ARPA ORDER NO.: 189-1

R-909-ARPA

December 1971

Soviet Cybernetics Research: A Preliminary Study of Organizations and Personalities

Simon Kassel

A Report prepared for

ADVANCED RESEARCH PROJECTS AGENCY

Rand
SANTA MONICA, CA. 90406

This research is supported by the Advanced Research Projects Agency under Contract No. DAHC15 67 C 0141. Views or conclusions contained in this study should not be interpreted as representing the official opinion or policy of Rand or of ARPA.

ARPA ORDER NO.: 189-1

R-909-ARPA

December 1971

Soviet Cybernetics Research: A Preliminary Study of Organizations and Personalities

Simon Kassel

A Report prepared for

ADVANCED RESEARCH PROJECTS AGENCY

Rand
SANTA MONICA, CA 90406

Bibliographies of Selected Rand Publications

Rand maintains a number of special subject bibliographies containing abstracts of Rand publications in fields of wide current interest. The following bibliographies are available upon request:

Aerodynamics • Arms Control • Civil Defense
Communication Satellites • Communication Systems
Communist China • Computer Simulation • Computing Technology
Decisionmaking • Game Theory • Maintenance
Middle East • Policy Sciences • Program Budgeting
SIMSCRIPT and Its Applications • Southeast Asia
Space Technology and Planning • Statistics • Systems Analysis
USSR/East Europe • Weapon Systems Acquisition
Weather Forecasting and Control

To obtain copies of these bibliographies, and to receive information on how to obtain copies of individual publications, write to: Communications Department, Rand, 1700 Main Street, Santa Monica, California 90406.

Published by The Rand Corporation

PREFACE

This Report was prepared as the first part of a preliminary study of Soviet cybernetics and deals specifically with the past and current activities of two of the pertinent Soviet organizations and their personalities. This preliminary study, designed to give an overall broad outline of these activities, is a prerequisite for subsequent studies concerned with analyses of specific theories, systems, or devices generated by Soviet cybernetics, and ultimately with the significance of cybernetics in Soviet society.

A detailed picture of this area is necessary because cybernetics as a subject of study is not only difficult to define, but its definition differs in the United States and the Soviet Union.

This Report has been submitted to the original sponsor in preliminary form and is being published now for wider distribution under the auspices of the Advanced Research Projects Agency.

Information in this Report should be of interest to those agencies concerned with cybernetics development, and with the gathering and interpreting of data on the development of the Soviet economy.

SUMMARY

Soviet scientific authorities recognize cybernetics as a legitimate branch of science and technology, a distinct target for research and development planning, and a major element of the scientific-industrial complex of the Soviet Union. Furthermore, cybernetics is regarded as one of the principal stimulants of Soviet economy in the same sense as electric power has been regarded ever since the revolution, and chemistry is regarded now. The significance of cybernetics in the Soviet Union is brought out with particular force by the fact that the Academy of Sciences, USSR, has for a number of years classified cybernetics as one of the four major divisions of science and technology, the other three being the physico-technical and mathematical sciences, chemico-technical and biological sciences, and social sciences (see Section III of this Report). This treatment of cybernetics within the hierarchy of a national research and development effort is without precedent in the world. It also justifies looking at Soviet cybernetics as perhaps the most important general R&D progress indicator and, as such, a prime target for a comprehensive analysis of Soviet science and technology.

The first two of the three sections of this Report provide detailed coverage of two research and development institutes: The Institute of Automation and Remote Control (Technical Cybernetics); and the Central Mathematical Economics Institute. The two institutes play major roles in the Soviet cybernetics effort but differ considerably in their subject areas, functions, and effectiveness.

The first institute is mainly concerned with the design and construction of industrial automation systems and hardware; the second was conceived with the idea of developing and realizing a general theory of automating the national economy. Both illustrate the current state of affairs in Soviet cybernetics, viz., the apparent failure, at least for the present, of the grand design that would impose a unified automated management on the national economy, reaching from the top down to the smallest enterprise; and the evident success of the more pragmatic approach of building automation systems at the level of the individual industrial units.

The success is a qualified one. The considerable momentum of research and development effort built up by the Institute of Automation and Remote Control does not appear to be spent appreciably among the industries reflected in open-source publications. Although the rate at which the Institute's research is being applied to industry is quite high, the areas covered are very spotty, suggesting that military applications may be a major target of its work. In fact, the shift of emphasis away from economic cybernetics to industrial management and process control is what one would expect in a military-oriented economy.

The position of the two institutes within the Soviet cybernetics community is illustrated by material in Section III, which presents the cybernetics achievement reviews by the Academy of Sciences, USSR. This Section gives an overall view--in the cybernetics area--of the year-to-year activities, projects, and organizations that are subject to the jurisdiction of the Academy.

Because of its preliminary nature, this Report cannot provide definite answers to the major questions regarding Soviet cybernetics. The Report does provide, however, a direct access to the material necessary for formulating comprehensive answers to some questions.

In particular the following activities of the Institute of Automation and Remote Control merit further exploration by in-depth studies:

- Theory of adaptive systems
- Theory of learning automata
- Automatic pulse-type systems for radar control
- Aircraft landing systems
- Pneumatic computer systems
- Complex analog control systems
- Pattern recognition research

Although the work of the Institute of Automation and Remote Control reflects a large share of Soviet cybernetics activities, it is by no means the only important organization in this field. The Academy of Sciences, USSR, reports regularly on the work of over 60 research and development institutes that are engaged fully or partially in work on cybernetics. The following organizations merit a detailed coverage similar to that given to the two institutes included in this Report:

- Institute of Cybernetics, Academy of Sciences, Ukrainian SSR
- Scientific Council on Cybernetics, the Presidium, Academy of Sciences, USSR
- Institute of Mathematics, Siberian Department, Academy of Sciences, USSR
- Institute of Mathematics and Computer Technology, Academy of Sciences, USSR
- Institute of Information Transmission Problems, Academy of Sciences, USSR
- Institute of Cybernetics, Academy of Sciences, USSR
- Institute of Technical Cybernetics, Academy of Sciences, Byelorussian SSR
- Institute of Automation and Electrometry, Siberian Department, Academy of Sciences, USSR
- Institute of Precision Mechanics and Computer Engineering, Academy of Sciences, USSR
- Steklov Institute of Mathematics, Academy of Sciences, USSR

The above list of organizations is not exhaustive; however, it serves to define the subject area for the next stage of the study of Soviet cybernetics.

CONTENTS

I. INSTITUTE OF AUTOMATION AND REMOTE CONTROL

FOREWORD

The material in this Section attempts to trace the development of the Institute during the period from the late forties to 1969, primarily in terms of describing the research and development projects handled by the Institute and the professional staff responsible for their implementation. Since no formal table of organization of the Institute is known to the author and very few explicit attributions of individual projects to specific persons have been published in the Soviet literature, the necessary correlation between the topics of research and the personnel was largely drawn from the large authorship data pool in the scientific and technical literature. The material was obtained from: (1) official Soviet reviews of activity of the Institute, (2) annual reports of the Academy of Sciences, USSR, (3) the *Soviet Cybernetics Review*, a Rand Corporation publication, and (4) the technical literature as reflected in the computer printout cards of certain projects. The most extensive official Soviet reviews were published in 1964 on the 25th anniversary of the Institute.[801-804*] These provided a wealth of information not normally available in the scientific and technical literature and were widely utilized in this report for the period up to 1964. The annual reports of the Academy of Sciences, USSR, were scanned for the years 1964-1969; the *Soviet Cybernetics Review* covers generally material from 1966 to the present; and Project Have-Check contains a portion of the available literature from the mid-fifties to the early sixties, provides a fairly comprehensive coverage from that time to late 1968, and attenuates considerably in 1969.

In the preparation of this Report a considerable effort was made to compare and correlate the data provided by the various source types. In particular, statements on the mission and descriptions of individual aims and projects made by officials of the Institute were used as an

---

*References are listed in numerical order, starting on p. 147 of Appendix A.

aid in topical structuring of the input. The resulting subject-classification of the work of the Institute is fairly clear and distinct, and while it may not necessarily correspond to the official organizational structure, it does present a detailed picture of the scope of activities and the distribution of skills and operational responsibilities of the members. These are the major aspects of information one would expect from a detailed table of organization. The topical structure of the Institute adapted for this Report is essentially that provided in the 1964 reviews, with modification mainly due to post-1964 events.

The narrative body of Section I consists of 15 subsections arranged under three headings dealing with theory, systems and units design, and industrial applications. The text of each subsection is followed by a list of names under the general heading "Authors Activity Structure." This reflects the attempt to identify and outline the specialized groups of authors pertinent to the subsection. Each such group may be regarded as a team dealing with a narrowly defined subject subordinate to that of the subsection. The identification of each group is based on co-author linkages involving a number of papers or patents and dealing with the same topic displayed as a subheading for the given group. Authors of papers that do not fall into any group are listed under the subheading "Individual Authors." Each name is preceded by the years of pertinent activity, based on the author's publications, and is followed by the pertinent references. Finally, the listings are arranged in reverse chronological order, and within that order, by the length of the activity period from the longest to the shortest.

Statistical material, biographic and specialized topical lists, and a chart illustrating the principle of co-author correlation can be found in Appendix A.

SUMMARY AND CONCLUSIONS

The structure of Section I, consisting of three basic parts that deal with theoretical research, design and construction, and industrial applications, reflects the three stages in the classic progression of a typical R&D effort. While many R&D facilities are limited to one or two stages of this progression, it is clear that the Institute of Automation and Remote Control has been--and is--active in all three. Furthermore, it is also clear (as is shown in detail later in this Section) that during the past twenty years there was a gradual shift of emphasis, during this progression, from basic research to industrial work, where the emphasis seems to rest at this time. This may be partly due to the youth of cybernetics itself--one may say that the Institute is simply reflecting the primary development cycle of the new technology. Another reason for this progression may be the pressure to automate the Soviet industry.

The material for this Report has been drawn exclusively from open-source published Soviet literature, and the picture developed in this material is of course conditioned by the nature of such literature. Thus, while the observed trends of events are clear enough, the details of their course, their continuity, and the degree of completeness of the resulting picture are very irregular. No claim to completeness of the Soviet literature available in the United States can be made in this study. However, the volume of the material that has been acquired may be deemed sufficient to ascribe at least some aspects of the irregularities and omissions to other causes.

The Institute of Automation and Remote Control has been involved in an impressive range of activities, a number of which gave rise to Soviet claims of significant achievements. Soviet officials such as the Director of the Institute, Trapeznikov, and the Academy of Sciences, USSR, have listed such claims on many occasions.[792-796,801-805]

Thus, in the area of theoretical research, the Institute claims credit for the initiation and successful development of the following work:

- The theory of invariance
- The theory of optimal systems, based on Pontryagin's maximum principle and including optimization in terms of operating speed
- Synthesis of optimal systems, based on Lyapunov's concept
- Theory of discrete automatic systems and its application to automatic pulse systems and digital computers

- o Statistical methods applicable to control theory and extremal system theory
- o Theory of learning automata
- o Theory of adaptive systems
- o Theory of "large systems," meaning complex interrelated systems with a large number of control parameters
- o Bionics

The research publications of the Institute indeed show that work on these problems was pursued steadily during the past twenty years. A great deal of this work culminated in the design and construction of automatic control and computer hardware, a partial list of which may illustrate the main directions of thrust:

- o Contactless actuators with magnetic amplifiers and motors
- o Analog and digital regulators, such as the TSR-2 single-channel and MR-1 multi-channel units
- o Automatic optimizers for industrial process control, such as the 1-AO-1 single-variable optimizer, 1-AO-1-2 multi-variable optimizer, 1-AO-12/5 electronic optimizer, and 3-AO-10/5 electronic relay optimizer
- o The ERA-1 and ARP-1 machine-tool control systems
- o Contactless remote-control systems, such as the BTF tonal telegraph and the BTMR-62T complex communications system for radio and electric power transmission
- o The TAF remote-control system for airport landing control and similar systems designated KST (TRDS), BCHT-60, and TCHR-61
- o The BTA-PU-S teleautomatic control of transport mechanisms, and the BTA-2 system for the mining industry
- o The PUMA series of universal diagnostics machines, such as the PUMA-E for testing electric locomotives
- o The EMU series of analog computers
- o The TsM-1 hybrid computer
- o Magnetic and solid-state electronic logic series
- o The Sirena automated airline reservation system

It is not possible to estimate the merits and significance of each of these activities in detail. However, there are several specific areas of the Institute's operation that seem outstanding and deserve mention.

For a number of years the design work of the Institute was subject to a persistent drive to promote modular design principles, industry-wide standardization, and interchangeability of parts. The success of this drive must have been largely indifferent, since the establishment of these characteristics was officially announced in a few cases only, involving contactless actuators, semiconductor logic elements, and pneumatic control devices. The last area, however, including hydraulic systems and pneumatic computer elements, does appear significant in the work of the Institute, both in terms of standardization and sophistication of the overall development. Publications on this subject began appearing in 1955 and in 1968 accounted for 10 percent of the authors of the Institute. The result of this work is the USEPPA system of industrial pneumatic control, consisting of standardized interchangeable modules. These are fabricated by methods similar to the printed-circuit technology in which the fluid channel network representing a control function is stamped into plates; the plates are then stacked to form module components. The Institute also developed the "pneumonic" system of computer elements where the logic function is performed by interaction of fluid jets. The printed circuit technique has been advanced here from stamping to photochemical etching of the channels.

Another aspect of the Institute's activities that should be noted is the considerable preponderance of analog work. The use of analog systems in industrial process control appears to be much more widespread in the Soviet Union than in the United States where digital solutions to control problems are dominant. While the Institute does design and build digital computer and control elements and entire analog computer systems, there is no evidence that it develops entirely digital computers. Its TsM-1 special-purpose computer is called "digital computer" in the literature (also the type designation "TsM" stands for Tsifrovaya Mashina - Digital Computer, in Russian), although it is a hybrid system with an analog-digital central processor. However, the broad theoretical and design base in analog computer technology developed in the Soviet Union, and in the Institute in particular, may be expected to produce unique and significant contributions that would merit a thorough study in depth.

Finally, a considerable amount of work has been done on the theory of adaptive systems based on the application of the invariance theory, a theory that originated in the Institute, caused a far-reaching controversy in the scientific circles of the Soviet Union, and continued to attract attention throughout the period covered in this Report. This work displays the main characteristics of a well-established concentrated research effort in that it involves a relatively large group of authors that are interconnected by a highly developed network of co-author linkages, have a large number of publications on the subject, and maintain this working relationship for a considerable period of time. It is interesting to note that one of the oldest, in terms of service, and most active members of this group is B. N. Petrov, a former director of the Institute.

The Institute staff responsible for these developments was ascertained for this study in terms of authorship of technical papers or patents, or by explicit attribution in the review literature. The periods of activity of individual people, however, could only be established through publication dates. These dates, imperfect as they may be for our purpose, provide a number of interesting insights into the patterns of activity of the Institute's authors. For example, we find that the leadership of the Institute is relatively stable. The incumbent director has maintained his position for 18 years. The average service of the two dozen leading research workers is over 11 years (see Appendix A), ranging from 22 years for Ya. Z. Tsypkin, the authority on nonlinear automatic control theory and learning machines, to five years for L. I. Rozonoer, a specialist in optimal systems. Since these periods are based on the acquired publications only, the actual service periods are in all probability much longer. A number of names on the list of the leading research workers have their last acquired publication dating in the mix-sixties. Since in many cases there are publication gaps of several years, these authors may be still active in the Institute and thus there is a fair probability that most, if not all, the leading workers on the list are currently active members of the Institute.

The same situation was encountered in the specialized groups of co-authors that were identified in order to trace more closely the individual research efforts. A total of 37 such groups was identified (see Appendix A), their membership ranging from 2 to 22 names. The groups based on the co-authorship of patents and dealing with industrial application of automatic control are larger than the theoretical research groups. They are also more numerous and more recent, indicating the increasing activity of the Institute in this area. A large majority of the groups have their latest acquired material published in 1968-1969, and only two had their most recent publication in 1963 or earlier. Thus we can again assume that most of the specialized groups are still in operation.

The entire published material acquired for Section I was treated statistically by counting the number of authors, the number of papers, and the number of patents for each year covered and each subject area. The totals were then cumulated for theory, design, and industry, and the publications were further cumulated in terms of periods of several years (see Appendix A). It is obvious that the resulting trends observed in the statistical material reflect both the publishing activity of the Institute and the year-to-year vagaries of the publications retrieval process itself. While the validity of this Report must rest in a large measure on the assumption that the publishing activity of an organization bears some reasonable relation to the actual activity it reflects, the deficiencies in retrieval of the published material constitute an independent variable that may seriously affect such a relation, particularly when we deal with statistics, and when the retrieval mechanism is subject to some seasonal variations. The deleterious effect of this can be significantly reduced if (1) the accumulated material is large, (2) several independent retrieval methods are used, and (3) different types of input are available. The use of different retrieval methods and input sources may tend to cancel out system errors that may be inherent in the retrieval mechanism. Fortunately all three conditions are present in some measure in our case. The total number of references used in Section I is over 800, their acquisition was based on a combination of Academy of Sciences sources, review bibliographies, and the Have-Check system, and the acquired input contains a fair proportion of different sources such as newspapers, regular periodicals, and irregular serials. While a combination of different types of articles, for example, reviews and research papers, can make the task of technical analysis more meaningful, different source types enhance the reliability of statistical inferences. Thus a periodic variation in the count of articles from regular journals alone might possibly be due to peculiarities of publication procedures, acquisition variations, or even retrieval defects. However, if similar variation is encountered in material from sources of an entirely different nature, it may be attributed with a fair degree of confidence to the subject of the count itself, i.e., the organization originating the material. In our case the role of the independent check was assigned to dissertations for the Candidate of Sciences degree awarded by the Institute and published in a large number in the newspapers. The frequency counts of candidate dissertations were thus plotted through the years parallel to those for authors and publications of the Institute. These plots were found to be in very good agreement, at least in their main features.

The plots in Figs. 1 and 2 show three distinct peaks associated with the years 1959, 1963-64, and 1968. The peaks are followed by abrupt drops that level off before the next buildup. The drop in 1969 is obviously spurious because of the incomplete coverage of that year. However, the area-of-activity distribution in 1969 may be significant. The interesting feature of all the peaks is that each is followed by a rearrangement of priorities among the areas of activity.

