources.

*"Kann 'Kybernetes' ein Parteigenosse Chruschtschows sein?," Monatsüberblick über die Entwicklung in der Sowjetunion [Monthly Report of Developments in the Soviet Union], Eastern Department of the (West) German Social-Democratic Party, Bonn, June 1962, pp. 1-12.

Can "Kybernetes" be Khrushchev's Fellow Party Member?*

Cybernetics Raises New Problems in Soviet Society

In May [1962] the Ukrainian press reported an unusual event in the field of science. A group of mathematicians and physicists from the Computing Center of the Ukrainian Academy of Sciences realized a daring project: From the Computing Center in Kiev, the "Kiev" computer poured steel by remote control in a Dneprodzerzhinsk factory, hundreds of kilometers distant. Reporters told not only of the scientists' and economists' achievement, but also the reaction of hundreds of workers, who followed uncomprehendingly their "displacement" by the machine. It was in the very act of pouring the steel that the miracle of cybernetics was so vividly expressed. This important process can never really be mastered from books and methodical instruction. Instead, a very special rapport is needed, so that by opening the furnace, the steel is sent into the rollers at just the right moment. Experienced metallurgists judge by the look of the flames and the character of the sparks. Skepticism that such a judgment could be made by a machine was therefore well founded. But the "Kiev" accomplished the task.

A poetically talented reporter, Michenko of the Radianska Ukraina, closed his report with the following words:

In ancient Greece the man who steered ships was called Kybernetes. This steersman, whose name is given to one of the boldest sciences of the present--cybernetics--lives on in our time. He steers the space ships and governs the atomic installations, he takes part in working out the most complicated projects, he helps to heal

*The article in this chapter was originally translated from the German by Barbara J. Ernst and edited by Horst Mendershausen for the RAND series, Translations of Political Interest.

humans and to decipher the writings of ancient peoples. As of today he has become an experienced metallurgist.

In the Soviet Union, this science has almost induced a psychosis. If one reads the countless articles, short stories, and other material appearing in the Soviet press on the subject, one cannot escape the impression that many Soviet citizens who are concerned with problems of the future are being tortured by the question, "Can 'Kybernetes, who is already a metal worker, perhaps shortly become a member of the CPSU?"

One expression of this psychosis is the strong difference of opinion (not technical, but emotionally based) between men of literature and some scientists. Academician A. Kolmogorov published an article (Izvestia, Sunday supplement "Nedelya," No. 5, 1962) in which he deduced that machines capable of such thinking and feeling can "surpass man in his development." He calmed his readers by saying that things had not yet gone this far, but that evolution was plainly heading in this direction. It will become possible to reach a stage in which such superperfect machines are in a position to build their own progeny--without human help. Another Academician, V. Petrov, reported of the penetration of computers into art and literature. It will become possible to create an electronic "editor" of music, etc. In the Literaturnaya Gazeta of May 29, 1962, an article by B. Byalik, Ph.D., appeared under the revealing title, "Comrades, Is This Serious?" Naturally the author pleaded in favor of man. He received his answer in the June 2nd edition of the same journal from Academician Sobolev: "Yes, it is very serious! ... In my view the cybernetic machines are people of the future. These people will probably be much more accomplished than we, the present people."

We shall not enumerate here the many fields to which

the vehement "discussions" of cybernetics have spread. But the discussion at Moscow State University in the Mechanico-Mathematics Faculty Seminar is interesting. Academician A. Kolmogorov spoke on the subject, "Automation and Problems of Life." This scientist, who is one of the world's foremost mathematicians, acknowledged his extremist position among the cyberneticists and explained that he sees "no fundamental limitations in the cybernetic approach to the problems of life." This speech started a new wave of discussion on the fundamental questions of biology. The material cannot even superficially be touched upon here, but we must mention that a significant departure from obsolete Marxist dogma is apparent in this matter.

Understandably enough, the Soviet military is showing great interest in cybernetics. For example, in the Ministry of Defense publication Krasnaya Zvezda of June 30, 1962, the first of a series of articles appeared, "Strategy and Cybernetics," by Colonel V. Larionov, Ph.D., and V. Vaneev, Colonel-Engineer. The authors emphasize cybernetics' special significance in the extensive elimination of human errors--an important feature for the modern military. This affects not only rocket guidance, but also solutions to many other military problems; e.g., calculations of the enemy's military potential and the distribution of its strategic forces, scientific analysis of one's own military potential, including analysis of strategic advantages and disadvantages. It is difficult to say whether the Soviet military has reached as advanced a position as the United States in its use of cybernetics and mathematical methods.

In addition to the one cited, many other sources also confirm that cybernetics has assumed a significant role among Soviet military leaders.

As far as the events of June are concerned, a Pravda interview with A. I. Berg, Chairman of the Scientific Council on Cybernetics of the USSR Academy of Sciences,

is important. In this interview, Berg told of a conference, recently held in Moscow's Science House, in which over 1000 scientists and specialists debated the philosophical problems of cybernetics. Berg gave a summary of the problems discussed. Some scientists announced the creation of cybernetic teaching machines for schools. They emphasized that teachers would not be excluded from the pedagogical process by this action, only their function would be changed; they would work out the program for the machine. The main problem was the question of how far it will be possible to develop a self-thinking machine. Berg reported that cybernetic systems are succeeding primarily in industry, but that experiments are in progress in other technical as well as cultural areas to open further the gates of cybernetics' infinite possibilities. Berg spoke, for example, about various kinds of diagnostic equipment for doctors. The conflict between cyberneticists and a group of economists was shown, among other manifestations, by the fact that the latter, as Berg reported, boycotted this conference.

"Our conference was devoted to the philosophical problems of cybernetics, and these are also largely the problems of economists; but they did not appear at the conference."

Two Opposing Positions of Soviet Economists

The rapid progress of the Soviet cyberneticists plainly confirms that the newly-achieved breakthrough (literally, only in the last 24-26 months) cannot be suppressed. On the other hand, it would be a mistake not to recognize that the hard fight between the conservative school of economic theorists and experts, who undoubtedly have good connections with the heads of the party, and the cyberneticists is far from ended. The situation is made more complicated in that the well known economist S. Strumilin

has made himself the spokesman of the conservative group. However, the cyberneticists' arguments sound so convincing that even Strumilin's group dares not offer widespread resistance to the use of mathematical methods in economic theoretical and practical applications. In an interview by the Warsaw economic paper, Zycie Gospodarcze of June 3, 1962, a question about the prospects of using mathematical methods in the Soviet economy was answered by Strumilin:

I do not see any major possibilities for the use of mathematics in the economic sciences and in the practice of planning. There is a fundamental difference in kind between mathematics and economics. The laws of economics are connections of a qualitative character, while those of mathematics are quantitative connections.

Further:

Naturally, mathematics was useful in national economic accounting. Today, because we have access to computers, the possibilities are greater. But they do not extend beyond the scope of quantitative problem-solving: maxima and minima, etc.

This view is opposed by a strong movement supporting a much less limited use of mathematical methods in economics. The movement finds its main support in the large scientific centers, notably of Leningrad and Moscow. At Leningrad University there is the famous laboratory for economic calculations headed by Professor Novoshilov. There the defenders of mathematical economics methods have their traditions, established since the 1920's under Professor Kantorovich, who is currently in party disgrace. In Moscow, the mathematical faculty at the University is directed by Academician Professor Kolmogorov. The most prominent figure on this front, however, is Academician Professor Nemchinov. Scientific centers in Armenia, the Ukraine, and Byelorussia are trying to catch up with the others as fast as they can. Especially to be mentioned are the above-average accomplishments of the Byelorussian mathematicians at the Computing Center in Minsk. Mention

should also be made of the new Computing Center in Baku, the capital of the Azerbaijan Republic, which specializes in the application of mathematical methods to the petroleum industry. All indications are that the Siberian division of the Academy of Sciences in Novosibirsk will quickly rise in this field.

One could see from Strumilin's interview that his group wished to restrict mathematical methods to economic accounting. Strumilin touched on the essential point of the present discussion, the question of the relationship between mathematics and economics. While the conservative group speaks only of the quantitative character of mathematical problems, the cyberneticists and economic mathematicians also point out that the use of mathematics in economic theory, as well as in practice, automatically affects certain qualitative aspects of economic problems.

A discussion on this topic recently took place in Leningrad, in which many economic theorists, mathematicians, and also party representatives participated. Until now, the conclusions of this discussion have only partially been made known. The most important of these follow.

1. The economy of today has at its disposal such a great variety of new technical resources, that optimization of planning and a better direction of economic processes is possible with the help of mathematical methods and electronic computers.

2. In using these modern methods of planning and economic practice, the Soviet Union has assimilated much experience that confirms the great economic advantages of mathematical computations. The new development cannot be limited to certain specific fields; it encompasses the entire range of micro-economics and raises a whole series of questions that until now were tabu, either for political reasons or because of the backwardness of Soviet economic thinking.

For example, Professor Novoshilov introduced the concept of "marginal cost" into Soviet micro-economics, and the discussion of this problem can no longer be suppressed.

3. The question of necessary structural changes in the economic system came up in the Leningrad discussion. Some time ago (in 1957), the regional economic councils were created to deal with this problem; in Leningrad, however, it was readily agreed that this change did not fully take care of the latest requirements.*

It is interesting to note that the differences of opinion occurring in the Soviet Union are typical for the entire Eastern bloc. Similar opposing groups exist in Poland, Czechoslovakia, and East Germany. One of the main defenders of the modern viewpoint is the Polish professor, Oskar Lange.

Many cyberneticists in East Germany also uphold the modern viewpoint. In the German Magazine for Philosophy (No. 1, January-June 1962, published in East Berlin) an article appeared, entitled, "The Existence of Cybernetic Systems in Society." In this article, authors Georg Klaus and Rainer Thiel formulated perhaps the clearest statement of motive for the conservative group's opposition to mathematicians and cyberneticists:

The concern that cybernetics could make economics superfluous appears rather to be the concern that the progress of science could lead to certain inconveniences because new questions are raised....The cybernetic character of societal systems is therefore not a marginal historical appearance; rather, it is an integral part of the dialectical process of history.

*Those interested in reading further about these problems can find a very informative report in Zycie Gospodarcze, June 17, 1962.

The Present Problems of the Cyberneticists

Cyberneticists adhere primarily to the conclusions of the Twenty-second Congress of the CPSU and to the party's new program, which first emphasizes the new role of science, and second, underscores as the most important aim of Soviet economic policy the increased effectiveness of capital investment. These are the points about which mathematicians and cyberneticists, despite diverse resistance, can take continuous offensive. It used to be that the mathematicians' and cyberneticists' equipment was placed at the disposal of industry, regional economic councils, or government bureaus. Clients were supposed to come to the computing centers with a request for this or that problem to be solved. The use of mathematics was thought only to be an instrument, and mathematicians could not propose scientific improvement of a plan whose problems they were supposed to solve.

Despite the constraints imposed by this procedure, the arrangement had its usefulness. Utilization of mathematics as a means to the solution of various problems became widespread in the Soviet Union; and the conservative part of the bureaucracy welcomed this because it created no conflicts with the prevailing order. Every day, though, it became clearer that the problem of economic rationality would eventually allow the mathematician to come into his own.

The year 1962 stands out especially in this development. Voprosy Ekonomiki (No. 4, 1962) reported on a coordinating conference which took place in Moscow, November 28-30, 1961, on the utilization of mathematics in economics. In this report an interested reader can find a survey of those fields in which cyberneticists and mathematicians are involved in greater number. Pravda (June 4) published a summary of Moscow's experience in the use of electronic

computers in the manufacturing, construction, and transportation industries. This information is important since it provides a fairly exact picture from a small sampling of experience and takes into account the most modern viewpoint.

Moscow's regional economic council and the Laboratory for Management and Organization of Production at the Ordzhonikidze Engineering-Economic Institute have worked out a series of projects which pertain to the planning and guidance of industry. A special system to relay information directly from industries to accounting centers has been developed. It is expected that evaluation and interpretation of this information will lead to changes in the technique of economic guidance. In the present system, for example, an industry's statement must include the data of past statement periods in order to show plainly the curve of that industry's development. This step can be left out when electronic computers are used. The computer is capable of holding several years' facts in its "memory." Industries therefore need only to post data once a year. Meaningful changes can be expected in other areas also. Four or five days are now required for the classification of statistical data into specific groups; for analysis and generalization, up to ten days. Both jobs can be done by electronic computers in one day. Pravda tells of other changes in industry that are being brought about through the use of the most modern computing methods. For example, it is estimated that in Moscow alone the regional economic council administration for machine construction must perform 60 million operations to carry out all the calculations of the planned economic codes; for the whole regional economic council the number is 675 million operations, for which, without the help of machines, over 3.5 million man-hours are needed. All these operations can be accomplished in forty hours with the help of electronic computers.

Pravda reports that experience has shown electronic computers to be of great use in industry. Especially high savings were realized by electronically planning Moscow's truck transport of goods. At this time, over 3000 trucks are being regulated by these plans, and the savings are supposed to be in millions of rubles. Interesting experiments are being made to perfect a system of running trains by remote control. One experimental train, which ran 7000 km, is now ready for use in the Moscow metro. It has already carried about one million passengers. A second such train has also been assembled.