Thus, 1959 is followed by a period when theoretical research is uppermost and industrial applications are barely perceptible. After 1964 and up to 1968, design and construction has the upper hand and shows an unprecedented rise to the 1968 peak. During the same period, the area of industrial applications also increases and reaches the 1968 peak at an even greater rate. After 1968 it clearly shows an overall ascendancy. The "authors" plot shows this more distinctly than the "publications" plot because patents play a much greater role during that period and the number of co-authors per patent tends to

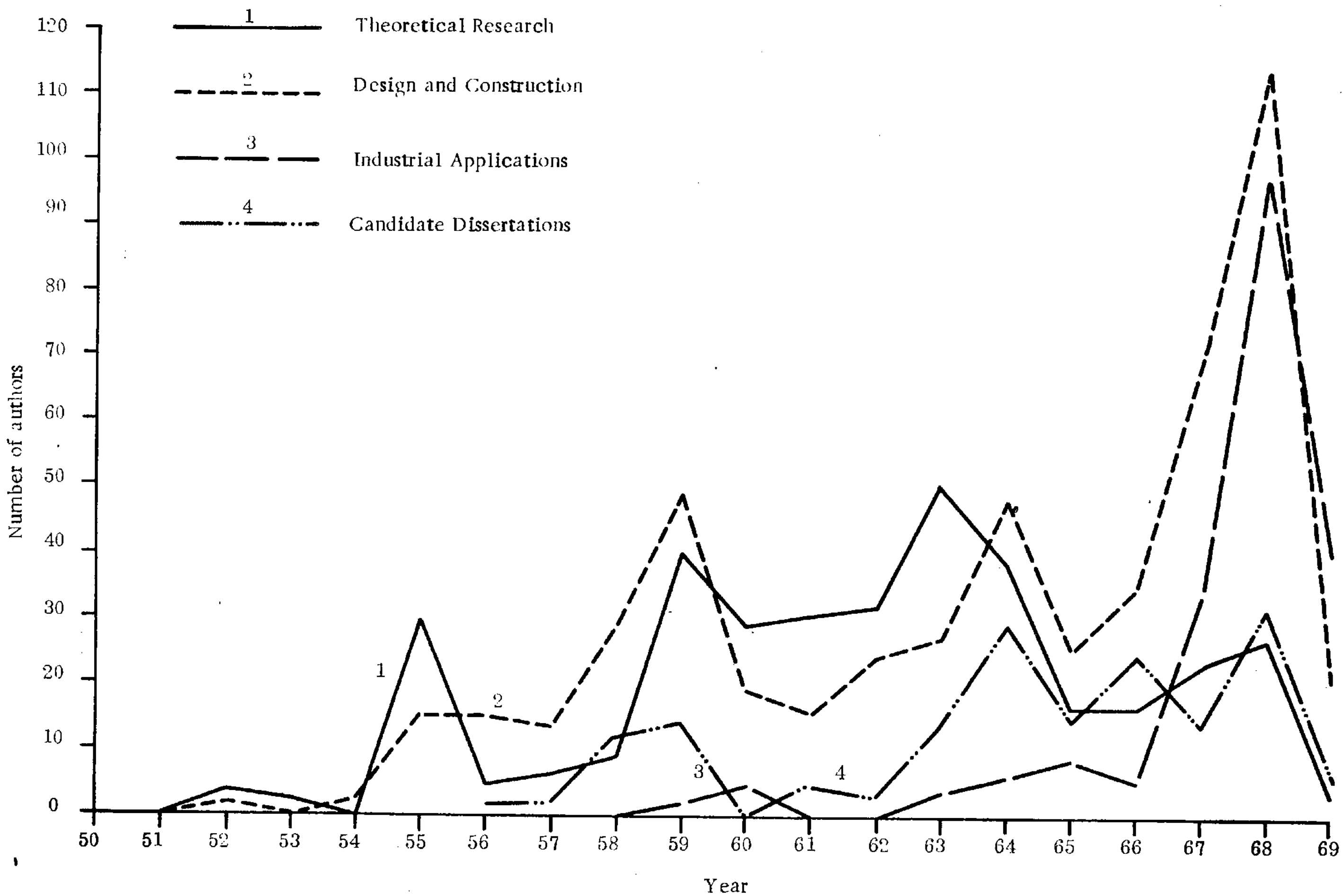


Fig. 1--Number of authors per year associated with the three major areas of activity of the Institute of Automation and Remote Control

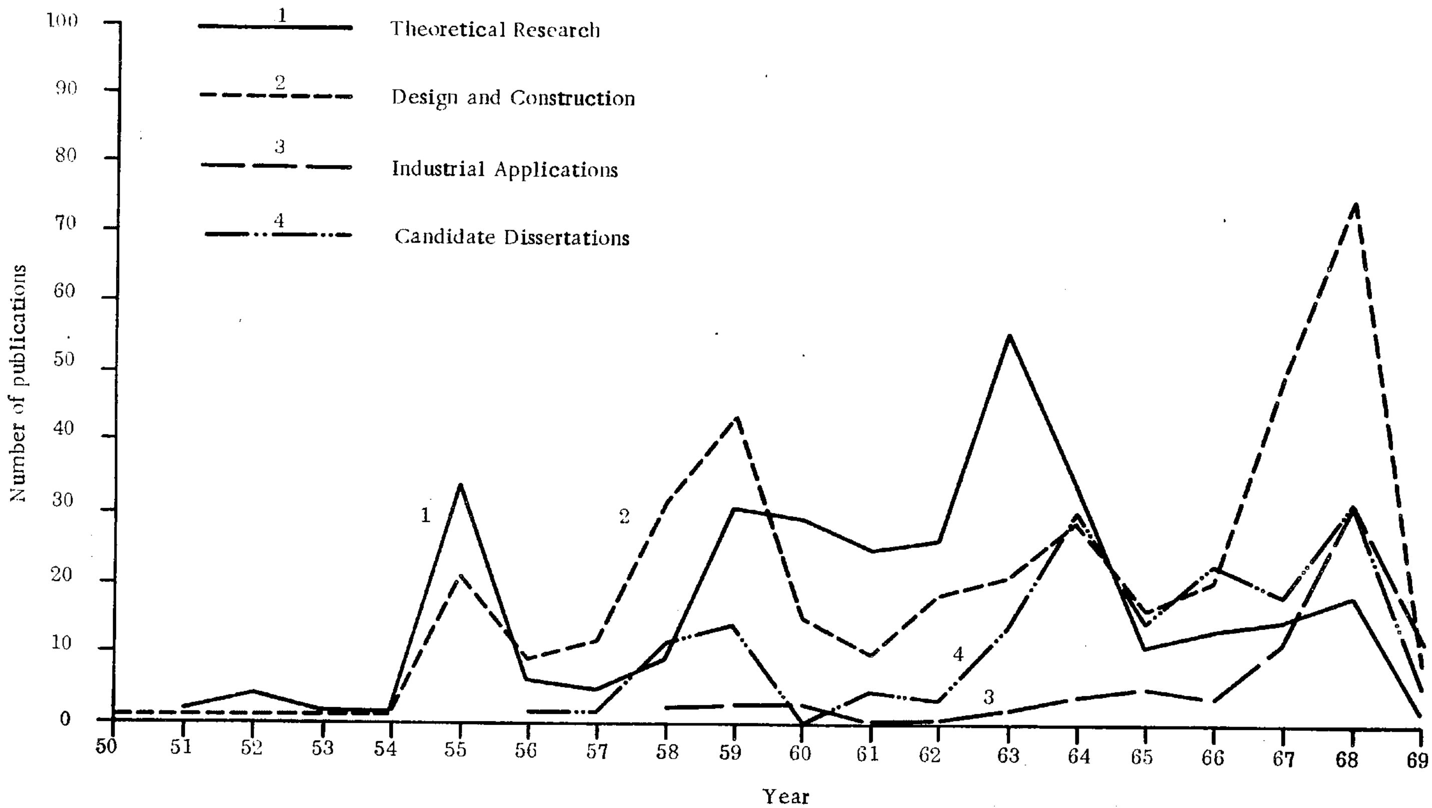


Fig. 2--Number of publications per year associated with the three major areas of activity of the Institute of Automation and Remote Control

be larger than per research articles. The existence of the peaks may be interpreted as indicating deliberate and planned decisions to reorient the priorities of the Institute, with the attendant need for what is the equivalent of retooling in the industry, and the stress on acceleration of the completion of existing projects before the beginning of the new cycle.

To gain an insight into the behavior of the major areas of activity in terms of specific subjects, consider Figs. 3 and 4. The topical distribution of authors for 1959 in Fig. 3 shows an approximately even contribution from the six leading subject subdivisions. The ascendancy of design and construction is due to the slightly higher proportion of work on electric drive automation, monitoring systems, and component hardware. The work on electric drive tapered off considerably in subsequent years. In 1964 the work on adaptive systems theory is outstanding and accounts largely for the ascendancy of theoretical research in that period. Similarly, the subject of components and units is already prominent in 1964, which marks the beginning of a climb that takes the entire area of design and construction to the front in the next period.

The peak year of 1968 is dominated by design and industrial work. The design of components and units takes up 16 percent of the total authorship for that year, but the largest share goes to direct applications in various areas of general industry with 23 percent.

Figure 4 tells a similar story. It represents a breakdown of publications, including patents, among several leading topical subdivisions, and shows each in two time periods, 1950-1962 and 1963-1968. We see that in a gross time scale all theoretical research topics suffered a decrease, while all design and construction work, with the exception of electric drive, increased, the largest share going to components and units.

Thus, the general development trends of the Institute can be summarized as follows:

1. Steady overall increase of research and development effort.
2. Intensification of advanced theoretical work, exemplified by the stress on adaptive systems.

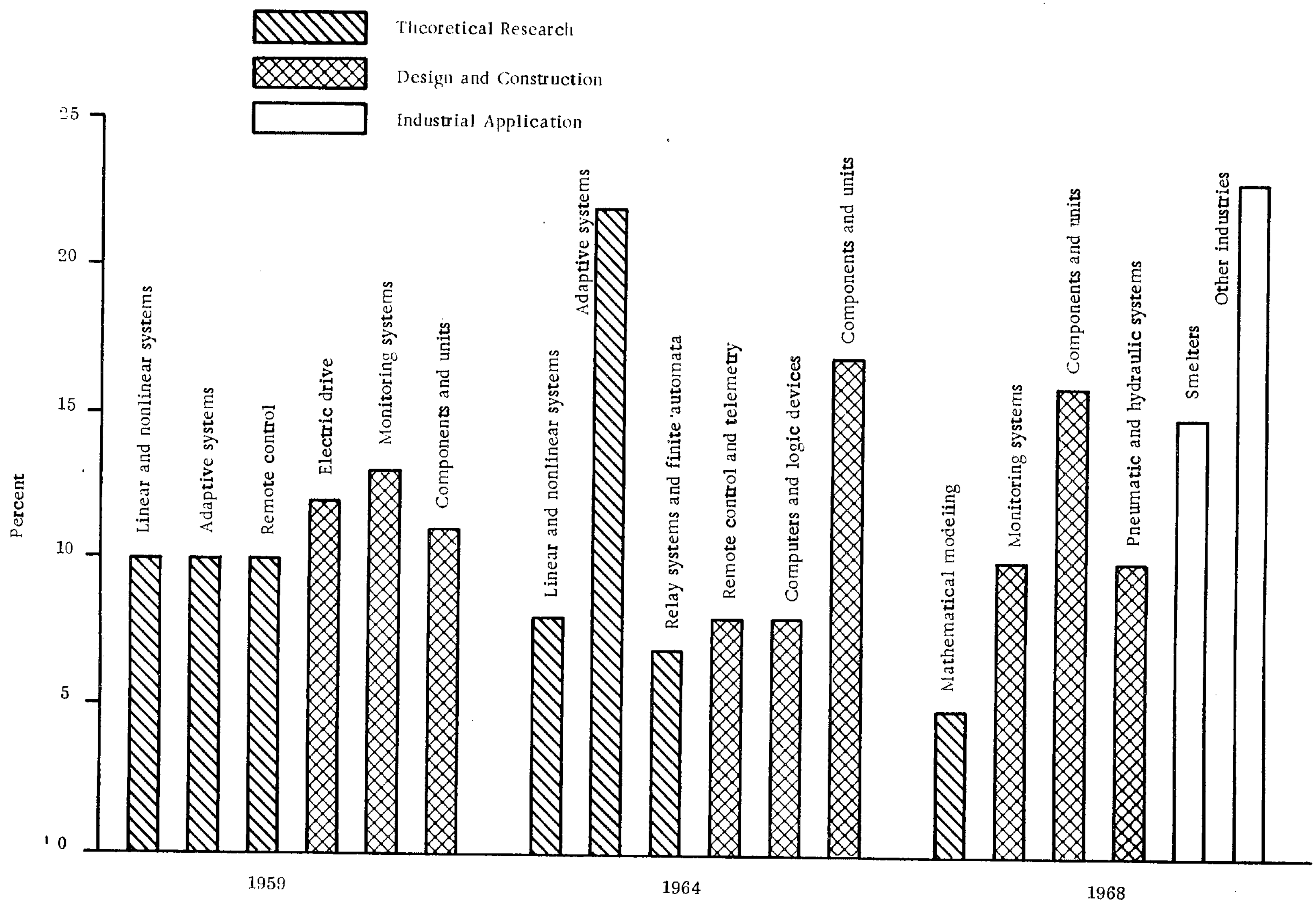


Fig. 3--Percent of authors in selected years and leading subject areas: Institute of Automation and Remote Control

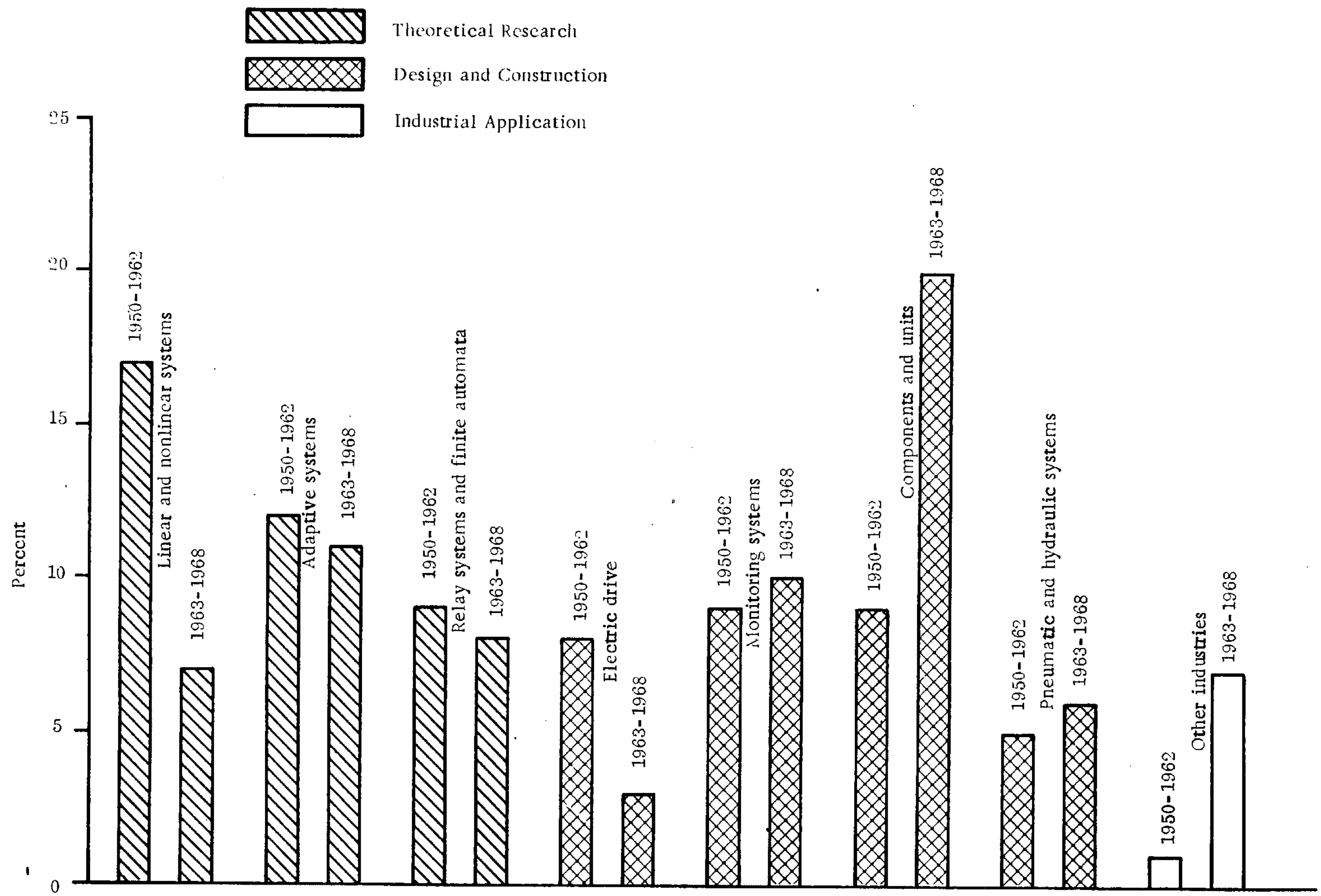


Fig. 4--Percent of publications in two periods (1950-1962, 1963-1968) and leading subject areas: Institute of Automation and Remote Control

3. Rapidly increasing work on design and prototype construction of hardware components for industrial process control systems and computers.
4. Considerable and quite recent expansion of the rate of work on specialized industrial applications of automatic control.

The last point merits some further consideration. A breakdown of the applications development by industries reveals a rather incomplete picture. There is a consistent large-scale work in metallurgy, particularly in the development of automatic control systems for machine tools, heat-treatment, and metal casting processes. Apart from this, we see a very uneven work scattered in relatively small efforts among the oil, chemical, and mining industries. This is particularly puzzling in view of the fact, often stated by Soviet cybernetic economists, that petroleum refining and chemical industries are by their nature the most readily adaptable to automation and therefore prime targets in any drive to disseminate automatic control systems of precisely the type that the Institute specializes in.

The significant aspect of the Institute's work in the area of industrial applications is its rate of increase, rather than the current level of effort. If this level, as reflected in the open-source publications, does not become more comprehensive and more logically distributed in the near future, one must conclude that the momentum of the Institute's research and development effort is being spent to a large extent in areas that are not free for open-source publication. The magnitude of this momentum can be judged, apart from all the considerations given above, by the fact that, of all organizations active in cybernetics, since 1964 the Institute had the highest frequency of recognition in the annual achievement reports of the Academy of Sciences, USSR, and that in 1969 it was one of two organizations awarded the Order of Lenin. Officially designated as the scientific base for the automation of the national economy and highly recognized for its performance by the Academy of Sciences, the Institute of Automation and Remote Control today is undoubtedly one of the top major cybernetics organizations in the Soviet Union.

INTRODUCTION

The full name of this organization is the Institute of Automation and Remote Control (Technical Cybernetics). The somewhat anomalous addition of the qualifying phrase in parentheses has been appearing in the official title of the Institute since 1967. The address of the Institute is Moscow, Kalanchevskaya ulitsa 15a. The Director of the Institute is V. A. Trapeznikov, member of the Academy of Sciences, USSR; deputy directors are A. B. Chelyustkin and B. S. Sotskov, corresponding member of the Academy of Sciences, USSR.[806] The Institute is subordinated to both the Ministry of Instrument Building Means of Automation and Control Systems, USSR, and the Academy of Sciences, USSR.[807]

The Directory of Selected Scientific Institutes[806] lists the Institute as "probably the largest of its type in the USSR" with a staff of over 1,000, including 300 professionals (1963). The official Soviet 1964 account of the Institute[803] claimed 24 doctors, 89 candidates of sciences, and 170 aspirants, which indicates a similar order of magnitude as the number of professional workers reported in 1963. In 1968 the staff was reported to include 40 doctors, 140 candidates of sciences, and 200 postgraduate students.[809] In this connection it is noted that a total of 27 doctoral dissertations published by the Institute between 1956 and 1964 were acquired (see Appendix A). The origins of the Institute, as well as the beginning of automation in the Soviet Union, can be traced back to the resolution of the Presidium of the USSR Academy of Sciences of June 10, 1934, which established a Special Commission on Remote Control and Automation (KTE AN SSSR) as a component of the Technical Group of the Academy.[803] The most significant achievement of the Commission was the organization of the first All-Union Conference on Automation, Remote Control and Flow Control in 1935. The Conference was intended to determine the prospects of developing automation in the USSR and to unify the organizations engaged in this field. The proceedings of this conference were not published. The journal, *Automation and Remote Control*, which began publication in 1936 as the official organ of the Commission, was founded at the Conference. The Commission was also active in scheduling the introduction of automation and remote control systems into the national economy in the Third Five-Year Plan. This work resulted in seven volumes that were completed at the end of 1938 and were used as a foundation in formulating the corresponding portions of the Third Five-Year Plan. Unfortunately, the political atmosphere of that time precluded proper development of work in automation.[803]

In 1938 the Presidium of the USSR Academy of Sciences transformed the Commission into the Committee of Remote Control and Automation. The Chairman of the Committee was V. S. Kulebakin, member of the Academy of Sciences, USSR, who redirected the work of the Committee from a coordinating organization to a scientific research facility capable of independent research in a broad range of subjects.