The salient point, expressed everywhere in the technical literature, is the lack of personnel for electronic computers, particularly specialists with acceptable qualifications.

It is significant of the present situation in the Soviet Union that the article in Pravda was written not by one but five authors--four scientists and a secretary of the CPSU City Committee in Moscow. This usually happens when the subject is a "hot potato," and a single author does not want to burn his fingers.

It is also important to remember that, even though in some cases the Soviets are able to produce the most modern computers, generally they are much poorer than their American counterparts. Bochkarev, the secretary of the CPSU City Committee in Moscow, wrote of this in the Ekonomicheskaya Gazeta of June 2, 1962. The backwardness of some Soviet computers affects their operative memory, the number of operations they are able to perform per second, and other technical details. The same source reports of the opposition aroused to plans for building cybernetic centers, mathematical laboratories, etc.

Closing Remarks

In the Soviet Union, cybernetics and mathematics appear to be institutions apart from ideology and, on the basis of the scientific and technical revolution, enable the rise of stronger and stronger demands to correct the Soviet system. What revolutionary features this development holds can be seen from a short comparison with the situation in the planning field three to five years ago, when it was still the exclusive domain of a group of planners and economic theorists.

While today's theorists must possess completely new technical knowledge, decisions are being taken away from them and largely given over to data processing systems. Naturally, electronic computers are not in a position to eliminate man completely; rather, in what is almost a dialectic process, the responsibility of man is being enormously increased. He is responsible for the data and input with which the machine is fed. The voluntarism of Stalin's time was a source of intermittent crises which could be eliminated by the introduction of slave labor and the exploitation of men. However, computers in the hands of voluntarists would mean nothing less than the complete breakdown of economic planning and of the economy itself.

Here lies the principal motive for the resistance of the Soviet bureaucracy's conservative element to cybernetics and mathematical methods. The bureaucratically deteriorated Soviet system offers only limited possibilities for the use of mathematical methods. These methods can, as Strumilin desires, help to improve economic accounting. That is not the meaning of scientific and technical development, however. The Communist bureaucracy is instinctively correct in perceiving that the epoch of cybernetics in the technical revolution is loosening its grip on the economy.

Chapter 3

"PROBLEMS IN CYBERNETICS," VOL. 5*

EDITORS' INTRODUCTION

Problems in Cybernetics (also translated as Problems of Cybernetics) is a collection of articles in the cybernetics field published more or less annually under the direction of the Scientific Advisory Group on Cybernetics of the Academy of Sciences, USSR. It is a good index of the more significant published works and the directions in which non-military cybernetics studies are being pushed in the Soviet Union.

The final chapter in each edition summarizes major conferences, meetings, and organizational developments in the USSR concerned with cybernetics and computer technology. Volume 5, published early in 1961, covers the period of the 1959-60 academic year. The Preface briefly points out the increasing importance of work in mathematical economics and biological problems, reflected in the introduction to the series of a separate section on mathematical economics, and inclusion of several long articles on biological applications.

Volume 5 tends towards a representative sampling of the various spheres in which cybernetics research activities are being applied. In the two succeeding volumes, the articles are more concentrated in a few areas, but present analyses and results of studies in greater detail.

In the following sections a translation of the Preface is given, together with a listing of the articles contained in the book. The two articles from the final chapter of the book are also included.

*Problemy Kibernetiki, Vyp. 5, A. A. Lyapunov, Ed., State Publishing House of Physio-Mathematical Literature, Moscow, 1961, 294 pp. Participating Editors: O. B. Lupanov, B. Yu. Pil'chak, Ya. I. Starobogatov, S. V. Yablonski, and Yu. I. Yanov.

Preface to "Problems in Cybernetics," Vol. 5*

The fifth volume of Problems in Cybernetics encompasses approximately the same areas as the earlier volumes. The section on mathematical economics, which at present is becoming very important, is new. A number of recently published monographs are devoted to problems in mathematical economics:

Barsov, A. S., "What is Linear Programming?" Moscow, Fizmatgiz, 1959;

Kantorovich, L. V., "An Economic Account of the Maximal Use of Resources," Moscow, Academy of Sciences, USSR, 1959;

"Linear Inequalities," a collection of articles edited by H. W. Kuhn and A. W. Tucker, with an appendix from the book by S. Vajda, Game Theory and Linear Programming, Moscow, Foreign Literature Publishing House, 1959;

"The Application of Linear Programming Abroad," a collection of articles edited by Academician V. S. Nemchinov, Moscow, Moscow State Economics Institute, 1959;

Charnes, A., Cooper, W., Henderson, A., "Introduction to Linear Programming," Moscow, Moscow State Economics Institute, 1960.

Studies on biological problems in cybernetics published in the present work are devoted to a clarification of control systems in higher forms of life. A study of the hierarchy of control processes in living organisms is of great interest. From this arises the important task of studying systems of interacting automata. Biology provides valuable materials in the search for clear formulations of such tasks.

The editor again urges readers to organize discussions of books pertaining to cybernetics.

The editor extends sincere gratitude to comrades

*The material in this chapter was translated from the Russian by A. S. Kozak, Roger Levien, and Barbara Scott, and edited by Wade B. Holland, from the book, Problems in Cybernetics, Vol. 5.

N. D. Vvedenskaya, T. L. Gavrilova, Yu. I. Zhuravlev, I. Kh. Zusman, T. G. Isaenko, N. A. Karpova, O. S. Kulagina, A. A. Muchnik, V. A. Semyachkin, and T. A. Trosman, for their valuable assistance in preparing the present volume for publication.

The All-Union Conference on Computing Mathematics
and Computing Technology

The All-Union Conference on Computing Mathematics and Computing Technology, organized by the Ministry of Higher Education of the USSR, and Moscow State University, was held November 16-21 [1959], in Moscow.

The following lectures were delivered at the plenary sessions:

S. L. Sobolev and L. A. Lyusternik, "Current Problems in Theoretical Computations."

M. R. Shura-Bura and A. P. Ershov, "The Current Status of Automatic Programming."

K. A. Rybnikov, "On a Plan for Preparing Specialists in Computing Mathematics."

V. A. Ditkin, K. A. Karpov, "On the Work of the Computing Center, Academy of Sciences, USSR, in the Computing and Publication of Mathematical Tables."

The following sections were active:

- 1) Numerical Methods Section, L. A. Lyusternik, corresponding-member, Academy of Sciences, USSR -- leader;
- 2) Programming Section, Professor M. R. Shura-Bura -- leader;
- 3) Applied Mathematics Section, A. N. Tikhonov, corresponding-member, Academy of Sciences, USSR -- leader;
- 4) Cybernetics and Mathematical Logic Section, Professor A. A. Lyapunov -- leader;
- 5) Computing Machinery Section, V. B. Ushakov, Doctor of Technical Sciences -- leader.

The present survey is devoted to the Cybernetics and Mathematical Logic Section. The work of the section was

broken down into subject areas. Inasmuch as research in the field of cybernetics is expanding on a broad front in our country, the results of work in many areas are included in the reports.

Academician A. I. Berg and Professor A. A. Lyapunov presented a report commissioned by the Council on Cybernetics, "On the Prospects of the Use of Computers by the State." The great streams of information passing through the machinery of the state and the necessity for effective administration to process this information in extremely short periods of time, has brought the question of automation at various levels in the government to a head. The problem is particularly applicable to planning bodies.

Plans must be prepared a year in advance so that they can be transmitted to local executors in time. But, at the same time, they must be based on production levels realistically achievable by the beginning of the period concerned in the plans. Thus, in order to attain optimum results, formulation of plans must be initiated as late as possible when actual results of the preceding period's plans are known. On the other hand, plans must be formulated in advance of the planned period. This leads to the necessity for widespread use of computers, which make possible the development of several plan variations and selection of the best one.

The report of N. P. Buslenko, "Solution of Problems on the Theory of Mass Supply Through Modeling on an Electronic Computer," was devoted to the Monte Carlo method as a means of solving problems of this nature, using the "Strela" computer. Random values are set by a special generator. The flow of demands is regarded as a stream of uniform events.

It was shown in the report that in principle, two systems of modeling production processes are possible. In one, the status of the entire system is determined at

definite intervals; in the other, the moments of substantial change in status are determined by the Monte Carlo method, taking into account the law of distribution, and the nature of change in the status is determined.

The speaker pointed out that in many cases of modeling complex production processes, the second method turns out to be remarkably more effective than the first.

V. K. Korobkov's report was concerned with a mathematical description of highway traffic control. Cross traffic control is considered in which the control follows definite rules for preventing accidents.

Some of the algorithms were given, together with evaluations of results. The working algorithm serves to minimize either the total delays for a vehicle or the average delay.

The report of M. L. Tsetlin was devoted to a new method for solving the transportation problem. Using topological characteristics of finite graphs, the speaker offered an algorithm for determining loading plans, optimum according to several parameters.

The evening meeting on November 17 was devoted to problems of mathematical linguistics and machine translation.

"Mathematical Problems in Linguistics and Machine Translation," L. A. Kaluzhin, O. S. Kulagina, and G. S. Tseitlin, discusses mathematical problems arising in connection with the use of speech information in machines (i.e., in the field of machine translation from one language to another, in information machines, etc.). Only mathematical theories connected with the complex phenomena of linguistic symbols and their relationships to each other, independent of what these symbols mean, are considered.

Language is regarded as a complex of sequences (sentences) of defined objects (words); this complex may be given either as a list of sentences or as a mechanism

producing them. Different colloquial languages, as well as the formal languages of science, are included in such a scheme. The question of constructing thus-defined languages and also the question of the adequacy of a different type model, are considered. In modeling, two approaches to languages are possible: the analytic, in which, according to a given complex of sentences, laws describing it are sought out; and the synthetic, in which some sort of mechanism for generating sentences is given and the question of the degree of approximation of the generated complex to the studied language is considered.

These approaches are closely connected with one another and the greatest success can be anticipated through the use of both types. In the report, several different models (Chomsky, Dobrushin, Kulagina, Andreev) were briefly described.

In the report of N. D. Andreev, V. V. Ivanov and I. A. Mel'chuk, "Linguistic Problems in Machine Translation," some theoretical conclusions and some aspirations with regard to machine translation were formulated. The authors of the report expressed regret about the fact that translation algorithms remain for the most part without practical realization. They consider that it is necessary to clearly separate the concrete definition of a scheme's algorithmic principle from the development of individual details connected with realizing the scheme.

In many current studies in machine translation, primary attention is narrowly centered on a so-called independent analysis of various languages; as regards independent synthesis, with the exception of some specific preliminary outlines, there has only been very general consideration. The major result has been an absence of realization of success.

The authors formulated the following tasks:

- 1) In the field of mathematics--to develop precise approaches to evaluation of quality and usefulness of linguistic algorithms.
- 2) In the field of technology--to develop high-speed, high-capacity memory units; to create automatic reading devices; and to create a sufficiently productive and highly effective interpretive machine.
- 3) In the field of linguistics--to work out a lucid system for describing language structures, formal methods for research into the meaning of text, and linguistic composition parameters which contain complete linguistic information about the text.

In the report by T. L. Gavrilova, "An Experiment in Structural Analysis of Language (Using Vietnamese as an Example)," an independent analysis for a limited part of the Vietnamese language was described.

This model of the Vietnamese language was constructed in the following manner: Vietnamese mathematics text of twenty-seven sentences was taken as a base. Guided by normal Vietnamese grammatical structures, elementary configurations were isolated, augmenting the set of sentences. The number of phrases thus obtained was taken as the number of sentences under consideration. Units of information were catalogued for this number of sentences, sentence-structure trees were constructed, and proceeding from them, a grammar of the language was constructed. The grammar was graphically presented.

The Vietnamese language is interesting in that it does not exhibit syntactical word change. Thus, the members of a word family coincide according to the type. On the other hand, hierarchies of configurations turn out to be not completely clear, since a class of hierarchies must be defined dissimilarly. This makes it necessary to work out additional codes for the explanation of a class of

configurations in a specific sentence.

The morning meeting of November 18 was devoted to the theory of systems of control. A report by O. B. Lupanov and S. V. Yablonski, "On Some Problems in the Theory of Control Systems," was presented, containing an account of results obtained during the period from May to November 1959, by a group of mathematicians associated with the A. V. Steklov Mathematics Institute, Academy of Sciences, USSR, and the Mechanico-Mathematics Faculty of Moscow State University.

Additionally, the following reports were presented:

E. I. Arin', G. F. Ivanova, A. A. Lorents, "On the Formation of Concepts by Automata."

E. I. Arin', Ya. Ya. Dambitis, M. A. Shneps, "On Self-Organizing Systems."

Yu. I. Zhuravlev read a report on transformations and simplifications in normal configurations. G. I. Kozhukhin spoke on a programming model of a self-instructing machine.

The evening meeting was devoted to biological problems in cybernetics. G. I. Polyakov delivered his report, "On Structural Connections Between Neurons," subtitled, "A Glance at the Cybernetics of the Future from the Viewpoint of the Neurologist." He indicated that the principle of analogy is not always applicable, since there are great discrepancies between a model and an actual system. Therefore, there is reason to be guided more by structures existing in living organisms.