A year later, in 1939, the Presidium of the People's Commissars of the USSR decreed the organization of the Institute of Automation and Remote Control of the Academy of Sciences, USSR, within the Academy's Department of Technical Sciences. Kulebakin became the first director of the Institute. At that time the primary mission of the Institute was the development of theoretical foundations of the automation science. The first All-Union Conference on the Theory of Automatic Control was organized by the Institute in 1940. The topics discussed at the Conference were the general analysis of processes in control systems and the application of the matrix theory of differential equations to the control theory. During World War II the Institute was evacuated to Ul'yanovsk and was greatly reduced in size. The work of the Institute at that time was exclusively directed toward automatic control of dimensions and finish quality of mass-produced defense hardware.

After World War II the Institute was considerably expanded. Its mission, which has not changed significantly since its foundation, is the study of fundamental problems of automatic control, or technical cybernetics.[808] The term "technical cybernetics," added to the name of the Institute, is defined by Trapeznikov as an aspect of cybernetics dealing with the control of technological processes and with the design of artificial control systems.[802] Considerable stress is laid in the official accounts of the Institute on its role as the scientific and technical base for the automation of the national economy.[802,808]

During the post-war years the Institute has gradually progressed from the automation of individual machines to the theory of complex control systems and a general theory of automatic control. This progression was reflected in the transitions from linear to nonlinear and to statistical problems, and finally to the theories of discrete, optimal, and adaptive systems. The general theory of automatic control as developed at the Institute became a standard academic text.

A more detailed view of the highlights of the Institute's activities can be obtained from the annual achievement reviews of the Academy of Sciences, USSR, in cybernetics. The following are excerpts from these reviews pertaining to the Institute, for the years 1964-1968.

> 1964
>
> In the area of automatic control and automata the Institute developed a method based on the minimax criterion of solving the problem of optimal control of a linear stationary system operating in the worst conditions of perturbing forces. New methods were also developed to compute systems of automatic control with variable structure and infinite order of astatism, with complete and incomplete information on the condition of the system and perturbing stimuli. The Institute also participated in the construction of the "Avtomashinist" system for railroad traffic control. The first stage was completed in 1964.[796]
>
> 1966
>
> The Institute was noted to be the only organization working on the application of the method of stochastic approximation to the solution of certain problems of automation. This method is considered a powerful tool in solving a large number of problems in pattern recognition, automatic control, determination of characteristics of projects, and the solution of linear equations systems.
>
> The theory of optimal processes received its finishing touches in terms of important results that have now become the classic models of applying mathematics to the problems of technology. Specifically, significant results were obtained in the theory of self-adaptive and self-organizing systems. The Institute developed a theory of dual control, allowing for the design of systems capable of refining information on the object in the control process. A number of new algorithms were suggested in the area of extremal control. The main attention here was paid to multiparametric search and multi-extremal systems. In the area of relay devices and finite automata the Institute carried out work in the abstract syntheses of automata. Another project in this

area was mathematical modeling of relay devices, which more completely reflect the real properties of relay elements. Pursuing its work on the automatic design of computers, the Institute developed the study of structural reliability to a considerable extent. The Institute solved an important problem of designing structures of relay devices that are failure proof in the logic module and in the delay module.

The Institute also developed and introduced into practice a number of systems of network planning and management. These systems were brought to the point where they now control complex operations.

The Institute introduced a series of adaptive systems into the industry. Serially produced optimizers were installed in synthetic rubber plants. The work on the optimal design of chemical reactors was begun.[795]

<u>1967</u>

The Institute continued the study of new types of elements and systems of automation. It developed new types of diode-less magnetic digital elements, majority elements based on ferrite cores and new types of magnetic adaptive elements, as well as new principles of designing modules and blocks using solid state circuits. The Institute also continued work on the study of new principles and further development of pneumatic elements. New modular jet elements, pneumatic elements with acoustical control, and hydraulic arithmetic units were built. The Institute developed methods of theoretical and experimental evaluation of reliability of radio electronics, automation, and machine building products. Significant results were obtained in the area of structural reliability. The Institute developed methods of synthesizing structures of relay devices with a pre-assigned reliability by introducing structural redundancy that takes into account failures at inputs, lack of symmetry and unequal probability of failure.

In the area of adaptive systems, the Institute developed and applied algorithms for pattern recognition learning, including recognition of speech signals; diagnosis of diseases; acoustic diagnosis of machine defects; and classification of minerals and geologic strata. The direct Lyapunov method was used to study the stability of systems with variable structure, and a control algorithm was proposed capable of realizing a variable-structure control system using real elements. The method of stochastic approximation was used to develop adaptation algorithms to study objects and their control.

In the area of complex automation systems the Institute worked on the following projects: the design of a universal logic machine to monitor the operation and to locate defects in control objects; the design of BIUS-modular information control systems; the design of automatic digital regulators for precision regulation of objects in the metallurgical, oil refining, textile, and other branches of industry; the design of an automated airline reservation system (representing real-time mass-servicing system); construction of the BTA-2 teleautomatic system for complex control and monitoring of mining industry objects; construction of a universal modular system to monitor complex electromechanical and radio installations; and construction of solid-state teleautomatic systems for monitoring and programmed control of large objects with distributed structure, such as a hierarchical system with 10 regional base points operating 5,000 objects of national economy.

The Institute continued work on the theory of large systems (complex systems with a large number of control parameters) and designed models for managing operational complexes.

It suggested new methods and algorithms for analyzing network models aimed at the solution of optimal planning problems. It designed an algorithm for distributing material incentives in network planning systems, which was already applied in practice. The Institute suggested algorithms for managing the production processes for chemical, mining, machine building, textile, winery, and other branches of industry.

The Institute has prepared algorithms for finding optimal control in discrete systems with a large number of variables. These algorithms are of considerable interest in the solution of problems of organizing production and analyses of technological processes. The results of theoretical research of optimal systems were aplied to the design of control systems for thermal power stations, oil exploration, etc. For the cases where a priori information about the optimized object is insufficient, the Institute proposed to use adaptive methods that allow optimal control of an object after a learning interval.

Significant results were also achieved in theoretical work of technical cybernetics. Frequency methods were developed to synthesize nonlinear pulse systems and a criterion of stability for such systems, based on the compression method, was suggested.[793]

1968

The successful development of the theory of relay devices and finite automata allowed the Institute to automate the process of synthesizing complex technical devices and to create a number of important machines for technical diagnostics. An example of this is the PUMA-E machine, designed by the Institute for the testing of electric locomotives.

A number of important systems for industry and scientific research in biology and medicine and geology were designed on the basis of theoretical work of the Institute.

These are just some of the activities and achievements claimed for the Institute by the Academy of Sciences. Many of these projects are developed more fully in this Section, based on the scientific and technical publications of the Institute. In general, there is a fairly good agreement between the course of activities derived from the body of the technical publications and those accounts of the Academy of Sciences. The main aspect of the Institute that the Academy reviews fail to reflect, however, is information on the personnel, its leadership, and the role of individual research workers in the development of the projects.

The leadership of the Institute has shown a remarkable stability throughout its existence, except for the war years. The following are the directors of the Institute with their terms of office:

1939-1941	V. S. Kulebakin, Member Academy of Sciences, USSR
1941	A. F. Shorin
1941- ?	V. I. Kovalenkov, Corresponding Member, Academy of Sciences, USSR
1947-1951	B. N. Petrov
1951 to present	V. A. Trapeznikov, Member, Academy of Sciences, USSR

It is not clear from the available account[803] whether Kovalenkov served all the time up to the directorship of Petrov; furthermore, Kovalenkov's name does not appear in the post-war literature. Of the remaining directors, Shorin died in office, Kulebakin was an active member at least up to 1958, while Petrov continued as a key research worker at least until 1967.

The Institute has a governing body called the Scientific Council, which combines two sections: Automatic Control Systems; and Theory of Automation and Remote Control Design. The membership of the Scientific Council included (1964) B. N. Petrov and B. S. Sotskov.[808]

The Institute organizes permanent seminars with the participation of over 3,000 persons annually. Also, over 3,000 persons each year take part in conferences organized by the Institute on specialized problems of automation. Over 2,000 persons annually consult the Institute.[802]

THEORETICAL RESEARCH

Linear and Nonlinear Automatic Control Systems

Early research on automatic control systems was concentrated on a thorough investigation of stability and quality of control processes.

During the immediate post-war years this work was pursued by A. A. Andronov, Ya. Z. Tsypkin, and M. A. Ayzerman.[1-3,15] From 1950 to 1960 it was continued by M. V. Meyerov and Tsypkin,[4-6] who studied the class of systems optimizing both gain and stability. At the same time, Meyerov[7-9] was developing a control theory applied to objects with a large number of controlled parameters or, in the Soviet terminology, a "theory of multicoupled regulation." The broad range of industrial and technological applications renders this theory the principal theoretical foundation of the Soviet concept of "comprehensive automation." In the nonlinear systems theory, a principal subject of research of the Institute was variable structure systems described by equations with discontinuously variable coefficients.[10,11] Stationary linear systems and linear pulse systems were analyzed statistically by V. V. Solodovnikov, Yu. P. Leonov, Ya. Z. Tsypkin, and L. A. Tel'ksnis[16-20] in the years between 1952 and 1957, and more recently by A. A. Bulgakov[767] and M. P. Saharov.[768] Stability of nonlinear systems was also considered at that time, with a large part of the effort spent on the theory of absolute stability.[12,13]

Later the Institute began work on applying the methods of general theory of random functions to the analysis and synthesis of automatic processes. This work proceeded in the following main directions:

1. Development of a general statistical theory of optimal systems and optimal algorithms of processing information by the elements of automatic systems;
2. Development of statistical methods of determining the dynamic characteristics of industrial objects;
3. The application of the Markov random process theory to problems of statistical analysis of nonlinear systems.

The stochastic theory of optimal systems applies to the optimal dynamic characteristics of automatic systems as a whole, sometimes called problems in statistical synthesis, as well as to optimal algorithms of processing information in the individual elements that comprise automatic systems.

In the period from 1957 to 1962, V. S. Pugachev developed general methods of determining linear systems for nonstationary input signals that were applicable to any number of inputs and outputs.[21-23] A number of special cases in determing optimal systems were developed by Yu. P. Leonov and Ye. S. Kochetkov.[24-27]

Pugachev continued the work on the optimal systems, generalizing it over any statistical quality criteria in linear and nonlinear systems. The resulting theory was applicable to a wide range of problems involving separation of signal from noise and arising in the theory of information, communications, radio engineering, automation, and other areas of science and engineering.[28-31] He also showed that his general method is applicable to the design of algorithms for adaptive machines and to the case of signals depending on an infinite number of parameters.[32-35]

This body of theoretical work found a number of interesting practical applications, such as the work by L. P. Sysoyev on the detection of signals that depend nonlinearly on random parameters,[36] detection of useful signals by E. L. Nappel'baum,[37] and the study of M. Yu. Gadzhiyev on the detection of radar signals against white noise background.[38]

The second direction of the stochastic theory development concerning the study of industrial objects of control in situ was pursued consistently from 1959 on by Leonov, S. Ya. Rayevskiy, and N. S. Raybman.[39-47]

The third direction included Raybman's work on correlation methods of determining characteristics of automatic production lines,[48-50] which was continued by E. Paziyev,[51] and the theory of discrete random Markov processes applied to external control systems by A. A. Fel'dbaum, T. I. Tovstukha, and Pugachev.[52-55]

In 1966 the Academy of Sciences, USSR, noted that the Institute was the only research facility working on the stochastic approximation method in the automatic control field, and specifically on pattern recognition, solution of linear operation systems, etc.[795]

Of the three types of discrete automatic control systems--relay, pulse, and digital--the pulse type occupied a major portion of theoretical research effort by the Institute. The central figure of this research, preeminent for two decades from 1948 to at least 1968, is

Ya. Z. Tsypkin, working in close association with I. V. Pyshkin, M. M. Simkin, and later with A. I. Propoy. Their early work consisted in developing systems of difference equations and discrete Laplace transforms to formulate a general theory of pulse automatic control systems.[14,56,57] In the 1959-63 period, the theory was extended to cover pulse systems in which data input occurs within finite time intervals, and was then applied to engineering problems, such as automatic radar systems.[58-60]

In the sixties, Tsypkin turned to the investigation of absolute and partial stability of nonlinear pulse systems,[12,61,63-65] the results of which permitted him to solve a wide range of control problems without recourse to more complex adaptive systems. The method of harmonic balance was used by Pyshkin to determine periodic regimes in nonlinear amplitude-modulated pulse systems.[66] The results were applied to high-frequency periodic regimes[67] and complex regimes in which the periods are not multiples of the pulse repetition period.[68] At this time, Tsypkin also worked on the synthesis of optimal systems, using the method of dynamic programming.[69] The problem was also investigated using linear programming[70] and, at the same time, by another group which was basing this approach on difference equations.[71-73]

Digital automatic control systems were also studied, although to a lesser extent, by Tsypkin during the years 1961-64. Considering them a special case of nonlinear pulse systems, Tsypkin found that they can be analyzed directly by deterministic and stochastic methods, using the same stability and periodic regime criteria developed for nonlinear pulse systems.[74]

In the design of digital systems, particular stress was placed on transmission of information with efficiency and low noise.[75]

Tsypkin continued his work on the stability of nonlinear systems up to 1965.[76-79] After that time he went on with the synthesis of optimal systems[82] and in 1966-68 was active in research on adaptive systems.[83,84]

Tsypkin's range of interests in the nonlinear automatic control field extends to all its major aspects including sequential machines, considered a special case of discrete automatic systems with a finite number of discrete states varying in discrete time intervals.[85] This problem was also developed by Pyshkin.[86]

Among Tsypkin's co-authors, Simkin continued to work on nonlinear automatic systems,[80,81] and Propoy joined Tsypkin on work on optimal system synthesis.

Nonlinear Pulse Systems Group

Span of Years	Name of Author	Reference Number
1946-1966	Ya. Z. Tsypkin*	1,2,6,12,13,20,56,57,60,63,64 67,69,74,76,77,79,85,761,769
1961-1966	M. M. Simkin*	65,68,80,81
1966	R. G. Faradzhev	85
1965	M. S. Epelman	78
1958-1963	I. V. Pyshkin*	58-60,62,66,86

Individual Authors

Span of Years	Name of Author	Reference Number
1963-1968	A. G. Butkovskiy	72,666
1968	E. Payziyev	51
1967	A. A. Bulgakov	767
1967	M. P. Sakharov	768
1964-1966	G. G. Rakhimov	61,219
1966	Ye. P. Maslov	663
1966	B. S. Razumikhin	658
1957-1964	V. S. Pugachev*	21-23,28-35,55,664
1961-1964	N. S. Raybman	45-50
1961-1964	S. Ya. Rayevskiy	45-47
1962-1964	Ye. S. Kochetkov	26,27
1951-1963	M. A. Ayzerman	3,15
1963	F. R. Gantmakher	15
1963	A. I. Propoy	70
1956-1962	Yu. P. Leonov*	18,19,24,25,39-44

*In this and all of the following similar listings in this Report, the asterisk denotes more than three articles.

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1960-1962	T. I. Tovstukha	53,54
1962	Ye. L. Nappel'baum	37
1962	L. P. Sysoyev	36
1947-1961	M. V. Meyerov*	4,5,8,9
1959-1961	L. N. Lipatov	39-42
1960	M. Yu. Gadzhiyev	38
1960	V. M. Baykovskiy	75
1960	V. N. Novosel'tsev	73
1957-1959	L. Z. Tel'ksnis	19,661
1959	H. Wang	659
1959	A. A. Fel'dbaum	52
1959	L. I. Rozonoer	71
1959	V. I. Shadrin	660
1952-1955	V. V. Solovodnikov	16,17
1955	A. M. Letov	662
1955	P. S. Matveyev	17
1955	A. M. Popovskiy	7

Optimal and Adaptive Systems

The Institute plays a considerable role in the development of the theory of optimal systems, considered one of the most important aspects of the theory of automatic systems because it is directly applicable to industrial needs. Two distinct branches of the theory are recognized: deterministic and stochastic optimal systems. The oldest and most consistent worker using the deterministic approach in this field is A. A. Fel'dbaum, who studied optimal processes with linear control in 1949.[88] This was generalized in 1952 by A. Ya. Lerner,[89] another key researcher in the field. Fel'dbaum continued his work through the fifties, formulating the general variational problem of finding an optimal phase trajectory in n-dimensional phase space for any initial conditions,[90] and then obtaining a method of synthesizing the algorithm of optimal control systems.[91,92] The algorithm of ideally optimal systems was studied by A. A. Pavlov,[93] and Lerner developed a theory of optimal systems applied to objects with distributed parameters[94,95] based on a generalized concept presented by L. I. Rozonoer.[96,97] In 1967 I. S. Ibragimov advanced a method for synthesis of optimal control in a third-order system with two control inputs.[98]

The deterministic approach to optimal control was also pursued by A. M. Letov, M. Ye. Salukvadze, L. S. Kirillova, and I. A. Litovchenko, who started with the Lyapunov concept of perturbed-unperturbed motion and applied it to the synthesis of optimal regulators in nonlinear systems, time-lag systems, and systems with random parameters.[99-103] The participation of Tsypkin and his group in this area concerned the theory of deterministic discrete optimal systems, including pulse and relay systems,[87,104,105] and later resulted in a paper on the synthesis of automatic systems optimal in the mean.[82]

The stochastic aspect of the theory was based on the Kolmogorov-Wiener mathematics and attempted to determine the optimal transfer function of a linear system receiving a random signal and noise mixture.[106,107] Fel'dbaum again contributed to this area, using the method of dynamic programming in the development of his dual control theory.[108-110] The dual control concept is addressed to two distinct problems: obtaining information on the state of an incompletely known control object; and bringing the object into the desired state. It is credited with providing an optimal strategy for the control elements in fairly general system types.

The principle of invariance and the concept of invariant control systems originated in the Institute and are credited to G. V. Shchipanov, who formulated the principle of the "ideal regulator" that maintains zero deviations from the regulated quantity. Academician N. N. Luzin developed the mathematical apparatus and the notions of absolute and approximate invariance in automatic control systems.