The author presented some model representations of typical connections between effectors and receptors, making it possible to understand some of the problems therefrom.

The report by I. M. Gel'fand and M. L. Tsetlin, "A Mathematical Model of Heart Functions," contained some considerations resulting from a study of the nature of a model of the heart muscle. The model was of a continuous control system; i.e., a solid core of elements, having special characteristics. Among these characteristics is the

capacity for stimulation and the presence of a period of refraction between stimulations. It is assumed that the speed of reaction to the stimulation depends upon the interval of time between the individual stimuli. It is further assumed that the elements are capable of internal (spontaneous) activity. With the help of these assumptions, a model of a solid, homogeneous core, each point of which has memory and several other interesting characteristics, was described. In observing such a system, with a finite number of elements possessing memory characteristics, the authors succeeded in explaining a number of the more subtle effects obtained in the well known experiments of A. Rosenblueth.

A. A. Lyapunov and A. G. Malenkov analyzed definitions of basic concepts in genetics and applied rigorous new definitions to these concepts from a multiple-theory point of view. In a forthcoming volume in this series, an article will be published presenting the results of current work of the speakers.

At a joint meeting with the Programming Section, reports of interest to both sections were heard. A. P. Ershov, N. A. Krinitski, and R. I. Podlovchenko, presented the first review of basic trends in work in automatic programming in the Soviet Union. The report by Yu. A. Shreider was devoted to prospects in the development of logical circuits in electronic computers.

At one of the section's meetings, the ALGOL international algorithmic language project was discussed by A. P. Ershov.

The final meeting of the section was devoted to a consideration of some economic problems in cybernetics.

Below is a list of reports heard at the sessions of the Cybernetics and Mathematical Logic Section:

A. A. Lyapunov, "On the Prospects of the Use of Computers by the State."

- N. P. Buslenko, "Solution of Problems on the Theory of Mass Supply Through Modeling on an Electronic Computer."
- V. K. Korobkov, "On Some Mathematical Questions in Control of Highway Traffic."
- M. L. Tsetlin, "On the Transport Problem from the Standpoint of Graphs."
- L. A. Kaluzhnin, O. S. Kulagina, G. S. Tseitlin, "Mathematical Problems in Linguistics and Machine Translation."
- N. D. Andreev, V. V. Ivanov, I. A. Mel'chuk, "Linguistic Problems in Machine Translation."
- T. L. Gavrilova, "An Experiment in Structural Analysis of Language (Using Vietnamese as an Example)."
- O. B. Lupanov, S. V. Yablonski, "On Some Problems in the Theory of Control Systems."
- Yu. I. Zhuravlev, "On Simplification in Normal Configurations."
- E. I. Arin', G. F. Ivanova, A. A. Lorents, "On the Formation of Concepts by Automata."
- E. I. Arin', Ya. Ya. Dambitis, M. A. Shneps, "On Self-Organizing Systems."
- G. I. Kozhukhin, "A Programming Model of a Self-Instructing Machine."
- G. I. Polyakov, "On Structural Connections Between Neurons."
- I. M. Gel'fand, M. L. Tsetlin, "A Mathematical Model of Heart Functions."
- A. A. Lyapunov, A. G. Malenkov, "On Systematization of the Basic Concepts in Genetics."
- A. P. Ershov, N. A. Krinitski, R. I. Podlovchenko, "A Review of Work on Logic Circuitry Algorithms."
- Yu. A. Shreider, "On Prospects in the Development of Logical Circuits in Computers."
- A. P. Ershov, "On the ALGOL International Algorithmic Language Project."

V. P. Cherenin, "Details of a Plan for Forming up Railroad Trains Using an Electronic Computer."

Yu. A. Oleinik, "Computer Solution of the Problem of Formulating an Optimum Freight Transport Plan."

Z. V. Alferova, "Characteristics in Programming Economic Problems on an Electronic Computer."

N. G. Lebed', "The Construction of Algorithms for Problems of Supply in the National Economy."

The work of the section indicated that a large, ever increasing number of scientific groups is now studying cybernetics and that many significant scientific results are being obtained.

In conclusion, the section noted that cybernetics finds fruitful application in many facets of science and technology, economics, medicine, and linguists. At the same time, there is a marked disparity between the organization of work in the field of cybernetics, and the importance and actual scope of the work. There is no organized preparation of personnel for work in the area of cybernetics. The status of publication of scientific reports is unsatisfactory. The cybernetics section turned to the Council on Cybernetics with a request that problems be formulated, the resolution of which would make possible an expansion and official systematization of work in the field of cybernetics.

Cybernetics Seminar at Moscow University

During the 1959-60 academic year, the Cybernetics Seminar under the leadership of Professor A. A. Lyapunov continued at Moscow University. During the course of the year twelve meetings were conducted, at which the following reports were heard:

A. P. Ershov, "On the ALGOL International Programming Language Project," (October 23, and November 13, 1959).

A. A. Malinovski, "On the Possibility of a Structural Approach to Some Questions on the Higher Nervous System" (October 30, 1959).

A. A. Lyapunov, A. G. Malenkov, "A Logical Analysis of Concepts and Methods in Genetics" (November 27, and December 11, 1959). Submitted for publication in Problems in Cybernetics.

E. G. Gol'shtein, D. B. Yudin, "Linear Programming Problems and Methods" (material from a book being published) (December 18, 1959).

N. V. Timofeev-Resovski, "Darwinism and Cybernetics" (January 8, 1960).

I. Ya. Aksenov, O. S. Kulagina, A. D. Smirnov, "On the Conference on Information Processing" (Paris, 1959) (February 19, 1960).

E. I. Arin', "On Self-Instructing Machines" (March 11, 1960).

Yu. A. Shreider, "On Dynamic Programming" (March 4, 1960). See this volume, pp. 31-48.

S. M. Blinkov, "On the Structure of the Brain" (April 7, 1960).

A. N. Kolmogorov, "On the Spatial Distribution of One-Dimensional Complexes" (May 20, 1960).

During the 1959-60 academic year the Seminar on Mathematical Questions in Cybernetics also continued work under the leadership of S. V. Yablonski at Moscow University. During the course of the year 25 meetings were conducted at which the following reports were heard:

O. B. Lupanov, "On One Class of Functional Element Circuits" (October 2, 9, 16, 23, 30, 1959). Submitted for publication in Problems in Cybernetics.

M. L. Tsetlin, "Some Characteristics of Finite Graphs in Connection with the Transport Problem" (November 13 and 20, 1959). Academy of Sciences Report 129, No. 4, 1959, p. 747.

V. L. Murski, "On Equivalent Transformation in Contact Circuits" (November 27, and December 4, 1959). See this volume, pp. 61-76.

- V. B. Kudryavtsev, "Absolute Theorems for One Class of Automata Without Inverse Circuits" (December 11 and 18, 1959). Academy of Sciences Report 130, No. 6, 1960, p. 1189; and 132, No. 2, 1960, p. 272.
- B. Yu. Pil'chak, "On One Method of Synthesis of Switching Circuits" (February 19 and 26, 1960). Based on the article: [In English] Okada, S., "Topology Applied to Switching Circuits," Proc. Symp. Inform. Networks, April 1954, Polytechn. Inst. Brooklyn, pp. 267-290.
- Yu. I. Zhuravlev, "On Algorithms for Construction of Minimal Disjuncts in Normal Configurations" (March 4 and 11, 1960). Academy of Sciences Report 132, No. 2, 1960, p. 260; and 132, No. 3, 1960, p. 504.
- Yu. G. Potapov, S. V. Yablonski, "On Synthesizing Self-Adjusting Circuits" (March 18, 1960). Academy of Sciences Report 344, No. 3, 1960, p. 544.
- S. M. Fedotov, "On the Maximum Flow Through a Network" (March 25, 1960). Based on the article: [In English] Elias, P., Feinstein, A., Shannon, C. E., "A Note on the Maximum Flow Through a Network," Trans. IRE, IT-2, No. 4, 1959, pp. 117-119.
- E. Yu. Zakharova, "On a Generalization on Vacuum Tube Circuits" (April 1 and 8, 1960). Submitted for publication in Problems in Cybernetics.
- V. I. Reznik, "On Realizing Monotonous Functions Using Functional Element Circuits" (April 15, 1960). Submitted for publication in Academy of Sciences Report.
- M. N. Vaintsvaig, "On the Capacity of Functional Element Circuits" (April 22, 1960). Submitted for publication in Academy of Sciences Report.
- B. A. Subbotovskaya, "On a Comparison of Bases for the Use of Formulas in Realizing Algebraic Logic Functions" (April 29, May 6, 13, 20, 1960). Some results will be published in Academy of Sciences Report.

List of Articles

I. GENERAL QUESTIONS

- E. G. Belaga (Moscow)
On the Computation of the Values of Polynomials of
One Variable with Preliminary Treatment of the
Coefficients
- V. Ya. Pan (Moscow)
Some Schemes for Computing the Values of Polynomials
with Real Coefficients
- Yu. A. Shreider (Moscow)
The Problem of Dynamic Programming and Automata

II. CONTROL SYSTEMS

- E. I. Nechiporuk (Leningrad)
On Multiterminal Networks Realizing Many-Valued
Logical Functions
- V. L. Murski (Moscow)
On Equivalence Transformations in Contact Circuits
- N. V. Belyakin (Penza)
University Computers with Potentially Infinite External
Memory
- V. V. Martynyuk (Moscow)
The Relationship between the Memory and Some of the
Potentialities of Finite Automata
- L. G. Gindin (Moscow)
On the Control of Chemical Reactions

III. THE THEORY OF INFORMATION AND CODING

- N. B. Demidovich (Moscow)
Towards a Theory of Group Codes
- V. I. Levenshtein (Moscow)
Application of Hadamard Matrices to a Coding Problem

IV. PROGRAMMING

- Yu. I. Morozov (Moscow)
On Standard Programs

Yu. I. Morozov (Moscow), A. A. Petrov (Moscow)
A Compiler Programming System (PSK-1)

V. MATHEMATICAL ECONOMICS QUESTIONS

E. G. Gol'shtein (Moscow), D. B. Yudin (Moscow)
On One Class of National Economic Planning Problems

VI. PROCESSES OF CONTROL IN LIVING ORGANISMS

R. L. Berg (Leningrad), N. V. Timofeev-Resovski (Sverdlovsk)
On the Course of Genotype Evolution

V. P. Efroimson (Moscow)
A General Theory of Plant Immunity and Some Principles
of Radioactive Selection of Resistance to Infectious
Diseases

V. P. Efroimson (Moscow)
An Analysis of Carcinogenesis Controlling Mechanisms

VII. MATHEMATICAL LINGUISTICS QUESTIONS

G. V. Vakulovskaya (Moscow), O. S. Kulagina (Moscow)
On Machine Translation from French to Russian:
III. Program Description

T. M. Nikolaeva (Moscow)
Synthesis of Russian Word Forms in Machine Translation
into Russian

VIII. BRIEF ITEMS

I. S. Balakhovski (Moscow)
On the Possibility of Modeling the Simplest Behavioral
Acts by Discrete Homogeneous Media

Yu. V. Glebski (Gorky)
Feasible Sequences in Finite Automata

V. I. Mudrov (Kalinin)
Queues of "Impatient" Customers and Variable Service
Times, Linearly Dependent on the Length of Time
the Customer is in the Line

IX. REVIEWS AND BIBLIOGRAPHIES

P. P. Troyanski

"A Translating Machine," reviewed by T. N. Moloshnaya
and T. M. Nikolaeva

X. NOTICES

The All-Union Conference on Computing Mathematics and
Computing Technology

Cybernetics Seminar at Moscow University

Chapter 4

"PROBLEMS IN CYBERNETICS," VOL. 6*

EDITORS' INTRODUCTION

The sixth volume in the series, Problems in Cybernetics, covers work reported during 1960, and was published late in 1961. Its plan is the same as the preceding volumes, except that it contains no Preface. There is, however, a note from the editor stating that the series has now been more or less defined and will no longer carry a Preface, unless there is a special need for one.

It is interesting to note the number of articles in the area of cybernetics applications in biology and medicine, especially in regard to modeling of radioactivity and radiation sickness. Undoubtedly, the Conference on Biophysics during the summer of 1960 spurred increased attention in these areas, as reflected in Vol. 6. Also noteworthy, is the discrepancy between actual work reported which deals with problems of transportation and economics planning, and the amount of attention given these areas in general discussions of cybernetics and computer applications and prospects.

The organization of a cybernetics section at the Ukrainian Academy of Sciences, reported in Vol. 6, is a demonstration of the growing influence of and respect for cybernetics in the Soviet Union. Such formalization and channelization of cybernetics activities is apparently in response to the criticisms being levelled by both non-scientists and scientists. From the latter group has come a criticism that cyberneticists are too little concerned

*Problemy Kibernetiki, Vyp. 6, A. A. Lyapunov, Ed., State Publishing House of Physio-Mathematical Literature, Moscow, 1961, 302 pp. Participating Editors: V. S. Gurfinkel', O. S. Kulagina, V. I. Levenshtein, B. Yu. Pil'chak, Ya. I. Starobogatov, and S. V. Yablonski.

with practical applications, and are failing to provide for the training of second generation workers in the field. The section's purposes are to increase interaction between the cyberneticist and other disciplines, and to promote publicity and informational aspects of the science.

In the following sections translations of the two articles from the last chapter in the volume are presented, followed by a list of the papers contained in the book.

The Conference on Biophysics in Miassovo*

The second expanded conference of the Biophysics Laboratory of the Urals Branch of the Academy of Sciences' Institute of Biology, held July 13-17, 1960 at the "Miassovo" Biostation,** was devoted to several questions on biophysics. Seventy biologists, physicists, and mathematicians from Moscow, Leningrad, Sverdlovsk, and Novosibirsk participated in the proceedings of the conference.

The first group of papers was concerned with the problem of the interaction of ionizing radiations with living matter. The basic concepts and present understanding of the concept of "fallout" were characterized in the introductory paper by N. V. Timofeev-Resovski. New views on the origin of chromosomic mutations, developed from recent work at the Biophysics Laboratory, were summarized in a paper by N. V. Luchnik (Sverdlovsk). According to these views, in the majority of cases the passage of an ionized particle through a chromosome does not lead to its destruction, as believed earlier, but rather is only a source of potential damage, with the definite probability of its destruction resulting at some later time, the possibility of which can be influenced experimentally. The significance of new information on several problems of biophysical ionizing radiation was discussed in the paper. It was shown that the potential damage is realized during the process of transferring hereditary characteristics from the maternal cell to its daughter. In connection with this, a quantitative study of the activities of radiations in cytoheredity may help in studying internal cellular control systems.

*The material in this chapter was translated from the Russian by Wade B. Holland, from the book, Problems in Cybernetics, Vol. 6.

**Translator's Note--Miassovo is located in the Urals near Cheliabinsk.

Reports by Biophysics Laboratory staff members N. A. Izmozherov, N. A. Poryadkovaya, and L. S. Tsarapkin were devoted to a description of the latest experimental data on the effect on the origin of chromosome mutations of the degree of ploidy, the dampness of the irradiated sperm, and the various chemical substances. In all cases, the effect of the investigated factors is best explained from the standpoint of the potential damage hypothesis. In a series of cases, it was successfully shown that these factors have no effect on the appearance of initial damage, but strongly affect the probability of its [eventual] realization.

Yu. Ya. Kerkis (Novosibirsk) presented experimental data on the dependence of living organisms' radiosensitivity on their genetic nature. Guinea pigs of different genetic types (pigmented and albinos) displayed statistical differences in radiosensitivity. For example, half a lethal dose, while not noticeably affecting the pigmented pigs, doubled the frequency of chromosome reorganization in the albinos.

L. S. Tsarapkin reported on an experimentally established case of an increase in the degree of radioactive damage to chromosomes under the effects of EDTA (Ethylene Diamine Tetra Acetate). These results are in agreement with Mazio's hypothesis, in that EDTA while forming complex combinations with Ca and Mg ions, which participate in the formation of intergenal connections, weakens these connections.

V. I. Ivanov (Moscow) set forth the results achieved in an investigation of the effect of EDTA on the number of dominant lethals of a drosophila.

A world-wide survey of the literature on the question of the significance of linear density of ionization on the biological activity of radiations was reported by E. N. Sokurovaya (Moscow). O. V. Malinovski (Koltushi) reported

on the results of an investigation on the effect on radio-sensitivity of the number of chromosome sets of an organism. Polyploid yeast cultures possessed the greatest radio-resistance in comparison with haploid cultures.

M. I. Shal'movym (Moscow) researched unrestricted peroxides as sensitometers of chemical radiation reactions. Sodium persulphate and hydrogen peroxide increase radio-sensitivity of pyrimidine groups--low-molecular forerunners of nucleic acids. The reporter enumerated a series of assumptions regarding the sensitizing activity of the peroxide, after devoting himself principally to the possible role of chain reactions in this process.

A discussion of the question of energy migration was opened with a survey paper by N. V. Timofeev-Resovski, in which the basic ideas on energy migration in biological systems were presented. Specifically, the reporter showed that intensive investigation of an energy migration mechanism was of interest in that it may lead to an explanation for a great amount of accumulated data on the effects of various factors on the appearance of a radiobiological reaction. This, in turn, would have the purpose of defining methods which may be used to influence this reaction, with the future possibility of being able to predict it. The paper of G. G. Taluts (Sverdlovsk) discusses the role of "exitone" in an energy migration mechanism. A. Ya. Kalmanson (Moscow) reported on methods of investigating radiosensitivity of biopolymers using modern physical methods; specifically, a method of electronic paramagnetic resonance. A. G. Malenkov and Yu. F. Bogdanov (Moscow) stated in their paper the assumption that in a particular case, energy migration occurs not in the macromolecule, but in the structural water surrounding it.

Several papers were devoted to the problem of biological cybernetics. A. A. Lyapunov (Moscow), while offering stability and instability, homogeneity and

heterogeneity as the basic characteristics of a substance's condition, gave a definition of life from this standpoint. He raised the problem of studying systems of control at various levels, the presence of such control being one of the basic characteristics of life. A. Ya. Kalmanson stated the assumption that nucleic acids, thanks to their segneto-electrical properties, can play a decisive role in the memory mechanism of living organisms. R. L. Berg (Leningrad) in her report on an example of insect-pollinated plants, demonstrated the role of the stabilization of selection in the attainment of stability, as defined by separate tests. Variations in the sizes of the different parts of a plant (leaf, flower) are significantly greater than the variations in sizes of insects. However, in those cases where a relationship between the sizes of the various parts of the plant and of the insects is of vital importance biologically, it is shown that the variations in the sizes of the parts of the plant are equivalent to the variation of the sizes of the insects. This was observed, for example, with the flowers of several plants, which are pollinated strictly by established types of insects (the foxglove and bees). In the report of V. M. Eleonski (Sverdlovsk), observations were given on the role of noise (mutations) in the transmission of hereditary codes, and of the maximum attainable level of such noises.

Two reports were devoted to questions of genetics. R. L. Berg discussed an experimental study on the features of a spontaneous mutation process. In a paper by A. A. Lyapunov and A. G. Malenkov, an attempt to formalize the basic concepts of genetics through the creation of a system of strict definitions was presented.

In the last group of papers, the problem of auto-reproduction of elementary biological structures was presented. The present state-of-the-art was dealt with by A. N. Orlov (Sverdlovsk), who defined the basic steps in

the design of models of biological structures, with an indication of the various possible ways of solving the problem. M. V. Vol'kenshtein, O. B. Ptitsyn, and A. M. El'yashevich (Leningrad) presented the model which they designed for catalytic biosynthesis, including processes of originating mutations. In this model, a macromolecule of a catalyst is regarded as a cooperatively functioning system, consisting of separate cells, in which component parts of the synthesized molecule are consolidated. In this, the binding energy depends on the nature of the cell, the nature of the consolidating particle, and the nature of the composition of the neighboring cells. In such fashion, the molecules of the catalyst play the role of a matrix, in which the synthesized molecules are formed. The reporters pointed out the lack of correspondence between the thermodynamic models and the experimental cases, and the necessity of calculating the kinetic regularities in analyzing auto-reproduction. In the course of the discussion the requirement for computation in creating similar models of real material, acceptable to the biologist, was brought out.

The majority of the reports precipitated lively discussion, during which the many aspects of the problems being discussed were pointed out and detailed.

The participants in the conference exhibited a tendency to become very concerned with physio-chemical methods in biology and with the necessity for closer contacts between the biologist and representatives of other fields in the physical sciences. Organizing similar meetings is an important means of airing problems and discovering methods for solving them, and also for cooperation and coordination of research in the area of physico-chemical biology.

--E. A. Gileva, I. I. Poletaeva

The Kiev Cybernetics Section

In February and March, 1960, an initial group of staff members of the Computing Center of the Academy of Sciences, Ukrainian SSR, and the Institute of Automation of the State Planning Committee, Ukrainian SSR, started organizational work on the establishment of a section on cybernetics.

The cybernetics section was organized in April 1960 under the government's A. S. Popov Radio and Electronics Scientific-Technical Society and the Kiev Scientific-Technical Publicity House. The section's tasks are the organization of interdepartmental scientific research and study activities and the centralization of scientific publicity and information activities in cybernetics. Taking part in the work of the section are staff members from the majority of organizations and institutions in Kiev occupied with research in the area of cybernetics and its applications (The Computing Center, Academy of Sciences, Ukrainian SSR; The Institute of Mathematics, Academy of Sciences, Ukrainian SSR; The Institute of Automation of the State Planning Committee of the Ukrainian SSR; Kiev State University; The Institute of Electronics, Academy of Sciences, Ukrainian SSR; Kiev Polytechnic Institute; Kiev Pedagogical Institute; and others), and also those interested in cybernetic problems.

A Bureau of nine men, under the chairmanship of Prof. L. A. Kaluzhnin, heads up the section. The section carries out its work in close contact with the Commission on Cybernetics, under the Soviet for Automation of the Presidium of the Academy of Sciences, Ukrainian SSR, directed by Prof. V. M. Glushkov.

In accordance with its plan of activities, the section at its sessions in 1960 discussed the following problematic and informational reports:

1. "Cybernetics and Biology," B. V. Gnedenko, Academician, Academy of Sciences, Ukrainian SSR;
2. "The Development of Cybernetics at the Computing Center of the Academy of Sciences, Ukrainian SSR," V. M. Glushkov, Academician, Academy of Sciences, Ukrainian SSR;
3. "The Development of Mathematical Linguistics at the Computing Center of the Academy of Sciences, Ukrainian SSR, and Kiev State University," Prof. L. A. Kaluzhnin;
4. "Technical Cybernetics," Prof. A. G. Ivakhnenko;
5. "On the Principles of Designing Self-Organizing Systems," V. M. Glushkov, Academician, Academy of Sciences, Ukrainian SSR;
6. "Economic Cybernetics," V.S. Mikhalevich, Candidate in Physical Mathematical Sciences.

Two scientific seminars were set up: 1) "Some Questions on Cybernetics," in which questions relating to mathematical linguistics, self-organizing and self-regulating systems, the application of cybernetics in various branches of science and the national economy, and the construction of some specific automata were brought out; 2) "Mathematical Logic."

A study series of lectures was organized:

I. The Mathematical Cybernetics Staff

1. "Mathematical Logic," V. M. Glushkov, Academician, Academy of Sciences, Ukrainian SSR; and Prof. L. A. Kaluzhnin.
2. "The Theory of Probabilities, Mathematical Statistics, and the Theory of Information," B. V. Gnedenko, Academician, Academy of Sciences, Ukrainian SSR; Prof. I. I. Gikhman; and V. S. Korolyuk, Candidate in Physical Mathematical Sciences.
3. "Algorithms and Automatic Devices," V. M. Glushkov, Academician, Academy of Sciences, Ukrainian SSR.

4. "Linear and Dynamic Programming. The Theory of Research Operations," Prof. I. I. Gikhman; I. N. Kovalenko, Candidate in Physical Mathematical Sciences; and V. S. Mikhalevich, Candidate in Physical Mathematical Sciences.

II. Fundamental Organization of Digital Electronic Computers--G. A. Mikhailov, Candidate in Technical Sciences, and Z. L. Rabinovich, Candidate in Technical Sciences.

In addition, a study series, "Digital Electronic Computers and the Solution of Transportation Problems," is functioning, led by B. del Rio, Candidate in Technical Sciences.

Popular lectures for the public on cybernetics and its applications are being prepared and being delivered:

1. "Electronic Computers and Cybernetics," V. M. Glushkov, Academician, Academy of Sciences, Ukrainian SSR;
2. "Cybernetics and Language," Prof. L. A. Kaluzhnin;
3. "Cybernetics and Medicine," Prof. N. M. Amosov;
4. "Economic Cybernetics," V. S. Mikhalevich, Candidate in Physical Mathematical Sciences;
5. "The Application of Cybernetics to Railway Transportation," B. del Rio, Candidate in Technical Sciences;
6. "On the Construction of an Automatic Reading Device for a Computer," V. A. Kovalevski, Candidate in Technical Sciences;

and a series of other lectures on cybernetics is being prepared by graduate students, scientists, and engineers.

Students from other cities in the Soviet Union and from foreign countries are being attracted to the series of popular and informative lectures and reports. In 1960, the following lectures were presented:

1. "Error-Correcting Codes," (June 1960), R. L. Dobrushin (Moscow), Candidate in Physical Mathematical Sciences;

2. "Optimum Adaptive and Learning Systems," (June 1960), Prof. O. J. Smith (USA);

3. "Development of Optimum Systems with a Calculation of Practical Limitations," (June 1960), Prof. O. J. Smith (USA);

4. "Probability Analysis and Synthesis of Non-Linear Systems," (July 1960), Prof. N. Wiener (USA).

Work is being developed on the establishment of a catalogue of the literature in cybernetics, and a library is being organized, in which such items as scientific literature on cybernetics and its applications, and manuscripts (notes from lectures and reports, study lecture series, and also scientific seminars and conferences) will be included.