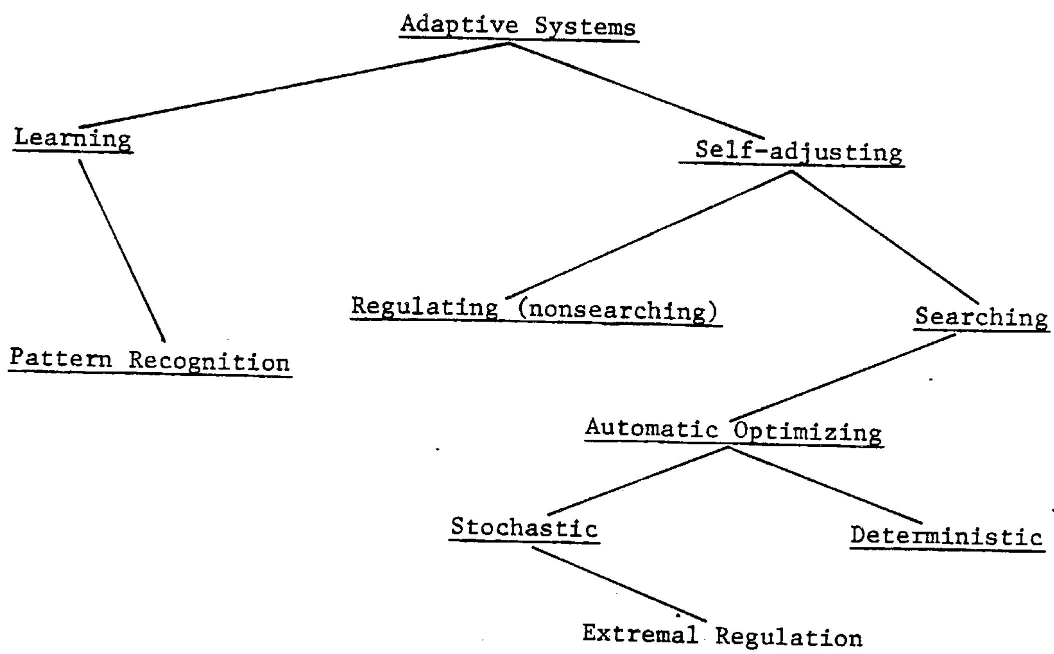
Few subjects in the history of the Institute display such a persistent line of development and are given such prominence in official accounts as the theory of invariance, IAT's own homegrown product, whose birth in 1939 was followed by a fairly bitter dispute about its basic validity. Shchipanov founded the theory on the so-called "compensation conditions" for designing automatic control systems in which the controlled quantity "is independent of the perturbing stimulus."

Although the idea was soon rejected by the Academy of Sciences, research continued and showed that the invariance principle can indeed be realized in hybrid systems, bridge networks, gyroscopic devices, etc. In 1959 the Academy officially recanted and pronounced the idea valid. The feasibility and applicability of the invariance condition was studied at that time by V. S. Kulebakin, B. N. Petrov, and G. M. Ulanov, who considered it in connection with hybrid automatic control systems.[111-116] Petrov and Ulanov, together with S. V. Yemel'yanov, further studied the stochastic and informational criteria of invariance in systems, including variable-structure systems, and their application to concrete problems.[117-119] At the same time the principle of invariance applied to linear symbols was studied by R. S. Rutman and M. S. Epelman.[161] L. I. Rozonoer developed a variational approach to the problems of invariance, introducing the notions of "strong" and "weak" invariance and establishing a common ground between the theory of invariance and that of optimal processes.[119] Somewhat later, the increasing application of the invariance theory to variable-structure systems was accompanied by consideration of invariance in adaptive systems.[120-122] The new method afforded an opportunity to compute automatic control systems with variable structure and infinite order of astatism and with complete or incomplete information on the system state and the perturbing stimuli.[796]

Adaptive systems are defined (see diagram below) in Soviet literature as those in which the control algorithm varies automatically and purposely to achieve successful and, only in a sense, optimal control of the object.

A special case of the adaptive system class is the self-adjusting system in which the adaptation processes occur in a closed loop. The adaptive element here varies the algorithm of the control element, based on the incoming information on the performance of the system as a whole. The self-adjusting processes may be either of a regulating or of a searching type. The work of the Institute is mainly directed toward the searching process, considered more complex of the two.

IAT DEFINITION OF THE HIERARCHICAL STRUCTURE
OF THE ADAPTIVE SYSTEMS THEORY



A major portion of the class of automatic searching systems is the automatic optimization systems described by Fel'dbaum and developed by the Institute in both the deterministic and stochastic aspects.[123] The research in this area dates back to 1956 and again involves Fel'dbaum to a considerable extent, particularly during the period up to 1964. In this earlier period a significant proportion of the work was also done by L. N. Fitsner. Later adaptive systems research was carried out by B. N. Petrov and V. Yu. Rutkovskiy in connection with applications of the invariance theory, and by Tsypkin in connection with self-learning systems.

The simplest type of an automatic optimization system is the extremal regulation system studied by Fitsner and others between 1957 and 1963.[124-127,694] Fitsner's subsequent work attempted to clarify the searching process for various applications.[127,128]

Stochastic methods of analyzing automatic optimization systems permitted the consideration of random drift of the object characteristics and random noise imposed on the output signal. The researchers involved in the effort were Fel'dbaum,[129,130] T. I. Tovstukha,[131] Ts. Ts. Paulauskas,[132] and S. A. Doganovskiy.[133]

The effect of low noise sensitivity in rigid-structure systems without clearly expressed adaptation processes, equivalent to self-adjusting systems, was studied by Meyerov.[134]

Another area of research was the study of automatic search principles using a self-adjusting model of an object rather than using the object directly. The group of workers active in this area includes K. B. Norkin,[693] L. M. Osovskiy,[135,136] Ye. P. Maslov,[137-139] S. D. Zemlyakov, and V. Yu. Rutkovskiy.[140] I. I. Perel'man applied regressive methods in this work.[141] Adaptation principles using a model but avoiding the searching mode were advanced by Rutkovskiy and I. N. Krutova[142-144] and later by Rutkovskiy and Petrov.[122] A thermodynamic model of adaptation was studied by Yu. I. Shmukler.[145]

The above list of research workers engaged in the adaptive systems area reveals a distinct group of names linked by co-author associations evident from 1961 to at least 1967 (see Appendix A chart). The interesting feature of this group is that it brings together work on adaptive systems with rather intensive research on the invariance principles and systems with variable structure. In addition to Petrov, Yemel'yanov, Rutkovskiy, and Zemlyakov, this group includes V. I. Utkin, N. Ye. Kostyleva, M. A. Bermant, M. B. Gritsenko, I. N. Krutova, Y. I. Mishenin, and V. A. Viktorov.[120-122,140,146-149]

The class of automatic learning systems is defined as comprising a type of adaptation process in which the quality criterion varies until it enters the permissible region. The corresponding theory is regarded as being still in its initial stages. Such a theory may be based on the principle of dual control (see above) where in the absence of a known stochastic distribution of object parameters the control element accumulates information on these parameters from cycle to cycle. Again, Fel'dbaum provided an analysis of this type in 1964.[150] Other contributors of theoretical insight were Tsypkin[83,84] and Yu. P. Leonov,[163] who published papers in 1966 and 1968.

Pattern recognition systems constitute an element of the class of automatic learning systems. It is claimed that pattern recognition machines were being developed at the Institute as early as 1964. The The problem then consisted in designing a machine or a universal computer program capable of clarifying input situations by a learning process rather than by previously defined criteria. In this work the Institute pursued two directions of research. The first consisted of a geometric interpretation of the problem as a grouping of points in fixed space into sets, where the only association criteria available can be derived from examples of points already belonging to specific sets. This problem was studied by E. M. Braverman, beginning in 1960,[151] who then advanced an intuitive hypothesis of the compact nature of the point assembly in receptor space[152] and proposed two learning algorithms: the random-plane algorithm,[152] and the potential-function algorithm discussed by M. A. Ayzerman in 1962 and developed by Braverman and I. B. Muchnik in 1964.[153,154] These algorithms were used in experiments with general-purpose computers learning to recognize decimal digits. Braverman, Ayzerman, and Rozonoer further developed the potential-function method and the compactness hypothesis.[155] For example, the perceptron, such as the Mark-1, was conceived as a manifestation of the potential-function principle solving the convergence problem of the perceptron algorithm.

The second approach was based on the idea that classes of patterns are determined not only by their subjective properties, but also by the subjective properties of the recognition machine. The concept of a "generalized portrait" was introduced as a vector in the state space of the learning machine. The scalar product of a vector representing the state of the machine confronted by an input pattern and the "generalized portrait" of a given class could attribute the pattern to that class. This approach was pursued in 1962 and 1963 by V. N. Vapnik and A. Ya. Lerner.[156,157] L. M. Dronfort regarded this approach as a problem in which one machine simulates the pattern classification performed by another machine.[158]

In 1963 Braverman introduced new aspects to the design of learning machines, such as learning time-dependent transformation of input-into-output patterns and accumulation of control experience.[159] In 1964 Vapnik designed an analog computer for automatic determination of the "generalized portrait."[160]

Materials on pattern recognition continued to be published beyond 1964 only in the form of patents, although the 1967 account of the Academy of Sciences, USSR, notes the Institute's mode in pattern-recognition learning applied to recognition of speech signals, diagnosis of diseases, acoustic diagnosis of machine defects, and classification of minerals and geologic strata.[793]

Theory of Invariance Group

Span of Years	Name of Author	Reference Number
1964-1967	V. Yu. Rutkovskiy*	121,122,140,142-144
1955-1967	B. N. Petrov*	14,113,116-118,120-122,146,148,149
1967	V. I. Mishenin	146
1967	V. A. Viktorov	146
1967	S. D. Zemlyakov	140
1962-1966	S. V. Yemel'yanov*	10,11,117,118,120,147-149
1966	M. B. Gritsenko	149
1963-1964	N. Ye. Kostyleva	11,148
1963-1964	V. I. Utkin	120,147
1964	I. N. Krutova	142-144
1954-1963	G. M. Ulanov	114,115,117
1963	Ye. B. Dudin	118
1962	M. A. Bermant	10

Individual Authors

Span of Years	Name of Author	Reference Number
1960-1968	Ya. Z. Tsypkin*	82-84,104
1968	P. A. Ilyukhin	692
1968	A. V. Lanshin	692
1968	Yu. I. Shmukler	145
1968	K. K. Zhiltsov	692
1964-1967	A. I. Propoy	82,87

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1967	I. S. Ibragimov	98
1949-1966	A. A. Fel'dbaum*	88,90-92,108,109,123,129,130,150, 687,691
1952-1966	A. Ya. Lerner*	89,94,157,686
1966	Yu. P. Leonov	163
1959-1964	L. I. Rozonoer*	96,97,119,155,685
1960-1964	Ye. M. Braverman*	151,152,154,155,159
1960-1964	L. N. Fitsner*	125-128,683,684
1962-1964	M. A. Ayzerman	153,155
1962-1964	V. P. Vapnik	156,157,160
1963-1964	Ye. P. Maslov	137-139
1964	O. A. Bashirov	154
1964	A. Ya. Chervonenkks	160
1964	M. S. Epelman	161
1964	I. B. Muchnik	154
1964	R. S. Rutman	161
1964	V. A. Trapeznikov	688
1964	V. P. Zhivoglyadov	110,139
1962-1963	L. S. Kirillova	102
1963	L. M. Dronfort	158
1963	L. M. Osovskiy	135,136
1963	A. A. Pavlov	93
1963	I. I. Perel'man	141
1963	Yu. S. Popkov	694
1963	M. V. Meyerov	134
1963	L. P. Sysoyev	107
1957-1962	V. S. Pugachev	106
1960-1962	A. M. Letov	99,100
1961-1962	M. Ye. Salukvadze	101
1962	K. B. Norkin	693
1962	Ts. Ts. Paulauskas	132
1959-1961	A. G. Butkovskiy	94,95,685

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1961	I. A. Litovchenko	103
1960	S. A. Doganovskiy	133
1960	V. N. Novoseltsev	105
1960	T. I. Tovstukha	131
1955-1959	V. S. Kulebakin	111,112
1959	V. A. Ivanov	689
1959	V. Yu. Nevrayev	690
1957	I. S. Morosanov	124

Relay Systems and Finite Automata

Beginning with 1942, the Institute commenced planned comprehensive research on the theory of relay devices in connection with the design of complex remote control systems. This work can be divided into three periods.

The first period from 1942 to 1950 was marked by the review of previous research and the development of terminology; the central figure in this period was M. A. Gavrilov, who was active from 1945.

The second period from 1950 to 1957 marked a concentrated attention on the problems of structural synthesis and analysis of relay systems. Again, Gavrilov was the principal investigator in this field.[164] Another prominent worker in that period was G. N. Povarov.

In structural analysis, topological methods of identifying networks operating on a given element (the cross-sectional method) were developed by Gavrilov.[165] Povarov continued this work and, in 1956, published papers on matrix methods of analyzing the structure of relay systems and the solution of the problem of determining the number of paths in a relay system structure.[166] He also generalized this to the analysis of networks and partially oriented graphs.[167] Povarov also at that time published a paper on the minimum structural elements in relay switching systems.[168]

In structural synthesis, Povarov developed one of the first algorithmic methods of synthesizing bridge structures--called the cascade method[169]-- and a graphic method of synthesizing symmetric structures.[170] General methods of designing bridge structures, such as the method of false networks and the method of cross sections, were developed by Gavrilov.[171,172] The synthesis of individual classes of relay systems was performed by V. M. Ostianu and V. I. Ivanov.[173,174] In 1956 the first prototype of a machine for analyzing systems with 20 variables was built by P. P. Parkhomenko.[175] The prototype of this machine was later adopted by industry.

The third period extends from 1958 up to the present and is marked by work in the abstract theory of relay systems, theory of finite automata, and considerable expansion of work on structural theory. Structural reliability of relay systems and theory of signals, as well as mechanization of relay systems synthesis, were also studied.

The theory of finite automata began in 1960. From 1960 to 1963 most of the work in this area was done by M. A. Ayzerman, L. A. Gusev, L. I. Rozonoer, I. M. Smirnova, A. A. Tal', and O. P. Kuznetsov. The main attention of these scientists was centered on developing a language for writing the algorithms of the machine design. It was proved that the problem of recognizing the representation of recursive events cannot be solved algorithmically.[176] Consequently, the problem of synthesizing an automaton can be formulated only in a language that is different from the natural language. As a result, a special method of synthesis was proposed in which the problem is not formulated in advance and the necessary information is obtained in the form of answers to typical questions occurring in the synthesis itself (questionnaire language). This was studied in 1964 by A. A. Tal' and in 1969 by Parkhomenko.[177,178] Another area developed by the Institute concerned the Glushkov language of regular formulas, the predicate language of Trakhtenbrot, and the theory of asynchronous automata developed primarily by O. P. Kuznetsov.[179-181] An area of abstract theory of relay systems is the theory of distribution or coding of states. This is a study of instability and reliability of operation of the system. The main problem here is the determination of minimal necessary redundancy. The distribution of states theory was developed by Yu. L. Tomfel'd and Parkhomenko.[181,182] The questions of redundancy to improve reliability were studied by Gavrilov.[183,184]

Another method of solving this problem was furnished by the theory of correcting signals, considered equivalent to the task of determining minimum redundancy. The theory of signals was developed by R. R. Varshamov and Ostianu,[185] and permitted a solution in the most general form for any probability distribution of noise sources, including nonsymmetrical distortion. There is evidence of a systematic research effort on the theory of codes and coding, extending from 1963 to at least 1968, and mainly due to Varshamov, who published papers on linear error correcting codes,[186] theory of nonsymmetrical codes,[187] and others.[188,189] In 1968 Varshamov took out a patent for a decoder device.[190] It should be noted at this point that while Varshamov has been explicitly associated with the research work on finite automata, the specific purpose of his work on the coding theory is not clear. Ostianu, the other key researcher in this field, published papers on asymmetric codes,[191] and on the construction of nonbinary signals.[192] His contribution in this field, however, does not seem to extend beyond 1963.

A major part of the work on relay systems and finite automata carried out by the Institute concerned the theory of minimization of structures. The approach here consisted of the development of methods, based on the comparison of working and forbidden states, aimed at the achievement of minimal forms. To obtain general minimal forms, a so-called test method was suggested and found to be most effective in terms of the number of operations. The principal workers in this field were G. V. Tumanyan, V. P. Didenko, and V. D. Kazakov.[193-200] Other finite automata specialists such as Parkhomenko, Tomfel'd, and Timofeyev also participated in this effort.[201-203] The construction of absolute minimal forms is the most difficult problem in the theory of relay systems. Its solution is now only possible in the individual cases of ordered structures. A general solution of this problem was given in the case of symmetric structures. It must be noted that no further evidence of this work is available beyond 1964.

Another important area of research concerning the structural theory of relay systems is the development of methods of synthesizing bridge structures. The key specialists in the general area of relay systems and finite automata, such as Didenko, Kazakov, Vavilov, Timofeyev, Tomfel'd, and Parkhomenko, were also concerned with this problem. Automation of the above design work obviously requires sophisticated computer equipment. There is indication that the Institute was engaged in the design of specialized computers for that purpose for several years.[205-208]

In general it should be noted that work on relay structures and finite automata in the Institute seems to have attenuated somewhat after 1964. The years 1963 and 1964 marked a high point of activity in this area. A number of workers at that time presented general papers, such as the state of relay devices theory by Gavrilov,[208] relay devices and finite automata by Kuznetsov,[209] and an operational study of relay structures by Vorzheva.[210] Other papers in this area from a later period deal with problems presented by work capacity control and trouble shooting in finite automata,[211] and realizing finite automata with two binary shift registers.[212]

Coding Theory Group

Span of Years	Name of Author	Reference Number
1964-1968	R. R. Varshamov*	186-190,726
1968	V. A. Arakelov	190,726
1968	G. M. Tenengolts	190,726
1963	V. M. Ostianu	191

Relay Network Group

Span of Years	Name of Author	Reference Number
1964	G. B. Tumanyan	203
1959-1963	V. P. Didenko	720,722
1959-1963	V. D. Kazakov	200,720,721
1959-1963	O. P. Kuznetsov	209,720
1959-1963	P. P. Parkhomenko*	201,719,720,727
1959-1963	B. L. Timofeyev	202,720
1963	Yu. L. Tomfel'd	201,209
1959	V. M. Kharlamov	720
1959	A. D. Talantsev	720

Individual Authors

Span of Years	Name of Author	Reference Number
1957-1969	P. P. Parkhomenko*	175,178,182,206,211,716
1968	V. V. Devyatkov	212
1965	V. V. Karibskiy	211
1965	Ye. S. Sogomonyan	211
1961-1964	A. A. Tal'	176,177
1963-1964	V. P. Didenko	193,196,207
1963-1964	O. P. Kuznetsov	179,180
1964	Ye. D. Stotskaya	180
1952-1963	M. A. Gavrilov*	164,165,171,172,183,184,204,208, 707,709-712
1960-1963	V. D. Kazakov*	194,195,197-199
1955-1963	V. M. Ostianu*	173,185,192,715
1963	V. R. Gorovoy	206
1963	V. M. Kucherov	206
1963	B. L. Timofeyev	205
1963	Yu. L. Tomfel'd	181,182,206
1963	R. R. Varshamov	185
1963	V. V. Vorzheva	210
1962	V. B. Naumchenko	198
1961	M. A. Ayzerman	176
1961	L. A. Gusev	176
1961	L. I. Rozonoer	176
1961	I. M. Smirnova	176
1959	A. D. Talantsev	708
1955-1958	V. I. Ivanov	174,713,714
1955-1956	G. N. Povarov*	166-170

Remote Control

In the course of theoretical research on the problems of remote control, the Institute developed detailed analyses of multi-channel and multi-level information transmission systems and defined the characteristics of the equipment. The existence of noise-proof parameters was determined and specific problems of optimizing transmission parameters in telemetry and remote control channels were solved for various types of modulation and coding systems. The principal investigators in this field, from 1955 up to the present, are V. A. Il'n and G. A. Shastova,[213-215] working with the participation of V. A. Kashirin and R. R. Vasil'yev.[216-218,220] Kashirin's contribution started in 1955 when he reported on a telephase meter developed by the Institute.[221] At that time Shastova was designing noise-proof capabilities in remote control systems.[222]

In 1960, noise-proof properties and efficiency of information transmission in remote control systems were studied by L. V. Venchkovskiy,[223] who a year later published a paper on calibration procedures in using the photographic method for analyzing random processes.[224] One of the most effective statistical methods to decrease noise and increase efficiency was found to be statistical coding applied to a set of control objects,[225] by Vasilyev and Shastova in 1963. Shastova continued this work in 1964-65,[226,227] and Vasilyev in 1967.[228]

An interesting development in 1959 was the application of adaptive methods to systems of information transmission. N. V. Pozin found that the adaptive principle can be successfully applied to the flow of telemetered information.[229] In the same year Pozin, together with a large group of co-authors, published a paper on the theory of information transmission,[728] which was delivered at the Sixth Scientific Technical Conference of Young Scientists held at the Institute of Automation and Remote Control. Some of the other co-authors, such as Venchkovskiy, Chugin, and Zenkin, were members of the Institute active in the remote control field. No further indication of Pozin's work is available, however.