The establishment of communications and the institution of exchanges of printed material and reports with cybernetics sections in other cities of the Soviet Union is being planned. The possibility of, and the bases for the establishment of a Cybernetics Society in the Republic is being studied and prepared for.

--L. A. Kaluzhnin, A. A. Stogni

List of Articles

I. GENERAL QUESTIONS

O. B. Lupanov (Moscow)

On Realizing Algebraic Logic Functions with Formulas from Finite Classes (Formulas of Limited Depth)
Based on & [AND], \vee [OR], \neg [NOT]

II. PROGRAMMING

R. I. Podlovchenko (Yerevan)

Finding Proper Values for Matrices through a Method of Sequential Diagonalization on an Electronic Computer

V. A. Shurygin (Cheliabinsk), N. N. Yanenko (Cheliabinsk)

On Realizing Algebraic Differential Algorithms on an Electronic Computer

- V. V. Martynyuk (Moscow)
On a Method of Symbolic Addressing
- L. Kh. Vyazalov (Cheliabinsk), Yu. I. Morozov (Cheliabinsk)
A Standard Auxiliary Routine for Program Correction
(SPO-1)

III. COMPUTERS

- V. I. Sobel'man (Moscow)
On the Geometry of Wiring Ferrite Matrices

IV. MATHEMATICAL ECONOMICS QUESTIONS

- A. I. Berg (Moscow), A. I. Kitov (Moscow), A. A. Lyapunov
(Moscow)
On the Possibilities of the Automation of Control in
the National Economy

V. CONTROL PROCESSES IN LIVING ORGANISMS

- N. A. Bernshtein (Moscow)
Recurrent Problems in Physiological Activity
- V. P. Efroimson (Moscow)
Mechanisms for Controlling the Development of Anti-
bodies, Taking into Consideration the Subject's
Genetic Immunity and Anomalous Hemoglobin Biochemistry
- V. P. Efroimson (Moscow)
Radiation Sickness Control Mechanisms

VI. MATHEMATICAL LINGUISTICS QUESTIONS

- I. A. Mel'chuk (Moscow)
Morphological Analysis in Machine Translation (Pri-
marily on Material from the Russian Language)
- V. A. Matveenko (Moscow)
Towards a Definition of Verb Stems for Automatic
Analysis of Russian Language Text
- L. N. Iordanskaya (Moscow)
The Morphological Types of Stems in the Russian Language
(For Distinguishing Homonyms of Morphemes in a
Process of Machine Translation Analysis)

N. M. Grishchenko (Kiev)
Coding and Programming Features of an Algorithm for
Morphological Analysis of the Russian Language on
the "Kiev" Computer

VII. NOTICES

The Conference on Biophysics in Miassovo

The Kiev Cybernetics Section

Chapter 5

"PROBLEMS IN CYBERNETICS," VOL. 7*

EDITORS' INTRODUCTION

The most recent edition of Problems in Cybernetics is Vol. 7, published in early 1962 covering work reported during the 1960-61 academic year. It contains no articles on cybernetics work in biology and medicine, a subject of considerable interest in Vol. 6. Further, the section on mathematical economics contains only one short article, concerned with the use of linear programming in "calendar" problems in industry.

It should be pointed out, though, that the Cybernetics Seminar at Moscow University heard a number of articles on applications in medicine and biology. The symposium held in Kiev appears to have been largely devoted to complex information processing, and especially to recognition processes. The lists of reports heard at these conferences, some of which are abstracted in Vol. 7, are perhaps a better guide to current research trends than the articles presented in full in the collection itself.

Although a number of the abstracted articles presented at the Kiev Symposium would be of interest to researchers in the applicable fields in this country, we have been unable to obtain the full texts. Though it is stated that most of them have been published, it is possible that as yet they have only been submitted for publication. Quite often reports so mentioned are carried in the next volume of Problems in Cybernetics.

The four articles from the last chapter in the book have been translated in the following sections. Also included is the list of articles in Vol. 7.

* Problemy Kibernetiki, Vyp. 7, A. A. Lyapunov, Ed., State Publishing House of Physio-Mathematical Literature, Moscow, 1962, 235 pp. Participating Editors: N. A. Karpova, V. I. Levenshtein, B. Yu. Pil'chak, and S. V. Yablonski.

Symposium on "Principles of Formulating a
Self-Organizing System," Kiev*

The symposium was organized by the Computing Center, Academy of Sciences, Ukrainian Soviet Socialist Republic, and the Ukrainian Government's A. S. Popov Radio Technology and Electro-communications Scientific-Technical Society. The symposium was held May 5-9, 1961; participating were specialists from scientific institutes in Kiev, Moscow, Leningrad, Tbilisi, Penza, and other cities. At the conference a series of scientific reports was heard, as annotated in the listing below. In addition, two meetings of the symposium were devoted to a discussion on the subject, "Principles of Formulating Organizing, Self-Organizing, and Self-Generating Systems." The texts of the majority of the papers read at the symposium have been published.

Resume of Papers

1. M. M. Bongard, Recognition Modeling on a Computer.

The paper was devoted to a description of a program which teaches recognition of tables of numbers constructed according to various rules. In the teaching process, the program selects "indicators" of identical characteristics in tables constructed according to the same rule. Recognition is obtained by assigning characteristics to an unknown table and comparing the input characteristics with data stored in the memory.

2. V. I. Varshavski, T. I. Semenova, A Learning Program for Discernment of Configurations.

3. V. M. Glushkov, V. A. Kovalevski, V. I. Rybak, On One Algorithm for Teaching Recognition of Shapes.

*The material in this chapter was translated from the Russian by Wade B. Holland, from the book, Problems in Cybernetics, Vol. 7.

The report contains a description of a problem to teach a computer representations of some simple geometric figures, independent of their dimensions and arrangements. Experiments were conducted on the "Kiev" computer, for which a special automatic reading device was used.

4. V. M. Glushkov, A. A. Stogni, N. M. Grishchenko, On One Algorithm for Teaching Recognition of Meaningful Sentences.

In the report an algorithm is described for teaching recognition of meaningful sentences made up of given standard input words in the Russian language, according to a fixed format. Running this algorithm on a "Kiev" computer showed that the algorithm, after randomly processing a mass of selected meaningful sentences and establishing paired connections between initial input words, may in all probability establish meaningful sentences not encountered before. With an increase in the quantity of processed sentences, the probability of incorrect answers and the average sentence processing time may be reduced. Variants on self-teaching and on being taught by a teacher are examined.

5. A. G. Ivakhnenko, Inductive and Deductive Methods of Reasoning as Bases for Creating Two Basic Types of Learning Systems.

6. G. K. Krug, Machine Learning with Program Control Extrapolation.

A formulation-type learning machine is described, which has collation, appraising, processing, and storage of current information, and output of summary recommendations concerning better (in several senses) controlling of the processes. It possesses capability for extrapolating (extending) recommendations concerning control influences into control parameter areas which have not been yet encountered.

7. O. S. Kulagina, On the Use of Machines for Composing Algorithms for Text Analysis.

A general problem is presented in the report; text--analyzed by a person to show the connection between words--and a type of analysis algorithm are given to a machine; the machine must formulate the given analysis algorithm so that applying it to the same text will give the connections between the words contained in the input text.

In the report is described the specified analysis algorithm, giving for a number of words connections which differed (errors). An error-correcting chain (learning) gradually complicates the formulated analysis algorithm. The experimental results are applied to an analysis algorithm for texts in the areas of mathematics and physics, and in the Russian, French, German, and Arabic languages.

8. A. I. Kukhtenko, On Self-Organizing Control Systems.

9. A. A. Letichevski, A. A. Dorodnitsyna, Modeling Natural Selection.

Experiments with a program which models the development of behavior by means of natural selection (evolution) in some systems are described. Such phenomena as the reproduction of objects (with mutations) and survival of those more adaptable to changing conditions of environment are modeled.

10. E. K. Letski, A Tabular-Type Learning Machine.

11. A. A. Lyapunov, Yu. Yu. Finkel'shtein, On the Formation of Behavior in a Group of Automatic Machines.

In the report are examined the characteristics of several economic production models, supplied with an evaluation function. Several general theorems are reported.

12. M. L. Tsetlin, On the Behavior of a Finite Automatic Machine in Uncertain Situations.

The report is devoted to a study of behavior of a

finite machine in situations encountered by chance in the course of its runs.

13. P. I. Chinaev, Self-Learning--One of the Basic Means of Development of Self-Regulating Systems.

The report contains a survey of several characteristics and principles of construction of self-organizing and self-regulating systems.

14. V. K. Chichinadze, On the Possibilities of Machine-Orienting Processes for Synthesizing Corrective Devices for Self-Regulating Systems.

The report is devoted to a survey of works on machine-oriented processes of synthesizing systems, developed at the Institute of Electronics, Automation, and Telemechanics, Academy of Sciences, Georgian SSR. A unit from operational amplifiers which model Ashby's homeostat is used. The system was used for solving several linear and nonlinear problems of synthesizing automatic control systems.

Seminar on Cybernetics at Moscow State University

During the 1960-61 academic year, the seminar on cybernetics under the direction of A. A. Lyapunov continued its work at Moscow State University. During the course of the year, thirteen sessions were conducted, at which the following reports were presented:

A. A. Lyapunov, On Several Features of Control Processes in the Animal World, (September 30, 1960).

L. A. Blyumenfel'd, On Magnetic and Electrical Characteristics of Major Biopolymers, (October 14, 1960).

N. M. Emanuel', Free Radicals and Inhibitors of Free Radical Processes in Experimental Biology, (October 28, 1960).

L. V. Chkhaidze, On Modeling Coordination of a Person's Arbitrary Movements, (November 18, 1960).

F. Ya. Vetukhnovski, R. E. Krichevski, A Theory of

Graphs and Its Application. Paper from the book: Berge, C., Theorie des graphes et ses applications, Paris, Dunod, 1958. (December 2, 1960.)

E. V. Glivenko, Quantitative Estimate of Electroencephaloscopic Data (Resemblances of Biopotentials), (December 16, 1960).

N. V. Timofeev-Resovski, The Biosphere and Evolution, (January 6, 1961).

M. M. Bongard, On the "Useful Information" Concept, (February 17, 1961). Submitted for publication in the volume, Problems in Cybernetics.

R. Kh. Zaripov, On an Algorithmic Description of the Processes of Composing Music, (March 3, 1961). See this volume.

O. S. Kulagina, Using a Computer in Compiling Text Analysis Algorithms, (March 17, 1961). See this volume.

M. M. Bongard, Modeling the Recognition Processes, (March 31, 1961). See Biophysics Journal 6, No. 2, 1961.

V. K. Chichinadze, On Homeostasis and Several of its Technical Applications, (April 14, 1961).

I. M. Gel'fand, V. S. Gurfinkel', M. L. Tsetlin, On Tactics of Controlling Complicated Systems, (May 12, 1961).

In the 1960-61 academic year work also progressed in the Seminar on Mathematical Questions in Cybernetics, under the direction of S. V. Yablonski. During the year 25 sessions were held, at which the following reports were heard:

V. I. Levenshtein, On the Construction of Maximal Codes. Paper from the article: Bose, R. C. and Ray-Chaudhuri, D. K., "On a class of error correcting binary group codes," Information and Control, 3, No. 1, 1960, 68-79. (October 7 and 14, 1960.)

N. I. Glebov, On Displaying Operators from Storage and Equivalence in a Category's Subquantities, (October

21 and 28, and November 4, 1960). Submitted for publication in the volume, Problems in Cybernetics.

O. B. Lupanov, On the Principle of Local Coding and Finding Separate Function Classes Using Diagrams of Functional Elements, (November 11, 18, 25, 1960). See Academy of Sciences Report 140, No. 2, 1961, 322.

V. K. Titov, On the Indivisibility of Graphs and Networks, (December 2 and 9, 1960).

Yu. Yu. Finkel'shtein, On an Economics Model, (December 16, 1960). See this volume.

O. B. Lupanov, On Finding Algebraic Logic Functions with Formulas of Limited Depth Based on \vee [OR], & [AND], \neg [NOT], (February 10, 1961). See Problems in Cybernetics, Vol. 6, 1961, 5-14.

M. L. Tsetlin, On the Behavior of Finite Automatic Machines in Uncertain Situations, (February 17 and 24, 1961). Academy of Sciences Report 139, No. 4, 1961, 830.

V. I. Levenshtein, On Several Characteristics of Coded Systems, (March 3 and 10, 1961). Academy of Science Report 140, No. 6, 1961, 1274.

V. I. Varshavski, Synthesis of Diagrams of Threshold Elements, (March 17, 1961). Academy of Sciences Report 139, No. 5, 1961, 1071; 139, No. 6, 1961, 1325.

A. D. Talantsev, On an Algebraic System Reflecting Periodic Regularity in the Behavior of Several Objects, (March 24, 1961). Academy of Sciences Report 139, No. 6, 1961, 1332.

Yu. I. Zhuravlev, Simplification of Normal Forms and Related Questions, (March 31, 1961). Academy of Sciences Report 139, No. 6, 1961, 1329.

S. V. Yablonski, On Functional Systems with Operations, (April 7, 1961).

V. I. Levenshtein, On Simplicity and Lag in Decoding, (April 14, 1961).

Aizerman, M. A.; Gusev, L. A.; Rozonoer, L. I.; Smirnova,

I. M.; Tal', A. A., On the Algorithmic Insolubles in a Problem of Presentation of Recursive Events to Finite Automatic Machines, (April 21, 1961). Automation and Telemechanics 22, No. 6, 1961, 748.

O. P. Kuznetsov, On Asynchronous Logical Nets, (April 28, 1961). See Problems in Information Transmission, Vol. 9, 1961, 103.

Yu. L. Vasil'ev, Several Appraisals of Complexity of Normal Forms (Survey Report), (May 5, 1961).

S. M. Shvartin, On Highway Transportation with a Calculation of Losses, (May 12, 1961). Academy of Sciences Report 141, No. 6, 1961, 1325.

Lectures on Cybernetics at the Moscow Mathematics Society
and at the Methodological Seminar of the
Mechanico-Mathematics Faculty at Moscow State University

During the 1960-61 academic year a series of reports on questions concerning cybernetics was presented at the sessions of the Moscow Mathematics Society and the Methodological Seminar of the Mechanico-Mathematics Faculty at Moscow State University:

A. A. Lyapunov, A Survey of Works on Programming, (November 15, 1960).

N. I. Glebov, On Synthesizing Operators, (November 15, 1960).

A. P. Ershov, On Programming Languages, (November 15, 1960).

Yu. A. Shreider, Developing Logically Structured Contemporary Digital Computers, (December 22, 1960).

Yu. I. Zhuravlev, Several Algebraic Logic Problems and Their Relation to Problems of Mass Supply, (December 22, 1960).

A. A. Markov, What is Cybernetics?, (February 21, 1961).

R. L. Dobrushin, The Theory of Optimum Coding of Information, (March 29, 1961).

A. N. Kolmogorov, What is Information?, (April 4, 1961).

A. N. Kolmogorov, Automatic Machines and Life, (April 6, 1961).

A. N. Kolmogorov, Appraisals of the Difficulty in Defining and Calculating Finite Sequential and Digital Functions, (May 16, 1961).

L. V. Kantorovich, Mathematical Methods in Economics, (May 25, 1961).

Seminar on the Use of
Mathematical Methods in New Technologies for the
Industrial-Technical Scientific Research Institute
(City of Gorky)

At the end of September 1960, a seminar on the use of mathematical methods in new technologies was organized at the Industrial-Technical Scientific Research Institute. The seminar addresses itself to the problems of studying specialized areas of mathematics (the theory of algorithms, linear and dynamic programming, game theory, econometrics, and others) with the aim of making clear the possibilities for their uses in industry in the Gorky economic region.

The following reports have been presented at the seminar recently:

1. A. I. Seleznev, On Approximation Tables.
2. L. B. Belyakova, On Coding Components of a Plane.
3. O. M. Orekhova, On Linear Programming.
4. D. K. Lipatov, Several New Coding Methods.
5. V. N. Ivanova, On Practical Application of the A. M. Gil'man Coding Method.
6. A. V. Shubin, A Symbolic Method of Notation of Information on Engineering Blueprints.

7. A. I. Seleznev, A Determination of Bar Dimensions for a Given Assortment of Blanks with a Calculation of Complexity.

8. N. V. Gurenko, On a Method of Solving L. V. Kantorovich Factors.

9. A. A. Shapchenko, On the Problems of Operational Calendar Planning.

10. A. I. Seleznev, On Polynomial Approximation of Tables.

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List of Articles

I. GENERAL QUESTIONS

N. N. Vorob'ev (Leningrad)
Strategy Breakdown in Position Games

V. Ya. Pan (Moscow)
On Several Methods of Computing the Values of Polynomials

M. E. Tylkin (Moscow)
On the Development of Distance Matrices in Isolated Cubes

II. THE THEORY OF CONTROL SYSTEMS

E. Yu. Zakharova (Moscow)
On a Generalization on Vacuum Tube Circuits

O. B. Lupanov (Moscow)
On One Class of Functional Element Circuits (Partial Memory Formulas)

E. I. Nechiporuk (Leningrad)
The Boolean Function with Inversion of Arguments

III. THE THEORY OF INFORMATION AND CODING

Yu. V. Glebski (Gorky)
Coding with the Help of Automata with Finite Internal Memory

IV. PROGRAMMING

- R. Kh. Zaripov (Moscow)
On the Programming of a Process for Composing Music
- R. I. Podlovchenko (Yerevan)
On Converting and Applying Flowcharts to Programming
- A. A. Stogni (Kiev)
The Solution on an Electronic Digital Computer of a
Problem in Differentiation
.

V. MATHEMATICAL ECONOMICS QUESTIONS

- A. L. Lur'e (Moscow)
On Several Problems of Calendar Planning

VI. MATHEMATICAL LINGUISTICS QUESTIONS

- O. S. Kulagina (Moscow)
On the Use of a Computer in the Compiling of Text
Analysis Algorithms
- T. I. Korovina (Moscow)
Formulation of Rules for Distinguishing Homonyms with
the Help of a Computer

VII. BRIEF ITEMS

- S. V. Yablonski (Moscow)
On the Question of the Length Bound of Impasse Dis-
junctive Normal Forms

VIII. NOTICES

Symposium on "Principles of Formulating a Self-Organizing
System," Kiev

Seminar on Cybernetics at Moscow State University

Lectures on Cybernetics at the Moscow Mathematics Society
and at the Methodological Seminar of the Mechanico-
Mathematics Faculty at Moscow State University

Seminar on the Use of Mathematical Methods in New Technologies for the Industrial-Technical Scientific Research Institute (City of Gorky)

Chapter 6

"COMPUTING TECHNOLOGY"*

EDITORS' INTRODUCTION

"Computing Technology" is the fifth chapter of the book, Achievements in the Field of Technological Progress in the USSR, published in 1961. The book is a collection of articles surveying levels of technological development in many areas of the Soviet economy. In Chap. 5, Professor V. I. Kuznetsov, Doctor in the Technological Sciences, provides a general view of the areas in which computers and cybernetics are being applied, and summarizes hardware developments.

Oriented towards the non-technician, the article opens with an examination of computer design and construction, using actual machines to illustrate the various types of computers, their design principles, and the uses of computing machinery. Computer applications in the fields of national economic planning, the ferrous metal industry, and transport are analyzed, presenting both present uses in these areas and prospects for increased levels of automation.

The article makes little mention of the potentialities which can be realized by the use of computers in such areas of research as medicine, biology, linguistics, mathematics, etc. In this respect, the article adheres to a long-standing pattern for reviews of this type; i.e., only most immediately realizable and recognizable computer applications are discussed. It has long been suspected that cybernetics research efforts in the Soviet Union are

*Kuznetsov, V. I., "Vychislitel'naya Tekhnika" [Computing Technology], Dostizheniya v Oblasti Tekhnicheskogo Progressa v SSSR [Achievements in the Field of Technological Progress in the USSR], All-Union Educational-Pedagogical Publishing House (Proftekhizdat), Moscow, 1961.

usually tied to practical applications; pure or abstract research is usually hidden behind what we would call commercial research efforts, in areas such as industrial applications, statistical analyses, etc. As has been pointed out before, though, judging from the technical articles being published in the Soviet Union, the effort in these "practical" areas is not as great as would be indicated by the survey literature.

Following is a translation of the complete article, together with pictures of the "Strela," "Ural," and "BESM" computers, which are discussed in the section on computers.

Computing Technology*

The necessity of carrying out large-scale computational operations for the solution of modern technological problems has led to the creation of electronic digital computers.

The 20th Congress of the Communist Party of the Soviet Union pointed out the need "to augment work on the design and construction of automatic high-speed digital computers for the solution of complex mathematical problems, and computers for the automatic control of industrial processes." The usefulness of these computers is by no means limited to one area of application. They can also be used for the solution of various logical problems. More precisely, computers can be an auxiliary device to the human intellect. In many cases they can perform certain functions of the human thinking process. In particular, computers are applicable to problems of industrial control.

The solution of such important contemporary problems as the computations for an atomic reactor, the determination of the trajectories of research satellites and space rockets, and many other problems which require the completion of tens or even hundreds of millions of operations within a short period of time, is made considerably easier by means of electronic digital computers.

The computer can complete a task when it is written in a form compatible with the program stored in the computer. When a task is fed to the computer and correspondingly recorded in a memory unit, it can be completed rapidly and accurately.

*This material is a translation from the Russian by Andrew Kozak, edited by Willis H. Ware, of the article "Computing Technology."

Digital computers are designed to free man of the enormous amount of exhausting work that his mind must accomplish. On the other hand, an unlimited field of activity on such problems as the control of various branches of the national economy, industry, and planning is thrown open to computer technology.

Doubtless, in these areas computer technology can and must render valuable assistance to man; herein lies the contribution of computer technology to future progress.

Computer technology is of great significance for complex automation in industrial processes.

I. Electronic Computers

Modern technology finds itself in a stage of development where every analysis, every new and more complete investigation of complex phenomena, and important engineering calculations require labor-consuming mathematical investigations and computation.

A modern automatic digital computer can provide: (a) accuracy of calculation to a millionth of one per cent, (b) rapid operation on decimal numbers, and (c) completion of several thousand operations per second.

The construction of automatic devices has led to the replacement of physical, as well as certain aspects of mental labor. This branch of technology is connected with the application of various electronic computing and control devices.

A modern electronic mathematical computer contains thousands of miniature and long-life electronic tubes, crystal electronic amplifiers and rectifiers,* cathode-ray tubes, and other elements necessary for "remembering"; i.e., for recording in one form or another a task and the

*Editor's Note--Transistors and diodes.

results of intermediate computations. All these components are grouped into a single mechanism.

Electronic digital computers are in operation at the present time. They are divided into two classes according to type of action: parallel-action computers and serial-action computers. In parallel-action computers a positional principle for representing a number is used, while arithmetic operations are carried out simultaneously on all digits. In serial-action computers numbers are represented by a time sequence of impulses, and arithmetic operations are carried out sequentially, digit by digit.

From experience in the operation of digital computers, it is possible to draw the following conclusions:

1. A serial-action digital computer of adequate computational speed can be constructed with a minimum amount of equipment. Such computers, which satisfy the requirements of scientific-research institutions and experimental design organizations, can be constructed through the efforts of a small group of engineers and assemblers (7-8 men).
2. Digital computers with a minimal set of commands make it possible to simplify programming and to construct the simplest computer circuits.
3. A two-address system of coding provides convenience in programming and is most economical from the point of view of using the components of the computer.
4. The application of direct coupling between units makes it possible to construct circuitry most economically, eliminating superfluous units.

The M-2 digital computer, containing 1700 electronic tubes, has a speed of 2000 operations per second on decimal numbers. The "Strela" digital computer, which operates at approximately the same speed, contains 6000 electronic tubes (Fig. 1), and has a speed of 2000 operations per second. In 1957 the "Strela" completed 17,899,200,000 operations.

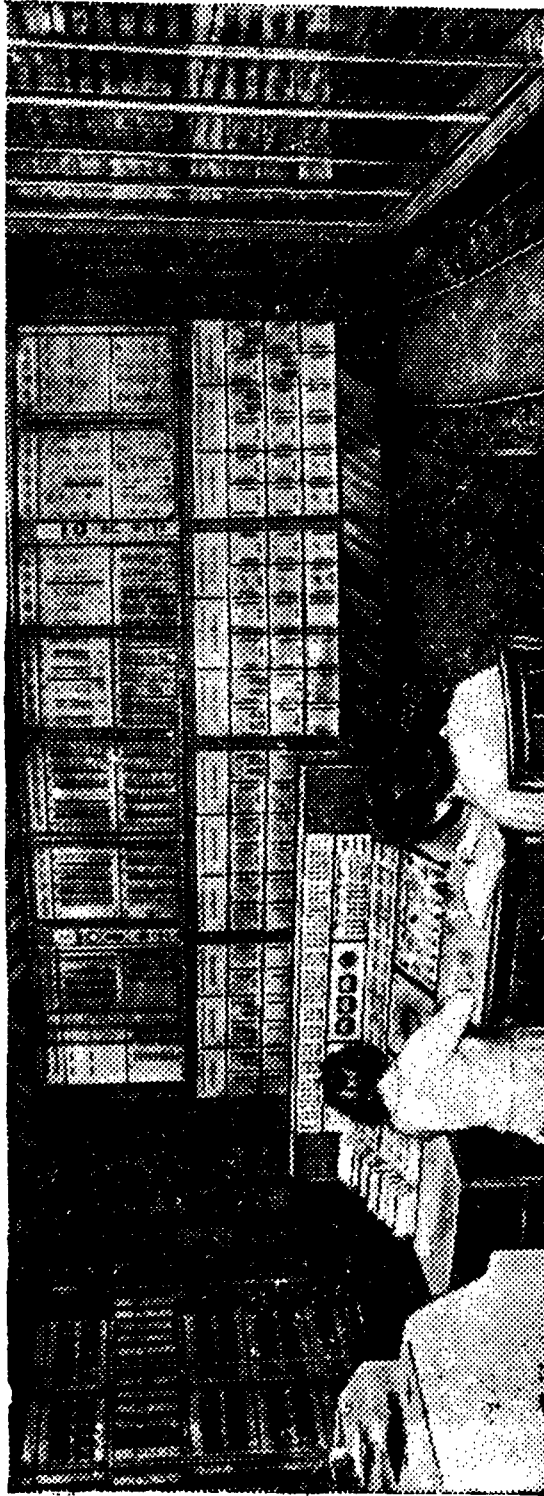


Fig. 1—The "Strela" electronic calculating machine

The M-2 occupies 22 square meters, and is serviced by one engineer. It does not have a separate transformer substation, a complicated cooling system, or a dehumidifier; it is ten times cheaper to produce, requires 7-8 times less electrical power, and contains four times fewer electronic tubes than the "Strela"; and its operating expenses are tens of times cheaper.