Another interesting result was the development in 1962 of a new method of receiving pulse signals with a time selector built of bridge elements. This system, characterized by a high noise stability and efficiency, was developed by A. I. Novikov.[230]

The theory of control information transmission has been developed in the Soviet Union for certain classes of codes and certain types of noise. Further development was deemed necessary for application to more complex codes and noise, and to the transmission of information in large systems with a highly developed hierarchy.

Work on reliability of remote control systems picked up in intensity in the second half of the fifties in connection with remote control of distributed objects. Il'n reported the existence of a reliability optimum in transmission network structures in remote control systems, and the solution of problems of optimizing such structures for distributed objects with a single-step control.[214] Il'n has been writing consistently on problems of telemetry and remote control since 1955, when he considered multi-channel telemetering systems.[231,232] In 1964 he worked on the stability of pulse devices[233] and complex remote control and teleautomatic systems with computer application.[234] A year later he reported on large telemechanical systems with multi-step control.[235] In 1968 he contributed encyclopedic articles on remote control systems.[215]

V. A. Zhozhikashvili and A. L. Raykin were a team in 1962 and 1963 concerned with the operating conditions and operational reliability of remote control systems. They considered the method of self-control with automatic detection of defects and programs for standby block systems.[236,237,239] Large systems for handling pipeline control were also the concern of V. A. Lytskiy, who considered the problems of structural organization and increasing the accuracy of telemetering processes.[238] Continuation of theoretical work on reliability of remote control systems in subsequent years was evidence by Ya. G. Genis and E. M. Mamedli, who analyzed the reliability of majority structures,[729] and by K. K. Abramov and L. I. Gusyatinskiy, who patented a device for increasing the reliability of telecommunications channels.[240]

Individual Authors

Span of Years	Name of Author	Reference Number
1955-1968	V. A. Il'n*	213-215,231-235,237,730
1967-1968	Ya. G. Genis	729,741
1967-1968	E. M. Mamedli	729,741
1968	V. L. Bakhrakh	736
1967	K. K. Abramov	240
1967	L. I. Gusyatinskiy	240
1967	E. O. Vasilyev	228

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1966	M. A. Rozenblat	731
1955-1965	G. A. Shastova*	217,222,225-227
1955-1964	R. V. Bilik	734,735
1960-1963	P. P. Vasil'yev	217,225
1962-1963	A. L. Raykin	236,239
1962-1963	V. A. Zhozhikashvili	236,239
1963	V. A. Lutskiy	238
1959-1962	Yu. I. Chugin	218,220,728
1962	A. I. Novikov	230
1959-1961	L. B. Venchkovskiy	223,224,728
1955-1959	V. V. Kashirin	216,221
1959	V. M. Baykovskiy	728
1959	S. N. Diligenskiy	728
1959	M. Yu. Gadzhiyev	728
1959	S. I. Ogandzhanyants	728
1959	N. V. Pozin	229,728
1959	V. D. Zenkin	728
1955	V. P. Demeshin	733
1955	A. V. Khramoy	739
1955	A. M. Petrovskiy	738
1955	V. I. Stepanov	737
1955	V. N. Tutevich	740
1955	S. M. Yakovlev	732

Mathematical and Physical Modeling Methods and Applied Mathematics

The development and application of physical and mathematical modeling methods began in the Institute in 1947. In the Leningrad Department of the Institute, a theory and the principles of designing special electrodynamic models were developed for large consolidated power systems.[241] A report on this work was published in 1955 by N. P. Kostenko and I. D. Urusov,[242] who described electrodynamic models of hydrogenerators for the Kuybyshev power plant.

One of the early workers in this field was B. Ya. Kogan, who discussed model studies problems in 1955.[243] According to Kogan, the Institute fostered the use of analog and digital computers, which he considers as models of indirect analogy.[244] Consequently, a large proportion of the work performed in the fifties consisted of the development of software and the appropriate mathematical apparatus for analog and digital computer operation and involved a relatively large number of specialists, including Kogan, Fel'dbaum--known for his adaptive systems work--M. A. Shnaydman, and others.[245-251,784]

The development of discrete or pulse-type automatic systems, described above, stimulated the search for methods of analyzing such systems by mathematical modeling. Methods of designing various pulse elements from typical linear and nonlinear logic elements of an analog computer were suggested by Shnaydman.[252]

Mathematical research was stimulated by the search for solutions to finite linear and nonlinear equations. Methods of setting up systems of differential equations based on the second Lyapunov method were developed by N. V. Rybashov,[253-255] who is one of the active aplied mathematicians of the Institute, publishing in this field since 1959.[276-278] From 1963 Rybashov worked with N. N. Karpinskaya and Ye. Ye. Dudnikov on the solution of mathematical problems using linear programming in conjunction with analog computers,[257,279] and in 1968--again with Dudnikov and a group of co-authors--he published a paper on mathematical models of optimal compounding of fields.[256] There are other indications of the application of mathematical modeling to the solution of specific technological problems in recent years, such as mathematical simulation of heat exchange by G. L. Polyak, M. Kh. Dorri,[258] and A. A. Tal';[775] determination of the structure of a mathematical model applied to a continuous industrial complex by L. G. Biskin;[259] and mathematical modeling of the synthesis of vinyl chloride by V. S. Beskov.[260]

In recent years, mathematical modeling machines also have been widely used as component parts of complex control systems. For example, the control method that uses forecasting requires an analog computer operating on an accelerated time scale with iterated solutions. Another example is the use of analog computers for correcting the parameters or regulators in adaptive systems operating on objects having time-dependent characteristics. The workers responsible for this type of application are F. B. Gul'ko, N. N. Mikhaylov, Zh. A. Novosel'tseva, and Kogan.[261-263]

The application of digital computers to mathematical modeling was studied by E. E. Zulfugarzade.[669] The literature for 1967 and 1968 contains material in the field of function analysis and operator calculus, which may have a bearing on the described area. A team of co-authors in this field consisted of N. A. Krasnosel'skiy, V. Ya. Stetsenko, P. P. Zabreyko, V. V. Strygin, Yu. V. Pokornyy, and V. N. Gershteyn.[264-269] Other mathematical papers of possible pertinence were published steadily in small numbers from 1965 to 1969.[755,270-275]

Mathematical Modeling Group

Span of Years	Name of Author	Reference Number
1959-1968	M. V. Rybashov*	256,276-279
1965-1968	Ye. Ye. Dudnikov	256,279
1968	V. C. Chinakal	256
1968	A. P. Kravchenko	256
1968	B. I. Kusovskiy	256

Mathematical Analysis Group

Span of Years	Name of Author	Reference Number
1967-1969	M. A. Krasnoselskiy*	264,266-269,275
1969	Yu. V. Pokornyy	275
1968	V. M. Gershteyn	268
1967	V. Ya. Stetsenko	267
1967	V. V. Strygin	269
1967	P. P. Zabreyko	265,267

Individual Authors

Span of Years	Name of Author	Reference Number
1968	A. Ya. Chervonenkis	746
1968	Ye. A. Lifshits	274
1968	L. G. Pliskin	259

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1968	B. N. Sadovskiy	274
1968	V. N. Vapnik	746
1967	Yu. N. Andreyev	271
1967	A. Yu. Levin	273
1967	V. M. Orkin	271
1967	M. V. Vishnyakov	273
1967	E. E. Zulfugarzade	669
1966	V. A. Chernyatin	270
1966	M. Kh. Dorri	258
1966	G. L. Polyak	258
1965	V. S. Beskov	260
1965	V. Ye. Goryushko	260
1965	M. V. Meyerov	755
1965	M. G. Slinko	260
1965	G. S. Yablonskiy	260
1964	N. N. Mikhailov	263
1964	Zh. A. Novosel'tseva	263
1955-1963	B. Ya. Kogan*	243,244,248,250,251,261
1961-1963	M. V. Rybashov*	253-255,257
1963	F. B. Gul'ko	261,262
1963	N. N. Karimskaya	257
1953-1960	M. A. Shnaydman	245,252
1955-1959	M. P. Kostenko	241,242
1959	A. A. Fel'dbaum	246
1959	N. L. Sosenskiy	247
1958	Yu. V. Novikov	745
1957	A. A. Tal'	775
1955	V. I. Ivanov	784
1955	P. I. Ryzhov	784
1955	V. K. Sirotko	784
1955	V. A. Trapeznikov	249
1955	I. D. Urusov	242

DESIGN AND CONSTRUCTION

Automatic Regulation and Control

Modular Systems Design. The concept of modular design of automatic control systems (AUS) was first advanced by the Institute in 1950. In an article by V. A. Trapeznikov and A. Ya. Lerner,[280] the modular principle was defined as follows: a modular system or device is a combination of several independent modules, each of which performs a specific function; different combinations of modules provide the necessary variety of devices to accommodate a range of purposes; the modules themselves can be modified by interchange of individual internal units; and the compatibility of different modules is assured by input-output standardization. The standardized modular concept provides for electrical, pneumatic, and combined forms of energy input to the system. Beginning in 1950, the Institute has been developing all three versions of modular structures.

A formal statement of the principles of standardized modular systems was made by Trapeznikov in 1955.[281] The development of prototype hardware in the electrical version of the standardized modular system reached a point, some years ago, where it was possible to establish standard technical specifications for all the main modules of automatic control systems and have them approved for inclusion in the official State Systems of Automation Instruments and Equipment, published in 1962 as a government standard.[282] A more up-to-date description of the specifications of the State Systems of Automation Instruments and Equipment was published in 1967 by Ye. K. Krug,[283,295] one of the active designers of the system.

An item of industrial automatic control equipment subject to such standardization--and particularly stressed by the Institute--is the contactless actuator discussed by Trapeznikov as early as 1955.[671] This has replaced the previously used contact relay motor systems, has been mass produced since 1958, and is being widely utilized in various branches of the industry for regulating temperature, level, pressure, rate of flow, etc. Contactless actuators were developed by Krug, O. I. Aven, and S. N. Domanitskiy.[284,286] The Institute developed a series of experimental prototypes of contactless actuators with magnetic amplifiers and motors ranging from 5 to 1,000 watts.[287]

A group of workers, consisting of Krug, Minina, P. M. Aleksandridi, I. L. Medvedev, and V. A. Khokhlov specialized in the development of electrical analog and digital regulators that allow for the selection of adjustment parameters based on the dynamic properties of the object of regulation. Examples of such regulators are the TSR-2 single-channel regulator and the MR-1 multi-channel regulator. The work has been carried on since 1962; a number of patents were published in 1967.[288-294,296,670]

Contactless Actuator Group

Span of Years	Name of Author	Reference Number
1963-1968	S. N. Diligenskiy	290,774
1968	V. V. Shulpekov	670
1956-1964	Ye. K. Krug*	286,288,290,292
1962-1964	O. M. Minina*	288,289,291,292
1963	T. M. Aleksandridi	290
1956-1960	O. I. Aven	284-286
1956-1960	S. M. Domanitskiy	284-286
1950-1956	A. Ya. Lerner	280,284
1956	E. D. Demidenko	286
1950-1955	V. A. Trapeznikov	280,671

Individual Authors

Span of Years	Name of Author	Reference Number
1966-1967	Ye. K. Krug	283,295
1967	I. L. Medvedev	294,296
1966	V. A. Khokhlov	293
1962	V. V. Karibskiy	282
1962	B. S. Sotskov	282
1960	D. E. Polonnikov	287
1955	V. A. Trapeznikov	281

Automatic Control of Electric Drive. One of the major areas of research and development singled out in the accounts of the Institute's work is the automatic control of electric drive, in connection with the planned effort to replace complex mechanical transmission elements of industrial machinery by synchronized individual drive systems.[320] Beginning in 1945, the research explored problems of continuous control of DC motors, involving amplidynes and controlled generators. The key researchers in this area are A. A. Bulgakov, Ye. D. Demidenko, and Ye. L. Orkina. The problem of automation of electric drive was described extensively at the Institute.[667,668] In the early years, work on general problems of automated electric drive, continuous control of DC motors, and speed control of AC motors and generators was developed by V. S. Kulebakin.[297-300] Thyratron-controlled servo drives were designed by Bulgakov,[301] who also submitted designs for automatic regulators of optimal regimes and frequency control of asynchronous motors.[302,303,672] Other frequency converter devices for motor control were developed by I. B. Semenov[304] and V. A. Il'n.[305] Research in the fifties in this area also included M. A. Boyarchenkov and a group of co-authors,[667] A. B. Chelynstkin,[668] Ye. K. Krug, who wrote on electric power units with controllable speed,[306] V. B. Gogolevskiy,[307] V. N. Bogoyavlenskiy, who studied controlled asynchronous electric drives,[308,309] D. P. Petelin, who dealt with automatic frequency control systems for synchronous generators,[310,311] and others.[674-679] The work was carried on well into the sixties, resulting in a number of patents granted to Ye. L. Orkina in 1967 for a reversing thyristor servo drive control,[312] and to A. Ya. Lerner and others for automatic power control of an engine-type electric drive.[313,673] Orkina also published papers on anti-parallel connection of semiconductor-controlled diodes in 1965[314] and the use of thyristors in controlling asynchronous motors in 1969.[315] Work on electro-hydraulic servo mechanisms was reported by A. R. Kazbekov and I. M. Krassov.[316] Electronic automatic control devices with magnetic tape memory were being developed from 1964 on by Bulgakov.[317,318] Bulgakov further designed program control with multi-track recording and frequency channel separation.[319] Design work aimed at replacing complex mechanical linkages between individual parts of machinery by synchronous tracking systems was carried out by Demidenko.[320] One of the prominent theoreticians of the Institute, V. V. Tsokanov, in 1964 published an article on a reversible, collectorless, direct-current electric drive.[321] V. N. Shadrin in the same year studied split-phase systems.[781,782]

Individual Authors

Span of Years	Name of Author	Reference Number
1965-1969	Ye. L. Orkina	312,314,315
1959-1967	B. G. Volik	313,673
1967	A. F. Baryshev	313
1967	A. R. Kazbekov	316
1967	I. M. Krassov	316
1967	A. Ya. Lerner	313
1959-1964	A. G. Cherkashin	667,679
1964	Ye. D. Demidenko	320
1964	V. A. Il'n	305
1964	V. N. Shadrin	781,782
1964	V. V. Tsokanov	321
1960	A. B. Chelyustkin	668
1954-1959	A. A. Bulgakov*	301-303,317-319,672
1959	M. A. Boyarchenkov	667
1959	Ch. Chao	667
1959	V. B. Gogolevskiy	307
1959	O. A. Kossov	667
1959	L. A. Milovidov	677
1959	I. B. Semenov	304
1959	V. S. Volodin	678
1959	A. A. Yanshin	667
1959	V. Z. Yarina	304
1951-1958	V. S. Kulebakin*	297-299,762
1958	V. N. Bogoyavlenskiy	308,309
1958	V. Yu. Nevrayev	674-676
1958	D. P. Petelin	300,310,311
1957	V. V. Gorskiy	298,763,764
1955	Ye. K. Krug	306
1954	A. M. Agafonnikov	317

Adaptive and Optimizing Systems for Automatic Regulation and Control. In the sixties the Institute did a considerable amount of work on the development and design of automatic optimizers of the extremal regulation type for industrial process control. The principal types of optimizers include the 1-AO-1-1 type, designed to find the minimum or maximum of a process quality indicator for a single variable, developed by L. N. Fitsner;[322] the 1-AO-1-2 multi-variable optimizer;[323] the 2-AO-12/5 electronic optimizer; and the 3-AO-10/5 electronic relay optimizer described by A. A. Fel'dbaum and A. B. Shubin.[324,325] It should be noted that Fitsner and Fel'dbaum are well-known theoreticians of the Institute.

The 1-AO-1-2 optimizer is part of the ARP-1 machine-tool control system, and both the 1-AO-1-1 and the 1-AO-1-2 types are manufactured by the industry under model designations ERA-1 and ERA-2. The electronic and electronic relay optimizers are used in machines for automatic synthesis of control systems, as well as for independent purposes.

The theoretical concept of a variable-structure control system described earlier was applied to the development of high-quality control of objects with interrelated technological parameters and characterized by time-lag operation. Again in this case the device, an integral regulator, was designed by the theoretician Yemel'yanov.[326,327] Yemel'yanov, with a team of designers including I. A. Burovoy, M. S. Lodyseva, and A. A. Rassmotrov, also developed systems for improving the dynamics of control of objects with large time constants operating under noisy conditions,[328] and a regulator for the control of transient processes.[329]

In the last four years Fitsner continued to work on automatic optimizers,[330,331] and more evidence appeared on adaptive systems hardware. Thus A. V. Kortnev and Ye. N. Dubrovskiy were given patents on self-adjusting systems with variable structure,[332] V. A. Putintsev received a patent for a method for regulating self-adjusting systems with a reference model,[333] and M. A. Rozenblat reported on the use of magnetic elements for the construction of learning systems.[334]

There is no evidence of a systematic effort involving any distinct group of authors in the area of learning machines. The only possible exception may be the work of G. P. Katys, V. B. Shirokov, and others on pattern recognition devices in 1968 and 1969. Patents were issued to this group for a symbol recognition system,[335] method of image scanning,[337] method for a two-dimensional resolution of an image,[338] and a device for recognizing printed characters.[651] A patent in this area for a method of recognizing specimens[162] was also issued to L. Ye. Chirkov and N. V. Kravtsov.