Such results were achieved by extensive use of semiconductors instead of electronic tubes. The memory unit of the M-2, using cathode-ray tubes, is one of the most technically complicated of the computer's components.

The first small-scale computer, the M-3, was recently built. It has 780 tubes, 3000 semiconductors, and occupies an area of less than 30-40 square meters. The M-3 has a speed of 30 operations per second. However, even at this speed it outputs far more work in eight hours than 200 operators armed with modern electrical calculators. The M-3 is simple to operate, and is designed for planning organizations, scientific-research institutes, and higher educational institutions.

The M-3 serves very well as a basis for experimental work in the design of specialized computers for the control of industrial processes. It is composed of three cabinets connected by removable cables, and therefore can be set up in any location.

Small-scale analog computers are of great interest. They make possible investigation of various systems of automatic control and the solution of complex problems in mathematical physics at amazing speeds. This computer has a set of nonlinear blocks which considerably broadens its mathematical possibilities, and a display which makes it possible to observe the graphical solution of a problem on a cathode-ray tube. It has a computing unit which enables it to select rapidly the most productive operating conditions for processing items on lathes, drill presses,

and milling machines, and to compute the time required for their processing.

The "Ural" electronic digital computer has been built. It contains 800 tubes and 3000 germanium diodes, requires 8 kw of power, and occupies 40 square meters. The "Ural" can complete 100 operations per second on numbers containing 35 binary digits (Fig. 2).

The storage units include a magnetic drum of 102^4 cells and a magnetic tape with a capacity of up to 40,000 cells. Printing of results, derived at a rate of 100,000 computations per minute, is done on a paper tape.

The BESM Soviet computer (a high-speed digital computer) completes 8000-10,000 operations per second, accomplishes addition in three microseconds, and multiplies in 192 microseconds (Fig. 3). It can calculate the trajectory of a missile faster than the missile itself travels. The computer has 5000 electronic tubes with a life of more than 10,000 hours; it requires an area of about 150 square meters, and up to 100 kw of power.

In order to produce a map from data of a geographical survey of an area, it is necessary to solve a system of algebraic equations containing up to 800 unknowns, and to complete more than 250 million arithmetic actions. For a man to solve a system of equations with more than 20 unknowns is practically impossible, because of the labor and protraction of the process, whereas such a task can be completed in 20 hours on the BESM.

In several days, the BESM computed, for the International Astronomy Calendar, the orbits of nearly 700 asteroids within the solar system, taking into account the influence of Jupiter and Saturn. Their coordinates were determined, and where they will be located, at 40-day intervals, for the next ten years. Earlier such calculations required many months of work by a large-scale computation bureau.

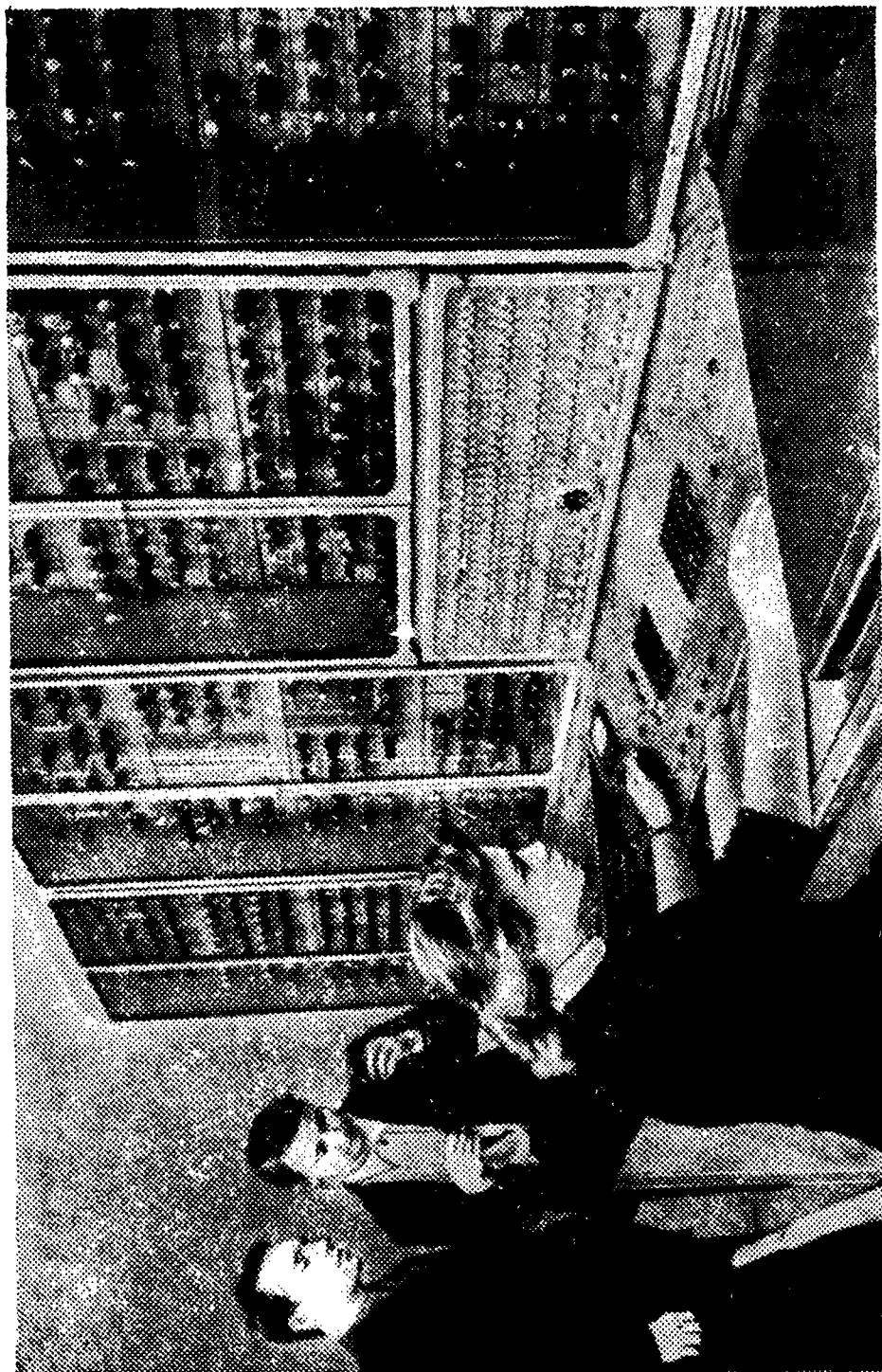


Fig. 2—The "Ural" electronic computer

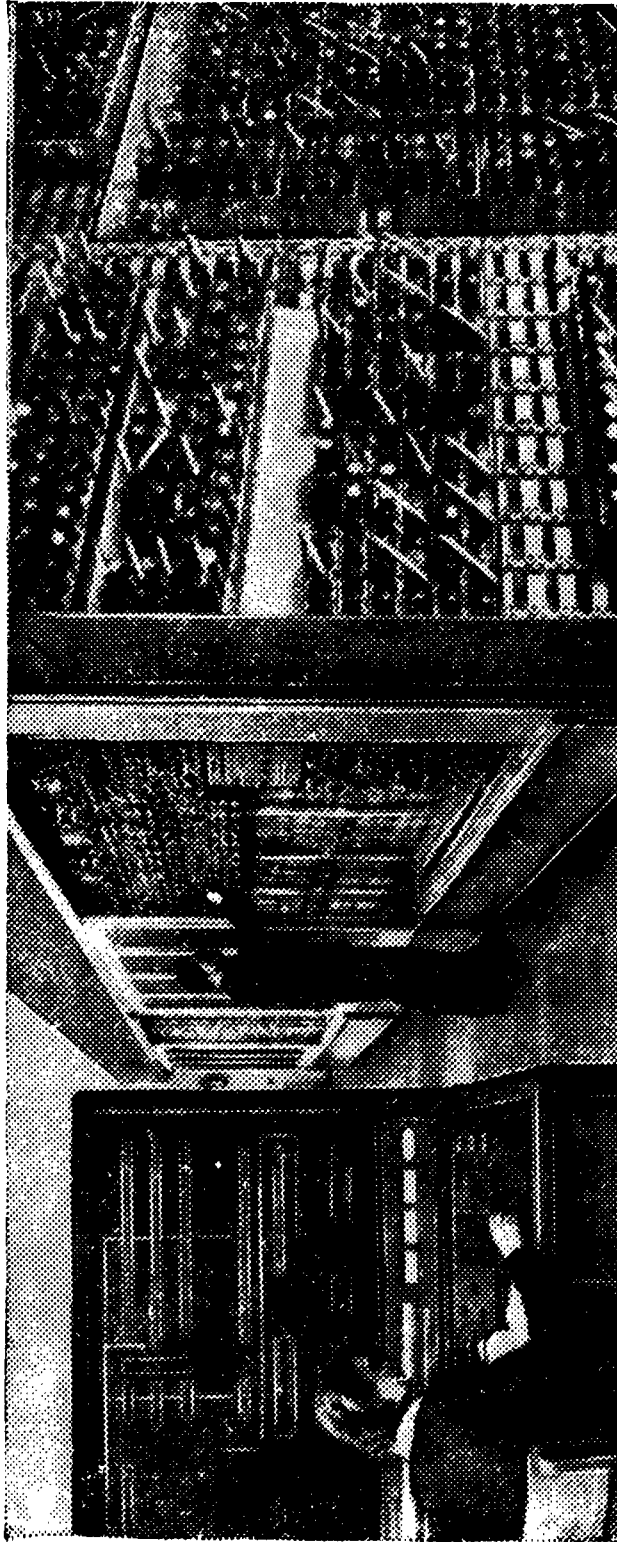


Fig. 3—The "BESM" high-speed computer

Instead of several decades, the BESM in one hour composed a table of integrals into which 50,000 values were entered. It calculated tables for the determination of contour lines of the most important channel slopes, which, because of a sharp decrease in the volume of work, led to a substantial saving of materials in hydrotechnical construction. Prior to the solution of this problem by the BESM, all attempts to compose similar tables even for one variable were not successful despite the fact that fifteen calculating machines were used for a number of months. The BESM, however, completed all these calculations for ten variables in less than three hours.

A high-speed digital computer, the BESM-2, has been built recently. It is a modification of the BESM-1 and is more convenient to operate. Furthermore, in addition to structural design, it differs from the BESM-1 in that it has twice the operational memory capacity.

The operational memory* of the BESM-2 has a capacity of 2048 numbers. Recording and retrieving a number requires ten microseconds. Ferrite cores are used in the memory unit.

The external memory of the BESM-2 consists of two magnetic drums and eight magnetic tape recorders. The drum capacity is 10,240 numbers. Up to 800 numbers can be recorded onto each drum per second. The capacity of the magnetic tapes is about 120,000 numbers.

It is important to note that this branch of industry is developing rapidly. For example, there is a computer capable of completing 30,000 logical operations, 8400 add operations, or 1200 multiply operations per second; It can "remember" eight million facts related to 150,000 names of items and equipment. The computer can insert daily 37,500 changes into a collection of data and

*Editor's Note--Primary or core storage.

incorporate these changes in its computations.

Two digital computers, the "Pogoda" and the "Kristall,"* have been turned out. The first of these is designed for the weather forecasting bureau, where it must provide rapid processing of information coming from meteorological stations. Thus, it permits release of sufficiently precise weather forecasts in good time.

Using the common electro-mechanical calculator for preparing a short-term weather forecast requires several weeks, which reduces the value of the forecast to zero. However, an electronic computing device can forecast weather in several minutes.

The "Kristall" is designed for carrying out labor-consuming computational operations connected with the processing of data from x-ray analyses of the structure of crystals.

The construction of a computer with an operating speed of 100,000, or even of up to one million operations per second, is entirely practicable.

These computers are destined for surveys and content analyses of scientific and technical literature accumulated by man over many years in various fields of knowledge. The development of science demands the formulation of high-speed computer techniques for processing the contents of the world's stock of scientific literature, and for selecting relevant material. The solution of this problem, through the use of information machines, will make possible an orderly and thorough use of the enormous potential riches accumulated by human genius in printed works, thus, increasing considerably the productivity of mental work.

For the recording and preservation of information, another long-life, high-speed computer "memory"--a permanent

*Translator's Note--"POGODA" in Russian means "weather," and "KRISTALL," is the Russian word for "crystal."

capacity memory unit--was created.*

This "memory" has no mechanical moving parts. Therefore, for an unlimited time (decades) and at very great speeds (one million "pages" per hour), it can reproduce written material in the form of electrical signals.

The recording and reading of information is carried out with a binary coding system.

Future technological perfection in the design of control computers depends considerably upon the perfection of high-quality semiconductors, and also upon scientific research in physics and mathematics.

In the near future small electronic mathematical computers will come into use. Small computers will find broad application in all branches of industry, in scientific-research institutes, in industrial laboratories, and in higher educational institutions.

II. The Application of Computers in Planning The National Economy

Guiding a socialistic national economy requires giving consideration to the interaction of a multitude of factors. In view of an enormously widespread industrial capability and the evolving economic intercomplexity of new enterprises scattered over the territory of the USSR, it is possible to accurately plan and keep accounts and analyses of economic activities only if the planning and guiding organs are fully informed of the behavior of the widespread socialistic production complex in all its fundamental aspects. To gather pieces of data, to process them, separating out the significant variables, and to act in accordance with the facts is an exceptionally difficult task. And it is becoming even more complicated, because as the

*Editor's Note--Probably the capacitance memory developed by L. I. Gutenmakher at the Laboratory for Electro-Modeling.

national economy grows, the stream of necessary information--no matter if the bookkeeping processes are shortened--unavoidably increases.

The most complex problem is that of working out a plan for the development of the national economy. The plan drawn up must be the most optimal of the many possible variants; to do this it is necessary to consider a great number of plans and subsequently to produce a set of computations. All of this work must be carried out in a limited amount of time. The planning points are determined by the output of goods intended for consumption and for inventory, or as they are otherwise called, the final products.

In order to provide an output of final products--let us say of automobiles, combines, machine tools, etc.--it is necessary to acquire a precise amount of raw materials. It is necessary to determine all direct and indirect expenditures of materials in the production of any kind of manufactured article. Thus, for example, all the expenditures of fuel in the production of a combine include not only fuel expended in the foundry and forging sections, but also fuel which is used in the metallurgy sections for smelting the metal from which the combine is made; in the electric power stations for producing current which is fed to the combine factory and the metallurgy sections; and in the mine pit, which supplies the production sections with raw materials and materiel for the combine factory.

Likewise, if we are to consider the total expenditure of metal and other materials, it is necessary to manufacture the necessary equipment for the production of the prototype of the combine.

By means of measuring total expenditures, it is possible to establish at which stage in the production schedule all components of the national economy must be, in order to obtain final products for consumption and

inventory. And this, incidentally, is also one of the factors in the composition of a balanced national economic plan.

Under the modern division of labor and industrial specialization, goods and machines are rarely encountered whose production in one way or another is not interdependent. Therefore, the computation of expenditures requires an enormous quantity of calculations.

If, for example, we reduce all the products being turned out in the national economy to 1000 basic items, then for the computation of the total expenditures for their production several billions of computational operations will be required. Thousands of skilled calculator operators would have to work ten years to solve this problem. It is clear that after such a lengthy period, their work would have lost all practical meaning. At present, only an estimate is provided for complete expenditures, which makes the composition of a completely balanced plan difficult.

Electronic computers offer remarkable possibilities in this area. Even a computer of average speed can solve the problem of computing total expenditures for 1000 manufactured items in two to three weeks.

At present, the methods for calculating total expenditures are being perfected on electronic computers, and methods for computing economically well-founded values are being worked out. Experimental calculations of tables of total expenditures containing 15, 17, and 44 fundamental products were carried out on the M-2. Hundreds of thousands and even millions of computations required for the calculation of these tables were performed by the computer using a stored program, and were automatically printed in several hours. Thus, computers are making it possible to automatically carry out economic planning, using as the base a projected output of final products.

Computers can also carry out other very important calculations for planning. In particular, we refer to the computation of tables of interregional activities, providing a most effective industrial cooperation between the national economic councils and between the republics of the Union, and calculations of the economic effectiveness of capital investments, etc.

Through the use of electronic computers it should be possible to solve a whole series of the most important economic problems, those which cannot generally be adequately dealt with by present means such as desk calculators and punched-card calculators.

III. The Use of Computers in the Ferrous Metal Industry

Recently computers have been applied with increasing frequency in the production of cast iron, steel, and sheet metal. A computer supplied with a definite program with which to observe operations is connected with blast furnaces controlled by a skilled crew. The computer is fed information on all processes flowing into the ovens; i.e., information on all technical difficulties, as well as on the activities of the controlling crews. Besides this, several prepared programs exist in the computer by means of which it may direct the operation of the furnaces; however, a number of program parameters are undetermined. Taking into account the extensive work period of the crew, the computer determines the missing parameters and introduces them into the program. In the course of several months of operation under such conditions, the computer has assumed all control functions of the blast process without intervention by the crew.

This type of automation of production control has great prospects. In this connection it is conceivable that, by means of a planned program, a computer will

control production and will be capable of taking into account the accumulated production experience of humans to a considerable extent. It is not difficult to design a modified computer which will take into account the experience of a number of different crews.

IV. The Application of Computer Technology in Transport

Computer technology will be of considerable importance to transport since there are enormous possibilities for the application of computers and automation. In one year transport industry handles about five billion tons of industrial and farm products. About 12.5 billion rubles per year are spent for their transportation. Each small economy in transportation saves the government enormous resources. Automation and computer technology will contribute to this economy.

Computers and control devices are called upon to automate the following processes in transport: transportation planning; transportation control; technology for operating such transportation agencies as stations, depots, factories, and ports; computational operations; bookkeeping accounts; etc.

For comprehensive state planning of transportation, computers will be applied first to the problems of distributing the workload among the various transportation facilities; such problems require a huge calculating facility using ordinary methods. It is necessary to take into consideration not only every transportation medium's load level and net cost of carting, but also its traffic capacity. Because of the complexity of the solution, this task is carried out periodically for only individual areas and separate classes of cargo.

In order to show the labor consumption involved in this kind of work, we cite a calculation. Imagine that in

a country there are 100 departure points and 100 destinations for freight; there are, thus, 10,000 possible transportation schedules for each type of cargo. If we include a network of railroads, the number of possible schedules reaches astounding figures. To single out from these figures the most logical connections and then to select the best one can be done only by means of modern computer technology.

The problem of planning motor vehicle transportation is equally complicated. Let us assume that in a region or city there are 20 cartage concerns servicing 100 departure points and 100 destination points. How does one determine routes in order to use the trucks optimally with respect to freight-carrying capacity and time, to reducing the empty runs to zero, and to providing a low net cost for transport? Only with the aid of modern computer technology is it possible to solve such a problem.

Thanks to the electronic analytic computer, it is possible to select the most advantageous network timetable for the movement of trains and vessels, one which provides the greatest speeds on both local and express runs and the greatest average number of daily runs. Labor-consuming calculations such as these are necessary for the compilation of plans for scheduling trains and boats to make optimal use of technical equipment and of stations and ports, and also for the development of operational standards.

Computers will play an especially important role in the automation of the operational control of transportation as a single entity. At present, railroad traffic control, even at the divisional level, is extremely labor-consuming. For the entire railroad operation, the labor of such a calculation increases several times, and for a nation-wide network of railroads, it attains enormous proportions. The complexity of railroad traffic control is caused by the massiveness and variety of the transportation modes

(passenger cars, locomotives, and freight cars); by the great variety in freight and types of hauling; by the multiplicity of dispatchers and recipients; and by the great number of origination and destination stations.

All of these factors bring about an enormous number of combinations for arranging--in a railroad network--trains, locomotives, cars, which are continuously on the move. If we also add seasonal fluctuations, then one can imagine how complicated it is to control traffic.

Today, transportation is controlled from offices, along the routes, at the divisional level, by the steamship lines, and at other levels by many workers engaged in computations, analyses, and in preparation of control measures. In addition, advanced control can be achieved only on the basis of preliminary information concerning the prospective arrival of cargo or freight cars at one or another station, division, or line.

In order to prepare a traffic schedule under today's rapid transport speeds for several days in advance, it is necessary to take into account several thousand kilometers of traffic at a center. Only digital computers can solve this problem.

A schedule of expected freight traffic and future operations composed by an electronic computer can be used independently for freight control, and, in addition, can be used both for informing freight recipients concerning the time of arrival, and for correlating operations of motor, water, pipeline, and air transport services, and for the operational coordination of different modes of transport.

However, for a greater degree of automation in operational control, the traffic schedule becomes only a basis for working out the necessary analyses. Having established a schedule of future operations for a network center, a computer will, depending upon its capacity and

type, aid in selecting the most effective complex of control measures with respect to the data at hand.

Communication will be of great significance for a scheduling system. A new system of automatic high-speed communication which transmits data directly to the computer must be developed.

Automation in the transportation of industrial products is a special application of modern methods in computer technology.

Experiments on the "auto-pilot" are being concluded. This device, provided with a program for guiding a train, automatically decreases and increases speed at corresponding points along its route, continually selecting the most advantageous speed, and stops the train at the required points.

An experimental test of a system which completely automates freight-car sorting is being made. The use of such a system will make it possible to dispense not only with brakemen but also with operators. Of course, engineers will not be able to fully automate the coupling maneuver for many years. Because of this, we must retain in the sorting yard many brakemen whose main function is to correct deceleration errors made by the operators.

Only high-speed electronic computers, on the basis of automatic input of information on speed, can determine the resistance of each coupling, instantly solve the complex equations, and provide each brake with the necessary braking adjustment. The new system will make possible automatic and precise determination of coupling movements, to bring cars to a halt without visual monitoring, and avoid dangerous collisions with cars standing in the path.

The effect of the automation of the sorting processes will be extremely important, since expenditures for the retention of the labor force and for the operation of locomotives for stopping cars will be decreased.

Modern computer technology makes possible most effective control of the continuously moving freight of the national economy.

Chapter 7

BRIEF ITEMS

EDITORS' INTRODUCTION

A short article published in a Czech journal* in 1962 concerns two research efforts in cybernetics at the Computing Center of the Ukrainian Academy of Sciences in Kiev. It deals very briefly with the application of a programmed control mechanism in machine tool production, giving only the principle upon which such devices are based.

The second part of the article describes the "Bio-electric Stimulator," an apparatus used in the "healing of the human organism."

*"Programmed Control of Machine Tools and Programmed Control of the Healing Processes in the Human Organism," Veda, Technika Mladezi, No. 12; translated from the Czech.

Programmed Control of Machine Tools and
Programmed Control of the Healing Processes
in the Human Organism

A very interesting "bioelectric stimulator," used for the programmed control of machine tools, was constructed in the Biocybernetic Division of the Computing Center of the Ukrainian Soviet Republic Academy of Sciences at Kiev. We will briefly report on the programmed control of machine tools based on the "record, play-back" principle, and then go on to the programmed control of the healing of the human organism.

Programmed control of any machine tool is based on a program which is stored on magnetic tape or punched cards.

The "Record, Play-Back" System

In the traditional use of machine tools, the operator prepares the machine, model, spindle speeds, etc., mounts the material to be worked on, and starts the machine. When the part is completed he removes it and mounts a new piece of material. In the "record, play-back" system, all of these steps are taken only with the first item; the operator then "teaches" the tool how to do it. The movements of all machine parts and the actions of the operator are recorded on magnetic tape; all additional items are produced automatically according to the program stored on the magnetic tape.

The Bioelectric Stimulator

The designers of this interesting apparatus are engineer Viktor Kij and Dr. Georg Kolesnikov. Mr. Kij, being familiar with the programmed control of machine tools, has applied this procedure to the healing of human organisms.

This is a very absorbing and original idea, which meets the basic concept of Cybernetics.

It is generally known that the Italian doctor and scientist Luigi Galvani (1737-1798) discovered galvanic electricity in frogs' legs. This electricity originates in the brain. This discovery made possible the construction of artificial biohands and biolegs and, recently, of the "bioelectric stimulator," which is based on the principle of programmed control of machine tools.

The designers recorded the bioelectric impulses on magnetic tape in the form of electric impulses. A magnetic recording unit is required for this purpose which accepts and records the electric impulses as in machine tool control. Once the bioimpulses of a healthy person are recorded they can be used for the healing of sick persons. All that is necessary is equipment to apply the bioimpulses to the sick person. In this way paralysis can be cured. For example, the bioelectricity of the big peripheral nerve of a healthy person is recorded and then applied at the same spot to a sick person. Only at the onset of paralysis can it be cured, not after muscles have atrophied. Bioelectricity of a healthy person can help to cure paralysis of hand or leg; for instance, where the pulsation of the nerves is revived, there is the resumption of heart activity, breathing, regulation of the heartbeat, and so on. When the problem of chemical reactions in the body is sufficiently known, rejuvenation of the organism will also be possible.

The bioelectro-stimulator has already been tested in the Institute for Infectious Diseases in Kiev, and a patent granted to the inventors.

A report was given about the invention at the Symposium for Biology and Physiology in Tbilisi in 1961, and also at the meeting of the Biological Department of the Academy of Sciences of the Soviet Union in Moscow on April 5, 1962.

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