Variable Structure Regulator Group

Span of Years	Name of Author	Reference Number
1960-1964	I. A. Burovoy*	326-329
1960-1964	S. B. Yemel'yanov*	326-329
1964	M. S. Lodyseva	328
1964	B. V. Lunkin	327
1964	R. I. Rapoport	329
1964	A. A. Rassmotrov	328,329

Pattern Recognition Group

Span of Years	Name of Author	Reference Number
1968-1969	G. P. Katys*	335,337,338,651
1969	S. Ye. Zdor	335
1968	V. B. Shirokov	338,651
1968	V. D. Zotov	337,338

Individual Authors

Span of Years	Name of Author	Reference Number
1968	L. Ye. Chirkov	162
1968	Ye. N. Dubrovskiy	332
1968	A. V. Kortnev	332
1968	N. V. Kravtsov	758
1968	V. A. Putintsev	333
1966	A. A. Romashchev	334
1966	M. A. Rozenblat	334
1966	V. A. Semenenko	334

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1960-1965	L. N. Fitsner*	322,323,330,331
1960	A. B. Shubin	325
1958	A. A. Fel'dbaum	324

Remote Control and Telemetry Systems

Remote control systems have constituted one of the principal areas of development of the Institute from its inception. However, intensive work in this area began only in the fifties, stimulated by an urgent need for remote control equipment in connection with the limitations and disadvantages of electromechanical machinery. The search for new principles and new designs in information transmission methods led to the development of contactless remote control devices and the use of magnetic elements with a rectangular hysteresis loop.[717] The principal investigator in this area, V. A. Zhozhikashvili, designed pulse distribution units, decoders, and other devices based on cyclic transmission of information by contactless systems.[340-344] The Soviet authors claim that contactless remote control devices were developed in the West several years later than in the Soviet Union. The Institute's work on contactless systems of remote control with time separation of signals culminated in the construction of the BTF system of tone telegraph and the BTMR-62T complex system of communications. The team responsible for this work included Zhozhikashvili, I. V. Prangishvili, R. V. Bilik, and V. M. Kharlamov.[343,665] The BTMR-62T system was intended for work in physical experimentation; high-frequency, radio-relay radio transmitting; and electric power installations possessing typical communications equipment. There was also a tendency to standardize remote control devices using magnetic and semiconductor elements.[345] The experience accumulated in building contactless remote control devices served to increase their operating reliability and allowed the Institute to build complex systems with a very large number of elements, such as the TAF remote control system developed by the Institute to control airport ground lighting and radio equipment for aircraft landing.

Methods of reliability analysis of complex remote control equipment with up to 10^4 elements were applied by Zhozhikashvili to new systems based on ferrite diode elements.[346]

High-Q electronic circuits and filters with ferromagnetic cores developed by the Institute are widely used in the oil industry; 35 percent of all oil wells in the Soviet Union have been provided with CHT, GCH, and SRP-1 remote control systems. Complex remote control systems of the type KST (TRDS), BCHT-60, and TCHR-61, with a two-frequency code, are being mass produced by industry. The Institute has also developed asynchronous remote control systems based on pulse bridge elements designed by Il'in.[347] Another new direction of activity is indicated by the first telemetry system that self-adapts to the flow of transmitted information.[348]

Research on contactless teleautomatic systems has continued through the recent years. In 1968 a patent for a semiconductor contactless switch was issued to B. G. Kozhushko, V. K. Nesnov, V. S. Oseledko, and V. Ya. Rubin.[349] Prangishvili has been working in this area continuously since the fifties. From a 1959 research on contactless relays,[350] he went on to contactless teleautomatic systems controlling continuous transportation installations (1964),[351] contactless programming devices (1965),[352] and contactless electronic devices (1968).[353] The systems designed by Prangishvili mark a turning point in the work of the Institute, which began to develop teleautomatic systems with programming and logic elements for automatic sequencing of operations. The first such system introduced on a large scale was the BTA-PU-S system developed in 1964 for teleautomatic control of transport mechanisms.[355] In 1966 the Institute introduced the BTA-2 system for the mining industry.[793] N. P. Vasilyeva later investigated the functional stability of such systems.[356] Zhozhikashvili, with a team of coauthors, was granted a patent in 1968 on a device for telemechanical-sequenced transmission of information with time signals.[354]

Teleautomatic Systems Group

Span of Years	Name of Author	Reference Number
1955-1969	V. A. Zhozhikashvili*	340,341,343,344,346,354,393,766
1955-1969	K. G. Mityushkin	341,343
1959-1969	I. B. Prangishvili*	343,350-353,355
1969	R. V. Bilik	343
1964	N. B. Grinberg	355
1964	L. A. Levin	355
1964	A. A. Zak	355
1962	Yu. I. Shmukler	346

Individual Authors

Span of Years	Name of Author	Reference Number
1959-1968	V. N. Silayev	772,777
1968	Ye. V. Kartuzov	771
1968	V. G. Kozhushko	349
1968	V. S. Krutenko	772
1968	V. K. Nesnov	770
1968	V. F. Oseledko	773
1968	V. Ya. Rubin	773
1968	G. E. Shleyer	776
1967	N. P. Vasilyeva	356
1962-1963	V. M. Kharlamov	344,345
1963	V. A. Il'in	347
1962	V. Yu. Kneller	357
1959	Ch. Chou	777
1959	B. P. Petrukhin	350
1959	N. V. Pozin	348
1955-1957	B. S. Sotskov*	765,778-780
1957	V. N. Tutevich	342

Automatic Monitoring Systems and Devices

This category accounts for a large number of papers and patents that have appeared during the period from 1965 to 1969. Automatic monitoring hardware is defined by Soviet authors as equipment designed to receive information on the internal and external operating conditions of objects, to detect clues of the monitored events, and to generate appropriate response signals.[357,783] The task of the Institute was to develop the design principles for such systems, for application to complex objects and industrial installations, and to design the corresponding data processing hardware.

Theoreticians of the Institute, such as M. V. Rybashov and E. L. Itskovich, were active in developing systems of centralized monitoring of continuous production. A patent published in 1967 indicates active work proceeding in this area.[757] A laboratory prototype of a logic machine for the analysis and inspection of relay systems, developed by P. P. Parkhomenko,[364] was an early result of the effort to build universal machines for automatic product inspection. Parkhomenko also developed principles of designing universal testing machines of the PUMA type for automatic qualitative and quantitative inspection of various objects whose state and behavior can be described by electrical and time parameters.[365] Typical of the PUMA machines is an interchangeable testing program, universal commutator coupling to test objects, and universal measuring circuits with variable tolerances and ranges. The first laboratory prototype of the PUMA-1 machine was built in 1958 for automatic control of electrical and time parameters. Since then similar machines for automatic testing of assembly of electronic computers, automatic telephone station blocks, magnetic starters of electrical drives, and complex cable networks were built. For example, in 1967 the PUMA-E technical diagnostic machine was built to test electric locomotives.[792]

The data processing devices built by the Institute were based on a wide range of physical principles. The utilization of electromagnetic and magnetic phenomena to detect and measure the flow of gas, liquids, and solids was developed by a group of workers, some of whom, such as D. I. Ageykin and I. N. Panasenko, were active in this area for the past ten years. The early work consisted in developing gas analyzers for the detection of oxygen,[366-368] which led to the production of the TMG-5 magnetic gas analyzers used by the majority of Soviet cement plants, automatic potential meters,[369] electromagnetic flow meters,[370,371] and devices for selective analysis of multi-component mixtures.[372,373]

Ageykin and his group continued this work through the sixties; an indication of their progress was the publication of a sizable number of patents in 1967 and 1968 for sensors, flow meters, etc.[375,377-380] Primary converters with frequency-modulated output were designed for devices intended to transmit information only in response to a query signal, as in translation pickups, stress pickups, pressure gauges, etc.[391-395,374,376] Noteworthy also is the work of A. A. Desova on multi-component mixture analysis, carried on from 1959 to 1964,[381,382] research on mass spectrometers by I. A. Tsaturova in 1959,[383] and the application of the Mossbauer effect to high-speed spectrometers in 1965 by Yu. A. Kalnin, Yu. V. Gushchin, and N. Salakhutdinov.[384,514]

A group including L. V. Mel'ttser, N. A. Pivovarov, and Yu. V. Gushchin worked on the use of radioactive isotopes in flow meters and measuring instruments.[385-390]

A distinct group involving G. P. Katys worked from 1962 until at least 1968 on the application of optical systems to measure parameters distributed in space. This is the group mentioned earlier in connection with its work on pattern recognition devices. Axially symmetric scanning devices and photo-electronic and mechano-optical scanning devices for searching and tracking light-emitting sources were developed in 1962 and 1963.[396,397]

In 1967 and 1968 a number of patents were published in the same area covering photoelectric servo devices,[652] light source trackers,[336] position trackers,[339] scanning pyrometers, optical gauges, and similar instruments.[398-400] A device for manufacturing three-dimensional analogs of solids was patented in 1967 (published in 1968).[810] The scope of this group's work is also indicated by a paper on an electro-optical signal frequency converter.[653] In the same year Katys reviewed the principles of designing optical flow meters.[401] A general review of the field of optical data processing was published by B. I. Filipovich.[654]

New types of frequency-dependent bridge networks balanced by frequency variators only, suggested by the Institute, led to the development of universal heavy-current impedance converters. This work was done by

V. Yu. Kneller and associates, who had specialized in the design of automatic measuring bridges and AC compensators since 1959 and who continue to publish papers and patents on this subject.[402-406,655-657,790,791]

The Institute also designed prototypes of memory circuits based on electroluminescence.[407]

Radioactive Isotope Group

Span of Years	Name of Author	Reference Number
1959-1962	L. V. Melttser	387,388
1959-1962	N. N. Shumilovskiy*	373,387-389
1962	Yu. V. Gushchin	385,386
1961	V. D. Kiryukhin	389
1961	V. N. Pozdnikov	389
1961	V. A. Yanushovskiy	389

Automatic Measuring Bridge Group

Span of Years	Name of Author	Reference Number
1958-1968	V. Yu. Kneller*	357,402-405,655-657,790,791
1963-1968	L. N. Sokolov	402,656
1968	Yu. R. Agamalov	657,790
1968	A. A. Desova	657
1965	A. P. Filipenko	406
1958	N. N. Shumilovskiy	403

Measuring Instruments & Indicators Group

Span of Years	Name of Author	Reference Number
1957-1967	D. I. Ageykin*	366-368,370,374-376,391-395
1961-1967	N. N. Kuznetsova	375,376,392
1957-1964	A. A. Desova	370,381,382
1960	E. N. Kostina	395
1960	G. G. Yarmol'chuk	395
1957	B. E. Galkin	370

Optical Systems Group

Span of Years	Name of Author	Reference Number
1959-1968	G. P. Katys*	336,339,371,396,397,400,401,651,652
1963-1968	R. N. Blaut-Blachev	397-399
1967-1968	L. Ye. Chirkov	400,653
1967-1968	N. V. Kravtsov*	336,339,400,653
1968	Ye. P. Chubarov	339,651,652
1968	V. M. Ilinskiy	651
1968	S. M. Konovalov	339
1968	V. I. Lalabekov	339,652
1968	Yu. D. Mamikonov	651
1968	V. B. Shirokov	336
1968	A. M. Tishin	339
1968	V. D. Zotov	336

Individual Authors

Span of Years	Name of Author	Reference Number
1968	B. I. Filipovich	654
1968	T. D. Gagina	377
1968	G. I. Koretskiy	378
1968	M. P. Kostogryz	378
1968	G. I. Kotlyar	379
1968	V. V. Pechnikov	377
1968	V. N. Tikhonravov	377
1968	V. A. Torgonenko	377
1968	N. Ye. Zakharchenko	378
1959-1967	I. M. Panasenko	369,374
1965-1967	N. Salakhutdinov	514,384
1965-1967	A. A. Kalmakov	514,384
1967	V. A. Glazyev	380
1967	M. G. Grudin	757
1967	V. M. Ilyinskiy	789
1967	Yu. T. Knopov	375,376
1967	F. A. Lantsberg	757

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1967	A. M. Litvinov	757
1967	Yu. D. Lukomskiy	757
1967	M. V. Pashkovskiy	757
1967	A. S. Seryakov	374
1967	N. T. Sivakov	380
1967	V. Ye. Solodilov	514
1967	N. D. Topchiyeva	380
1965	Yu. V. Gushchin	384
1965	Yu. A. Kalnin	384
1965	Yu. M. Tsodikov	786
1964	A. I. Galaktionov	407
1964	D. E. Gukovskiy	360
1964	E. A. Trakhtengerts	359
1964	V. Ye. Yurchenko	359
1957-1963	E. L. Itskovich*	358,361,362,366
1959-1963	P. P. Parkhomenko	364,365
1959-1963	M. V. Rybashov	363,369
1963	V. I. Ivanov	783
1959	V. P. Grabovetskiy	787
1959	A. A. Naumov	390
1959	N. A. Pivovarov	390
1959	V. N. Skugorov	372
1959	I. A. Tsaturova	369,383
1957	V. N. Shadrin	788
1957	I. N. Vorobyev	366

Computers and Computing Devices

The Institute is claimed to be one of the first organizations in the Soviet Union which developed analog computer technology and applied it in research on automatic control systems. The development, beginning in 1947, was relatively rapid. Two years later the first simulator, the EMU-1, was put into operation to solve linear differential equations up to the tenth order with constant and variable coefficients. This was followed by EMU-2 in 1950, EMU-3 in 1951, EMU-4 in 1953, EMU-5 in 1954, EMU-6 in 1955, EMU-8 in 1957, and EMU-10 in 1960. In this series the EMU-5, 6, 8, and 10 were taken over by industry for mass production. The designers of this series of simulators were B. Ya. Kogan, V. V. Gurov, A. D. Talantsev, A. A. Maslov, V. M. Yevseyev, and D. Ye. Polonnikov.[408-413] The EMU series employed high-quality DC amplifiers with reduced zero drift, as developed by Yevseyev, Polonnikov, and Gurov.[414-417]

Fast-action analog computers were being developed in 1962 and 1963 by Polonnikov[442] and R. A. Tamrazov.[443]

In 1967 I. I. Perel'man and B. G. Zinovyev published patents on a similar machine designed to model processes involving large numbers of users.[759,760] These processes occur in the so-called "mass-service systems" that received a considerable promotion in the Soviet Union at that time, such as the Sirena automated airline reservation system developed by the Institute in 1966.[793]

Hybrid and digital computer development has been worked on by the Institute since 1959.[444-446,454] Two approaches to computer application were used: combining analog and digital logic elements in a single computer, and joint operation of simulators and digital machines.

The TSM-1 special-purpose hybrid computer built by the Institute in 1964 featured a number of parallel logic elements performing a single or several mathematical operations simultaneously according to fixed algorithms. The machine was claimed to be faster than general purpose digital computers, had simple programming similar to analog computers, could integrate with respect to any independent variable, and had a higher accuracy than analog computers. In 1964 a patent was issued to Kogan, Maslov, Shileyko, and others for the development of the digital converter units of the hybrid central processor of the TSM-1 computer,[455,696] an effort that required over five years to complete. In 1965, a patent for a digital computer with programmed circuit control was issued to a group headed by Trapeznikov and including T. A. Turkovskaya, V. D. Zenkin, V. A. Vedeshnikov, and A. F. Volkov.[456] A machine similar to the TSM-1 was patented in 1966 by G. Kh. Babich,

V. T. Lysikov, and F. V. Mayorov.[457] Finally, in 1967, O. I. Semenkov and E. E. Zulfugarzade published an article on the selection of the optimal structure for a general-purpose digital control computer.[458]

Research on automatic synthesis of control systems constituted a separate and significant aspect of the Institute's activities in the early sixties. The concept of automating the processes involved in the design of optimal systems of control was advanced in the Institute by Fel'dbaum.[459] This was later realized by Fitsner, and others,[460] in a series of machines under a generic term of automatic synthesizer. The function of the synthesizer is to determine the optimal processes that must be known in the synthesis of a given system. The automatic synthesizer may also determine the optimal law that relates the input and output of a given control system; the resulting control algorithm may then be used in turn to synthesize a control element that has the same or a similar algorithm. Finally, the automatic synthesizer can be used to formulate a structural principle according to which the real control system is designed. The synthesizer equipment consists of the Z-AO multi-channel automatic optimizer, UNP-1 and UNP-2 non-linear controllable converters, a ULF-1 controllable linear filter, and a CU-12 memory unit.[461-463]

The automatic design concept was also applied to relay systems and devices. P. P. Parkhomenko reported in 1959 on the design of a logic machine for automatic analysis of relay circuits.[364] A year later he reported on a high-capacity universal machine for the analysis of relay systems,[464] in which the structural synthesis and operational algorithms of multi-cycle systems are based on the concept of a single-cycle equivalent. The input and intermediate elements of the machine assume all the possible combinations of states by means of a binary-counter generator operating according to the Gray code. In addition to analyzing relay contact circuits,[500] this system may also be used to resolve a circuit into sections, to compare circuits with one another, to analyze relay structures using contactless elements, and to solve other logic problems. Such a system is now being manufactured by the Institute.

The development of automated synthesis of relay structures is aimed at the design of specialized logic machines for the minimization of Boolean functions and the construction of multiple-output systems. The first such project was the automation of the process in which minimal terms of Boolean functions were generated using the test method developed in the Institute.[465] The "Implikanta" logic machine was the result of this work.

EMU Simulator Group

Span of Years	Name of Author	Reference Number
1955-1964	B. Ya. Kogan*	408-413,455
1956-1964	A. A. Maslov*	410-412,455,696
1959-1964	A. V. Shileyko	444,446,455
1964	A. Ya. Biryukov	455
1964	A. I. Kaz'min	455
1964	G. M. Kozyreva	455
1964	V. P. Nazarova	455
1958-1962	D. Ye. Polonnikov*	412,416,417,442
1959	N. N. Mikhaylov	446
1959	Yu. G. Purlov	696
1956-1957	V. V. Gurov	409-411
1957	V. M. Yevseyev	411,415
1955-1956	A. D. Talantsev	409,414
1956	V. A. Trapeznikov	409,410

Individual Authors

Span of Years	Name of Author	Reference Number
1968	G. Kh. Babich	457
1968	V. T. Lysikov	457
1968	F. V. Mayorov	457
1967	I. I. Perel'man	759,760
1967	O. I. Semenkov	458
1967	B. G. Zinovyev	759,760
1967	E. E. Zulfugarzade	458

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1965	V. A. Trapeznikov	456
1965	T. A. Turkovskaya	456
1965	V. A. Vedeshnikov	456
1965	A. F. Volkov	456
1965	V. D. Zenkin	456
1963	R. A. Tamrazov	443
1958-1961	L. N. Fitsner	460,462,463
1961	A. V. Shubin	460
1961	R. P. Stakhovskiy	460
1956-1960	A. A. Fel'dbaum	459,461
1959-1960	P. P. Parkhomenko	364,464
1960	B. L. Timofeyev	465
1959	S. P. Adamovich	445
1959	B. N. Strelkov	454

Components and Units

An area that has received an intensive development in the Institute, both in terms of time and in number of participating workers, comprises magnetic amplifiers. The work started in 1944 with the research on ferromagnetic elements, and culminated in 1949 with the first two series of universal magnetic amplifiers. Each series featured high-sensitivity reversive amplifiers with a sensitivity threshold of 10^{-11} W, magnetic modulators with a sensitivity threshold of 10^{-16} and 10^{14} W, as well as amplifier and contactless magnetic relays from 1 to 50 W. The optimal standards of sensitivity, gain, weight, cost, etc., developed in the course of this work served as a foundation for a set of All-Union Standards, published in 1963, for a limited series of forsidal core types.[466,467] Since then, the development of magnetic amplifiers has been in Fifkier types, largely in the hands of a team whose most prominent member is M. A. Rozenblat and which includes O. A. Sedykh, F. I. Kerbnikov, M. A. Boyarchenko, and others. The earliest papers on this subject were published in 1955 dealing with the design of single- and double-cycle amplifiers, wound-type cores, power supply for magnetic amplifiers, etc.[468,469,471-475,742,743]

In 1959 new types of high-efficiency, high-speed amplifiers were designed combining magnetic and transistorized electronic elements.[481,482] The development of magnetic amplifiers by Rozenblat's group continued until the end of the period covered in this Report.[475-478,504] In addition, patents in this area were granted to V. A. Shabanov, Yu. V. Chernikhov, and others.[479-480] Beginning with 1964, Rozenblat's group expanded somewhat and V. P. Zinkevich appeared as his steady co-author. At the same time, the group broadened its area of activity and began to develop magnetic logic elements,[520-522,697,698,701,702] magnetic memory systems for analog computers,[434-437,699,700,703,704] and other components.[510,515,706]

Magnetic memory and logic systems for analog computers were also developed by other members of the Institute, such as K. B. Norkin[429,432,433] and others.[506,509,705,723-725]

In the area of magnetic and semi-conductor logic elements, the efforts of the Institute were directed toward the design of an industry-wide standard series of reliable elements for use in automatic control equipment.[490-492] Two systems of magnetic logic units, the ELM Units for 50 and 400 H_2, were developed using half-wave fast-acting magnetic amplifiers. The ELM-50 system includes the usual "and," "or," and "not" elements, together with denial, implication, equivalence and nonequivalence functions built into a single core along with memory circuits and time relay.[493-497] Such a system reduces the total number of logic elements in control systems by a factor of 1.5 to 2 in comparison to the conventional systems. The ELM-50 system is mass-produced and widely used in the industry. The ELM-400 system features an inverter module and has also been accepted for mass production.[498,718] The methods of synthesizing control systems using magnetic logic elements were described by N. P. Vasil'yeva and I. Gashkovets.[490,499]

The development of electronic amplifiers is largely due to D. Ye. Polonnikov, who has worked in this field steadily since 1955. The effort was directed mainly toward the design of amplifiers for automatic compensators, such as balancing bridges, on the one hand, and for the measurement of extremely low currents and voltages, on the other. Polonnikov proposed the principle of consecutive stages that increased the bandpass to 1 MH_2 (10_v scale) or 100 KH_2 (100_v scale), and developed the theory of the so-called operational amplifiers that was applied in the design of the EMU series analog computers.[484-487,505] While Polonnikov developed solid-state technology in his work on amplifiers, this has become the specialized province of D. A. Kossov and V. D. Averbukh, who designed effective solid-state converters and power amplifiers with pulse-width modulation applied to frequency-controlled AC machines and pulse-controlled DC machines.[483,488,489,501,502,507,511]

Semi-conductor logic elements, sensors, and similar components received the concentrated efforts of a large number of members of the Institute. Among several well-defined teams working in this area was that of I. V. Prangishvili, who since 1967 has specialized in developing integrated solid-state logic circuits.[427,428,441,695] Another specialist in solid-state computer elements is V. G. Mashlykin.[512,516,517]

The research of the Institute, reflected in these publications, culminated in the construction of a unified series of semi-conductor logic elements for industry-wide application, as developed by the Institute of Automation and Remote Control together with the All-Union, Scientific Research Institute of Electric Drive; Central Scientific Research Institute of the Ministry of Communications; the Design Bureau "Tsvetmetavtomatika" and a number of other organizations. The series of logic elements operates with a voltage power supply variation of ±20 percent in the temperature range -45^{o} to $+60^{o}$ centigrade at a frequency up to 20 KH.

The design of nonlinear logic elements was based on the use of cathode-ray tubes, diode converters, and arithmetic units; the theoretical foundation for it was provided by Fel'dbaum and Fitsner.[418,419]

Digital computer elements and digital instruments, such as digital computer systems, have only evolved in the Institute since 1964. The personnel that appears active in this field includes a team centered around S. P. Khlebnikov and A. A. Shulepov that specializes in the application of computer peripheral equipment to statistical processing of information.[438,439,448,451,453,680-682]

Other recent patent holders in this field are V. P. Nosenko and L. I. Sorokin,[525,526] S. N. Diligenskiy and Ye. I. Artamonov,* Yu. L. Tomfel'd,[450] and others.[447,452,524]

The patent literature of the last few years also contains a number of entries concerning logic devices, automatic instruments, and other elements of automatic systems, whose authors do not appear to have been engaged in a systematic development effort in this area.**

A noteworthy research is being pursued by a small group consisting of A. P. Shorygin, V. S. Bororkov, and V. V. Treyer. From 1966 to 1969 this group has been working on the application of electrochemistry to automatic control elements, such as controlled-resistance cells, electrochemical analog memory, solid-state electrochemical triodes, etc.[534-538,744]

Semiconductor studies were reported in 1967 by a small group of authors.[785]

Solid-State Electronics Group

Span of Years	Name of Author	Reference Number
1959-1966	O. A. Kossov*	481,483,502,507,511
1964	V. V. Tsokanov	507
1961	O. I. Khasayev	483

Electrochemistry Group

Span of Years	Name of Author	Reference Number
1967-1969	A. P. Shorygin*	536-538,744
1965-1966	V. S. Borokov	534,535
1965-1966	V. V. Treyer	534,535

Solid-State Logic Group

Span of Years	Name of Author	Reference Number
1967-1969	I. V. Prangishvili*	427,428,441,695

*See references 430,449,503,518.

**See references 420-426,431,440,508,513,519,523,527-533.

Solid-State Logic Group (continued)

Span of Years	Name of Author	Reference Number
1969	Ye. V. Babicheva	441
1969	V. M. Gusakov	441
1969	M. A. Korolev	441
1969	A. I. Mishin	441
1969	Ye. S. Selkov	441
1969	N. Yu. Shaipov	427,428
1969	M. A. Uskach	441
1969	E. V. Yevreinov	441
1967	N. F. Cherenkova	695

Peripheral Digital Equipment Group

Span of Years	Name of Author	Reference Number
1959-1968	S. P. Khlebnikov*	438,439,448,451,453,680-682
1966-1968	A. A. Shulepov*	438,439,448,680-682
1968	A. Ya. Biryukov	451
1967	S. L. Gurevich	448
1966	V. M. Chadeyev	439
1966	L. V. Gigineyshivili	439
1966	N. S. Raybman	439
1966	Yu. L. Romanov	439

Magnetic Amplifier & Logic Group

Span of Years	Name of Author	Reference Number
1966-1969	V. P. Zinkevich*	434,436,437,521,699,700
1958-1968	M. A. Rozenblat*	434,435,466,467,473,474,476,478, 482,515,522,564,697,698,700-704, 706
1964-1968	M. A. Boyarchenkov	476,699,701
1966-1968	R. S. Kasimov*	510,515,520,699
1968	V. K. Rayev	701
1967	Yu. V. Aksenov	515
1964-1966	O. G. Kasatkin	698,702

Magnetic Amplifier & Logic Group (continued)

Span of Years	Name of Author	Reference Number
1966	V. V. Vasilyev	510
1955-1965	O. A. Sedykh*	466,470,472,477,497,498,718
1955-1965	N. P. Vasil'yeva*	468,469,472,477,490,491,498,499
1959-1964	I. Gashkovets	475,490,499
1962-1964	V. S. Matorina	497,718
1964	F. I. Kerbnikov	476
1964	O. A. Vasilyev	718
1963	Yu. D. Rozental	564
1963	T. M. Vorob'yeva	491

Magnetic Logic Element Group

Span of Years	Name of Author	Reference Number
1961-1964	N. L. Prokhorov*	493-496,506
1962	I. M. Gorin	493-495

Individual Authors

Span of Years	Name of Author	Reference Number
1969	R. N. Blaut-Blachev	530
1969	L. Ye. Epshteyn	529
1969	Yu. N. Fedin	529
1955-1968	D. Ye. Polonnikov*	484-487,505
1959-1968	K. B. Norkin	429,432,433
1963-1968	Ye. N. Artamonov*	449,503,518
1963-1968	S. N. Dilingenskiy	503,518
1966-1968	V. D. Averbukh	488,489
1967-1968	R. N. Chernyshev	485,785
1967-1968	V. G. Mashlykin	512,516,517
1967-1968	A. M. Shubladze	424-426
1968	D. I. Ageykin	523
1968	G. P. Batukhtin	452
1968	A. Ya. Biryukov	528

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1968	I. V. Bizin	519
1968	V. M. Chernyshev	480
1968	Y. Yu. Chernikhov	479
1968	V. A. Kamenev	519
1968	M. F. Karavay	524
1968	V. F. Khalchev	524
1968	D. I. Kirvelis	527
1968	I. L. Medvedev	421
1968	V. P. Nosenko	525,526
1968	A. I. Pavlov	480
1968	A. M. Petrovskiy	431
1968	V. Ye. Petrukha	525
1968	N. V. Pozin	527
1968	V. A. Shabanov	480
1968	V. P. Shchupov	519
1968	V. L. Shinkarenko	452
1968	L. I. Sorokin	525,526
1968	V. I. Stakhno	479
1968	O. B. Suslova	429
1968	Yu. L. Tomfel'd	450
1968	V. I. Utkin	426
1968	V. B. Yezerov	426
1967	T. M. Aleksandridi	513
1967	E. S. Eykelman	440
1967	V. V. Gurov	420
1967	B. I. Kazndzhan	785
1967	S. B. Kleybanov	440
1967	Yu. S. Legovich	513
1967	G. A. Lutskevich	430
1967	V. T. Lysikov	725
1967	O. I. Semenkov	725
1967	E. M. Memedli	725
1967	M. P. Vukalovich	785

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1964-1966	S. M. Domanitskiy	423,492
1966	L. P. Afinogenov	422
1966	S. D. Altshul	422
1966	B. B. Buyanov	423
1966	G. I. Gilman	422
1966	M. P. Sakharov	447
1966	B. S. Tantsyura	723
1966	V. A. Trapeznikov	423
1966	V. A. Vedeshenkov	423
1966	A. F. Volkov	423
1965	N. S. Anishin	724
1965	V. S. Khitruk	508
1965	N. D. Nanobashvili	509
1965	G. G. Rekus	724
1964	B. P. Petrukhin	492
1952-1959	L. N. Fitsner	418,419
1959	L. V. Sentyurina	533
1959	S. F. Stepanov	501
1959	Ye. P. Svitina	532
1958	I. Ye. Dekabrun	531
1958	B. S. Sotskov	500
1955-1956	M. N. Gubanov	742,743
1955	F. I. Kerbnikov	705
1955	G. V. Subbotina	471
1952	A. A. Fel'dbaum	418

Hydraulic and Pneumatic Control Systems

The Institute initiated the development of the standardized modules-type of pneumatic systems for automatic control that have been introduced into the industry. The pneumatic systems consist of individual modules, each of which is designed to perform a specific function such as formulation of the problem, generation of the control action, algebraic addition of signals, etc. The inputs and outputs of each module are standardized. The requirements imposed upon the structural form of the modules, such as compactness, standardization of types and standardization of parts, as well as the necessary accuracy, are met by using force and flow-rate compensation instead of movement compensation. The Institute followed two basic technical design principles:

1. The construction of instruments and systems from modular elements using "printed circuit" technology;
2. Construction of instruments without moving or elastic parts, using the effects of direct interaction of jets.

An example of the modular principle is the USEPPA universal system of industrial pneumatic control elements, developed and introduced into the industry by the Institute together with the Moscow "Tizpribor" plant.[539] The USEPPA system consists of a set of simple universal elements equipped with standard bases and mounted on special assembly panels. The panels are provided with connecting channels fabricated by the "printed circuit" technology. There are two main variants of pneumatic equipment: continuous-action, and discrete-action systems. The basic elements of continuous-action systems are amplifiers, passive elements (pneumoresistors and pneumocapacitors), and pneumorepeaters. The main elements of the discrete-action systems are pneumorelays that can solve all algebraic and logic functions. The pneumoautomatic systems are now considered adequate to perform not only automatic stabilization functions, but also automatic optimization functions involving control of cyclic processes and remote control systems. The USEPPA system has been patented by the Institute in a number of countries.

The second version of development is based on the aerodynamic principle of design called pneumonics and involves the properties of fluid flow without the use of any mechanical moving parts.[540] Computer elements built on the pneumonic principle are called jet elements. Relay jet elements can operate at power supply pressures of one atmosphere and over and at excess power supply pressures of the order of fractions of an atmosphere. Theoretical research indicates the feasibility of designing an aerodynamic oscillator in which the oscillations are generated by interaction of air flows. It is also possible to use printed circuit methods in jet technology. The stamped flat plates carry the imprint of functional elements and connecting channels that reflect the given control algorithm. Such a flat stamped plate covered by a lid plate represents the finished unit. Of interest also is the photochemical method of manufacturing pneumonic instruments in which tens of thousands of prints can be obtained from a single negative by photochemical etching. The pneumonic devices have a relatively high speed of operation. Individual jet elements operate in the KH_2 frequency range and control signals are transmitted along the connecting channels at fairly low excess pressures and at velocities close to the velocity of sound in air. The pneumonic devices are claimed to have high operational reliability, a very broad temperature tolerance range, and insensitivity to radiation, vibration, and inertial load. These principles were embodied in the SMST jet technology modular system, which was accepted for industrial production.[540] It is claimed that by 1964 the SMST devices had successfully passed industrial tests and were in operation.

Pneumonics was developed in the Institute as a natural consequence of the early work on hydraulic control mechanisms, which was recognized as early as 1945 by Trapeznikov as offering the fastest operating rates, especially in application to actuating mechanisms.[541] Many of the researchers in pneumonics had gained early experience in hydraulic systems.

One of the earliest statements on Soviet pneumatic control research was made by Ayzerman in 1955 in his paper on the basic trends in development of industrial pneumo-hydraulic automation, delivered at the Conference on the Engineering Aspects of Automatic Control in Moscow.[542] The rather large number of authors and holders of Soviet patents in this area that were active in the subsequent years includes several distinct co-author groups, many of whom appeared to have gone the route from the early research in hydraulics, through work on pneumatic devices, to recent developments in pneumonics. The most active such group centers around V. N. Dmitriyev. In 1958 Dmitriyev worked on hydraulic servo-mechanisms and pneumatic drives.[543,544] In subsequent years Dmitriyev and his group were granted a number of patents; in 1966 for a pneumatic time relay,[545] and in 1967 for a device for promoting artificial respiration,[546] a turbulence amplifier,[547] a discrete-action pneumatic pressure amplifier,[548] and an electropneumatic converter.[747] Their work in the area of pneumonics is represented by the patent granted in 1968 on a jet memory element.[549]

Another active group consists of L. A. Zalmanzon, Yu. V. Lutsuk, and A. I. Semikova. In 1958 Zalmanzon reported on the construction of a pneumatic oscillator without moving parts, on pneumatic chambers, and on an arithmetic machine based on a system of jet nozzles and intended for work in pneumo-automatic installations.[550-553] In 1959 Semikova presented a review of pneumatic elements and devices used in automation and remote control.[554] In 1965 Zalmanzon reported on modular principles of jet engineering developed at the Institute.[555] In 1967 and 1968 the group was granted a number of patents and published papers on jet elements,[556] methods of measuring temperature,[557] pneumatic or hydraulic devices for transmitting revolutions and acceleration,[558] and a device for converting the signal of a technological parameter into a pneumatic or hydraulic variable-frequency signal.[559]

The next group consists of A. A. Tal', T. K. Berends, A. A. Tagayevskaya, and others. As in the case of the preceding groups, its publications begin in 1958, reporting on the feasibility of building discrete-action computers designed on the pneumatic principle.[560] This was illustrated by the examples of a pneumatic relay and its application, and pneumatic discrete-action computers.[561] Berends was particularly interested in computer applications[562] and the development of a universal system of industrial pneumo-automatics on which he reported in 1965 and 1967.[563,564] In the same year the group was granted a patent on a pneumatic relay.[565]

A small team also active from 1958 consists of V. M. Dvoretskiy and V. P. Temnyy. Starting with consideration of gain in hydraulic tracking systems,[566] Dvoretskiy discussed hydro-automatics,[567] and continued work on hydraulics in 1965 and 1967.[568,569] However, the rapidly developing work on pneumonics also claimed his attention in

1967, as indicated by a patent for a method for controlling jet elements.[570]

Finally, there is a group of individual authors and holders of patents in this area with one or two publications in the period from 1958 to 1968, such as E. M. Nadzhafov, who reported on the work of the Institute in the field of pneumatic computers,[571,572] V. V. Petrov, investigating pneumo-hydraulic servo-mechanisms for automatic pilots,[573] V. G. Sholokhov and T. I. Telaurdze, who were granted a patent on automatic extremal optimizer using jet techniques,[574] A. N. Shubin and M. M. Belyayev, who developed an acoustic, pneumatic, electric analog converter,[757] and others.[748,752] A recent worker of interest in this area is Ye. V. Fudim, who in 1966 wrote a paper on discrete-action pneumatic computation technique,[576] and in 1968 and 1969 published patents on pneumatic capacitors and other pneumatic devices.[577-579] V. A. Khokhlov published several papers on hydro-mechanical principles.[749-750] V. I. Lezin was granted a patent on an aerodynamic oscillator for jet flow.[753]

Hydro-automatic Group

Span of Years	Name of Author	Reference Number
1958-1968	V. M. Dvoretskiy*	566,567,569,570
1958-1965	V. P. Temnyy	566,568

Industrial Pneumo-automatic Group

Span of Years	Name of Author	Reference Number
1958-1968	A. A. Tal'*	539,560,561,565
1959-1968	T. K. Berends*	539,562-565
1963-1968	A. A. Tagayevskaya	539,564,565
1963-1968	T. K. Yefremova	539,565
1968	L. Ye. Arkhipov	565
1968	P. M. Atlas	565
1968	V. I. Belov	565
1968	V. V. Cherni	565
1968	I. R. Iskra	565
1968	A. M. Kasimov	565

Industrial Pneumo-automatic Group (continued)

Span of Years	Name of Author	Reference Number
1968	V. I. Pershenkov	565
1968	V. S. Sushkin	565
1968	S. A. Yuditskiy	565
1968	V. A. Zharinov	565

Pneumatic Devices Group I

Span of Years	Name of Author	Reference Number
1958-1968	V. N. Dmitriyev*	543-549,747
1966-1968	V. G. Gradetskiy*	545-549
1967-1968	V. M. Yarol	547,549
1968	T. M. Koltsova	549
1968	N. P. Uvarov	549
1966-1967	I. B. Krishtul	545,546
1966-1967	V. I. Polyakov	545,546
1966-1967	M. K. Soms	545,546
1967	I. S. Mezin	547
1967	V. V. Vasilyev	548

Pneumatic Devices Group II

Span of Years	Name of Author	Reference Number
1958-1968	L. A. Zalmanzon*	550-553,555-559
1967	Yu. V. Lutsuk	557
1958-1959	A. I. Semikova*	551-554

Individual Authors

Span of Year	Name of Author	Reference Number
1966-1969	Ye. V. Fudim*	576-579
1969	M. M. Belyayev	575
1969	A. N. Shubin	575
1968	V. I. Lezin	753
1968	V. G. Sholokhov	574

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1968	T. I. Telauridze	574
1958-1967	V. A. Khokhlov	749-751
1967	B. S. Shkrabov	752
1960	V. V. Petrov	573
1958	Yu. I. Ivlichev	572
1958	E. M. Nadzhafov	571,572
1958	Yu. I. Ostrovskiy	748
1955	M. A. Ayzerman	542
1945	V. A. Trapeznikov	541

INDUSTRIAL AND RESEARCH APPLICATIONS

Work on direct application of the automatic control systems developed by the Institute to various branches of industry has been increasing to a considerable extent in recent years. Furthermore, this work has heavily involved some of the foremost theoreticians of the Institute, such as Fitsner, Perel'man, Domanitskiy, Rozonoer, Lerner, and others. Fitsner, who in 1957 led the discussion group of computer applications in industry at a conference on Automatic Control and Computer Engineering in Moscow,[580] was particularly active. Some of the foregoing workers who published numerous theoretical papers in the fifties and early sixties appear later only in connection with direct industrial applications of automatic control.

Machine Tool Control

Materials on machine tool control describe automatic systems that range from simple measuring devices to fairly sophisticated adaptive systems. Some of the latter appeared as early as 1960 in the form of self-adjusting systems for automatic control of electric tube-welding machines[581] and optimal control systems for flying shear drive in rolling mills.[582] In 1964 Fitsner published a paper on a computing instrument for the design of optimal metal-cutting bench systems.[583] Dynamic precision of program control systems for machine tools was evaluated by B. I. Andreychikov.[584] A significant effort involving a fairly large number of research workers was applied to rolling mills and involved systems for continuous gauging of metal,[585] measuring the length of a hot-rolled product,[586-588,754] and controlling the band thickness.[589]

Measuring Devices Group

Span of Years	Name of Author	Reference Number
1969	V. I. Gromov	586
1969	V. B. Yefimov	586
1968	Ye. T. Darov	587
1968	I. N. Kundyrevich	754
1968	Ye. I. Meybaum*	587,588,754,794
1968	Yu. F. Titov	754
1968	Yu. A. Yashchuk	587,754

Adaptive Systems Group

Span of Years	Name of Author	Reference Number
1958-1960	A. B. Chelyustkin	580,581,585
1960	V. A. Ivanov	581
1958	L. N. Fitsner	580
1958	V. Yu. Kaganov	580
1958	Ya. A. Khetagurov	580
1958	P. N. Kopay-Gory	580
1958	D. T. Vasilyev	580
1958	Yu. Ye. Yefroymovich	580

Individual Authors

Span of Years	Name of Author	Reference Number
1967	V. M. Burdin	589
1967	S. Ye. Khusid	589
1967	V. I. Kiryukhin	589
1967	A. I. Krylov	589

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1967	S. A. Leontyev	589
1967	I. I. Perel'man	589
1967	M. V. Meyerov	589
1967	O. G. Muzalevskiy	589
1967	Yu. I. Samokhin	589
1967	A. G. Shesterkin	589
1967	M. A. Shvartsgorn	589
1967	G. G. Zinovyev	589
1964	B. I. Andreychikov	584
1964	L. N. Fitsner	583
1960	B. B. Buyanov	582
1960	S. M. Domanitskiy	582
1960	L. N. Zagalskiy	582

Smelters

As in the case of the preceding subsection, the application of automatic control systems to blast furnaces and smelters has drawn a fairly large number of the Institute members. These break down into four distinct groups.

The first group is in evidence from 1963 and consists of a relatively small number of authors, including A. G. Butkovskiy, A. Ya. Lerner, S. A. Malyy, and others. The predominant interest of this group is the optimization of furnace controls. Their publications, which do not contain any patents, deal with problems presented by the optimal control in drawing production from a melt,[590] the optimal control of heating massive bodies,[591] automation of Martin furnaces,[592] optimal conditions for heating metal,[593] optimal programming of temperature in heating furnaces,[594,595] and minimization of metal surface oxidation in heating.[596]

The second group, consisting of P. P. Tartakovskiy and others, received patents for casting machine parts in 1964 and 1965 (published in 1968 and 1969).[597,598]

The third group, consisting of a large number of workers including S. K. Sobolev and V. V. Karnaukhov, is evident only in patent literature during the years from 1967 and deals with control of melt temperature in a smelting furnace,[599] converter control,[600-602] and speed control of rotating parts.[603] The last group, including N. V. Venediktov, A. G. Astakhov, V. I. Kirillov, and others, dealt with problems of controlling blast furnace changes.[604,605]

Finally, individual articles without co-author association were published in 1964 by V. A. Orlov, on the optimum regulator for an arc steel smelting oven,[606] and by B. P. Dovgalyuk on automating control of blast furnace operations.[607]

Oxygen Converter Group

Span of Years	Name of Author	Reference Number
1968–1969	V. S. Bogushevskiy	600–602
1968–1969	G. F. Gulyev	600,601,603
1968–1969	V. V. Karnaukhov*	600,603
1968–1969	I. S. Kukuruzniyak	601,602
1968–1969	G. T. Kuts	600–602
1968–1969	S. M. Serdyuk	599,600
1968–1969	S. K. Sobolev*	600–603
1968–1969	Yu. M. Talalayevskiy	600–602
1969	Yu. F. Akhonin	603
1969	V. D. Kolesnik	603
1969	M. I. Korobko	599
1969	P. I. Ostashevskiy	599
1969	V. Ye. Pronkin	599
1969	A. M. Raydel	601
1969	O. S. Sakhnovskaya	603
1969	A. S. Sizenko	603
1969	P. Ya. Vavulin	599
1968	Yu. V. Bashmakov	602
1968	V. Ya. Bushnev	600
1968	G. N. Kozin	600,602
1968	Ye. Ya. Suprunyuk	600
1968	I. G. Zeltser	600

Control Optimization Group

Span of Years	Name of Author	Reference Number
1963-1968	A. Ya. Lerner	590,596
1963-1968	S. A. Malyy*	590,592,593,596
1963-1967	A. G. Butkovskiy*	590,591,594,595
1967	E. S. Geskin	595
1967	E. M. Goldfarb	595
1965	Yu. N. Andreyev	591

Metal Casting Group

Span of Years	Name of Author	Reference Number
1968-1969	A. V. Bedrak	597,598
1968-1969	P. P. Tartakovskiy	597,598
1969	Yu. V. Postrichev	598
1969	D. Kh. Yakimenko	598
1968	V. P. Dubrinskiy	597
1968	Yu. N. Khotimchenko	597

Blast Furnace Group

Span of Years	Name of Author	Reference Number
1968	V. V. Arikhbayev	605
1968	A. G. Astakhov	604,605
1968	N. V. Fedorovskiy	604,605
1968	V. P. Grechanovskiy	605
1968	V. I. Kirillov	604,605
1968	I. L. Kondrashov	605
1968	I. I. Lavrentik	605
1968	L. R. Migutskiy	604
1968	V. N. Moskovkin	605
1968	V. I. Pleskach	604
1968	V. N. Shelestov	605
1968	L. U. Shevchenko	605
1968	N. A. Sumskoy	605
1968	M. V. Venediktov	605

Blast Furnace Group (continued)

Span of Years	Name of Author	Reference Number
1968	L. V. Zelenetskaya	605
1968	V. T. Zelinskiy	605
1968	O. Ya. Zhedenko	604

Individual Authors

Span of Years	Name of Author	Reference Number
1968	B. P. Dovgalyuk	607
1964	V. A. Orlov	606

Other Industries

Materials on the automation of industrial processes other than metallurgy fall in a very uneven manner into a very limited number of distinct groups. In spite of the frequent statements in Soviet literature about the urgent need to automate the oil industry and the unique compatibility of that industry to automation systems, the number of published articles in this area is negligible. A slightly larger amount of work was done in the area of chemistry and food processing, on the one hand, and aluminum production on the other. The rest of the published articles and patents is a fairly large quantity dealing with mining, handling of friable materials, coal processing, etc.

In general, the entire material in this subsection is characterized by the presence of large groups of co-authors. A small number of the names have occurred previously in this Report; usually these are the leading theoreticians of the Institute. The remainder are people who work in engineering and have not published in any other context.

In the oil industry area, V. I. Izaylova published an article in 1967 on simulation of forecasting gasoline octane rating.[608] Patents were issued in 1966 (published in 1968) to a large team of workers that includes Khlebnikov and Ivanov for machinery for handling volume products,[609] and in 1967 (published in 1969) to A. P. Kravchenko for a method of determining the octane prescriptions for mixtures of petroleum products.[610]

In the area of chemistry and food processing, a team including B. Ya. Livshits, A. Ye. Eydel'man, and others was issued a patent in 1967 (published in 1968) for a method of quantitative analysis of sugars in food products.[611] Other activities included automation of the evaporation installations in a sugar plant,[612] automatic synthesis of of a control system for an optimal chemical reactor,[613] analysis of physical constants of multi-component mixtures,[614] and the measurement of reactivity by the method of signal reduction.[625] In 1966 adaptive optimizer systems were introduced in synthetic rubber plants.[795]

In the area of aluminum production, a team based on V. F. Zarechnyy and Yu. I. Georgiyevskiy has been active since 1966. A number of patents reflect their work in controlling the continuous delivery of aluminum oxide into aluminum electrolyzers,[616] and controlling electrolysis of aluminum by changing the interpolar distance.[617,618,756] It is of interest to note that their last patent, published in 1969, has been apparently classified and no title or description was given.[619]

The area of mining and handling of materials is quite large and contains several groups of workers that displayed the cohesion of teams.

The largest such team is based on N. M. Rudnyy and has been in evidence since 1966, exclusively through the publication of patents. These reflected the work of rotary excavators,[620,621] content analysis, motion control, weighing of loose materials,[622-625] construction of instruments,[626,627] and various incidental inventions.[628-630] During the period from 1966 to 1969, two other groups received patents in the same general area.[631,632] A team based on T. I. Akhtyrskya and L. A. Bocharov received patents for work on sand-blasting machines.[633,634]

Coal beneficiation is the subject of a large team, headed by K. B. Norkin, which was granted patents in 1966.[635,636] Finally a number of small teams were granted mining patents,[637-639] and E. L. Itskovich, a theoretician of the Institute, developed an operational control system for cement production.[640]

Aluminum Processing Group

Span of Years	Name of Author	Reference Number
1968-1969	I. I. Balashov	616,618,619
1968-1969	Yu. I. Georgiyevskiy*	616-619
1968-1969	I. Ye. Manokha	616,618,619
1968-1969	V. F. Zarechnyy	616,618,619
1968	V. N. Boyko	616

Materials Handling Group

Span of Years	Name of Author	Reference Number
1968-1969	R. A. Bakhteyev	625,630
1968-1969	Yu. Ye. Kirichenko	622,629,797
1969	P. S. Kuznetsov	625
1969	V. S. Yatsenko	621
1967-1968	N. M. Rudnyy*	622-624,626-630
1967-1968	R. S. Stankevich	623,628
1968	N. V. Gelashvili	622
1968	T. L. Kofanova	626
1968	M. I. Kuznetsova	629
1968	A. G. Lakhtionov	622
1968	V. V. Maslovskiy	627
1967	R. Y. Nesterchuk	623
1967	A. Ye. Sogin	624
1967	V. L. Tatiyevskiy	624
1967	M. V. Venediktov	624

Blasting Machine Group

Span of Years	Name of Author	Reference Number
1968	T. I. Akhtyrskaya	633,634
1968	L. A. Bocharov	633,634
1968	B. I. Fedyanin	633,634
1968	I. R. Levitan	633,634
1968	V. D. Pepenko	633,634
1968	V. G. Rakogon	633,634

Coal Beneficiation Group

Span of Years	Name of Author	Reference Number
1968	V. V. Brantov	635,636
1968	P. I. Gandelsman	635,636
1968	B. G. Gershteyn	635
1968	A. I. Geyshes	635,636
1968	L. G. Melkumov	635
1968	K. B. Norkin	635,636
1968	A. S. Ruppo	635,636
1968	Yu. E. Sagalov	635,636
1968	A. D. Shkilnikov	635,636
1968	S. O. Slavatskiy	635

Mining Machine Group

Span of Years	Name of Author	Reference Number
1968	I. V. Kaplenko	637
1968	L. A. Shoykhet	637,638
1968	R. V. Shpakovskiy	637
1968	E. I. Snezhko	638

Individual Authors

Span of Years	Name of Author	Reference Number
1969	Yu. L. Bezusyak	639
1969	V. O. Chinakal	610
1969	N. A. Gozhenko	631
1969	A. Z. Grishchenko	639
1969	A. P. Kravchenko	610
1969	N. A. Krinitsyna	631
1969	B. I. Kusovskiy	610
1969	B. F. Rudko	631
1969	L. V. Saulova	639
1969	Ye. I. Tishchenko	631
1968	V. P. Alekseyev	609
1968	D. I. Buznitskiy	609

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1968	A. S. Bruk	611
1968	A. K. Alekseyev	632
1968	V. I. Donkov	611
1968	B. I. Kaul	632
1968	A. Ye. Eydelman	611
1968	Yu. A. Khvatov	632
1968	Ye. V. Dyachenko	609
1968	B. Koryakov-Savoyskiy	632
1968	S. K. Ivanov	609
1968	V. I. Lopatin	632
1968	A. N. Khlebnikov	609
1968	B. Ya. Livshits	611
1968	I. I. Klodnitskiy	609
1968	M. I. Marder	609
1968	G. M. Marchenko	632
1968	E. I. Shkuta	632
1968	V. Ya. Mayevskiy	609
1968	V. P. Shut	609
1968	S. Sh. Tverskoy	609
1968	F. Z. Yelenskiy	611
1967	V. I. Izmaylova	608
1967	P. S. Kuznetsov	620
1967	N. A. Smirnov	615
1967	L. A. Vereshchagin	620
1967	V. S. Yatsenko	620
1966	L. A. Girshov	640
1966	E. L. Itskovich	640
1966	Yu. P. Savitskiy	640
1965	O. N. Karpukhin	613
1965	K. B. Norkin	613
1965	V. D. Spiridonov	613
1963	P. F. Merabishvili	756

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1959	I. A. Mikhil	612
1959	B. A. Pereverzev	614

Biocybernetics

The Institute has been publishing material on biocybernetics research since 1965. The largest group working in this area includes N. V. Pozin, a theoretical worker specializing in modeling, and I. A. Lyubinskiy. The group published articles on information processing by the auditory system,[641] transient processes in a model of a neural-net,[642,643] and analysis of retina bio-potentials.[644] In a related research area, F. B. Gulko worked on nerve pulse propagation,[645] and mathematical modeling of excitation processes.[646] Other groups worked on quantitative characteristics of eye micromotion,[647] information on eye monitoring systems,[648] and the embryon as the structural area of an organism.[649] I. M. Panasenko was granted a patent on the method for recording movement of the eyes.[650]

Neuron Information Processing Group

Span of Years	Name of Author	Reference Number
1964-1967	N. V. Pozin*	641-644
1967	D. I. Kirvelis	643
1967	I. A. Lyubinskiy	641,642
1967	Ye. N. Sokolov	643
1964	S. H. Tott	644
1964	G. V. Voronin	644

Individual Authors

Span of Years	Name of Author	Reference Number
1968-1969	F. B. Gulko	645,646
1969	B. I. Khodorov	645
1969	Ye. N. Timin	645

Individual Authors (continued)

Span of Years	Name of Author	Reference Number
1969	S. Ya. Vilenkin	645
1968	N. G. Proskuryakova	647
1968	A. R. Shakhnovich	647
1967	L. V. Fatkin	650
1967	V. M. Krol	649
1967	I. M. Panasenko	650
1967	L. A. Tenenbaum	799
1966	V. U. Degtyar	800
1965	A. I. Lauringson	648,798
1965	L. P. Shchedrovitskiy	648,798

II. THE CENTRAL MATHEMATICAL ECONOMICS INSTITUTE

FOREWORD

The material presented in this Section was derived mainly from three sources: (1) reports of the Academy of Sciences, USSR, covering annual meetings, official resolutions, policy statements, and individual speeches and statements of its members; (2) material published by the *Soviet Cybernetics Review* (The Rand Corporation); and (3) the technical literature published by the Institute. The technical literature input

In analyzing the collection of technical research papers pertinent to the Institute, care has been taken to avoid arbitrary subject classification schemes; instead, the material was allowed to define actual areas of interest through co-author correlation techniques, explicit statements, and title analysis. Description of these areas of interest is given in the text and the personnel corresponding to these areas is listed in Appendix B.

SUMMARY

A year after its establishment in 1963, the Central Mathematical Economics Institute in Moscow was designated by the Academy of Sciences, USSR, as the principal agency charged with the theoretical development and practical implementation of a single, automated, nationwide system of economic control (comprising both the monitoring and management functions). The theoretical aspect of this project consisted of the construction of a comprehensive mathematical model of the entire national economy; the implementation of the project was based on a concept of integrated national networks of economic information channels and computer centers. The project was never developed to a significant degree, however. The years following its initiation mark a gradual erosion of its scope, fragmenting it into separate systems design work for the individual industrial branches and enterprises. The Institute thus appears to have gradually changed from an economics laboratory, engaged in the realization of a preconceived theoretical system of ideas, into an operational support agency for the Gosplan. In some measure this change could be attributed to the personality of the Director of the Institute, N. P. Fedorenko, an economist of the chemical industry who was without observable experience in computer technology or automation, but who nevertheless has a considerable influence as Chairman of the Scientific Council on Optimal Planning and Management of National Economy.

Indications of these developments, stemming from official reports, statements of leading personalities, and operational reviews, were compared to and found to be in good agreement with the information obtained by analyzing the technical research literature generated by the Institute. The analysis of this literature also yielded an operational picture of the Institute for the past five years in terms of personalities and the corresponding areas of interest, furnishing a general subject breakdown of the work of the Institute.

INTRODUCTION

The Institute is one of the main organizations charged with developing means of automating the planning for, and operation of, the national economy. The Institute is situated in Moscow and has a branch in Leningrad, with a Laboratory of Primary Data Processing Equipment, and a department in Tallin, Estonian SSR, consisting of two laboratories (Laboratory of Economics and Laboratory of Mathematics and Computer Technology) for the development of an automated system of planning and management of the Estonian Republic's economy.[1,2*]

The Director of the Institute is Academician Nikolay Prokof'yevich Fedorenko; Yu. Oleynik-ovod and A. Modin are deputy directors,[3-5] and N. V. Makhrov is Scientific Secretary.[6]

The Institute was established in the summer of 1963 by consolidating a number of institutions and scientific agencies of Gosplan, USSR.

---

*References are listed in Appendix B, starting on p. 194.

In 1964 the Institute was organizing the following departments:

- Modeling of expanded socialist production
- Scientific principles of automation of the national economy planning and control
- Scientific principles of territorial and branch systems
- Utilization of computer and informational equipment and problems of mathematical programming.

These departments were to include 26 laboratories designed to solve the most urgent and the least understood questions. Furthermore, the structure of the Institute was to have a department for information and methodology, as well as a computer center.

Work on solving complex problems to achieve specific economic objectives was to be performed by comprehensive scientific brigades being organized in the Institute. The brigades were recruited from members of the problem-solving laboratories and members of other scientific research institutes, as well as representatives of the interested economic planning agencies and enterprises. According to Fedorenko, the establishment of such brigades--to develop solutions to the economic-mathematical problems for mechanization of the national economy--has been accomplished. About 300 institutes have been associated with these brigades. Other brigades have been established for the development of automated systems of control on republican, Sovnarkhoz, and branch scales to produce a typical project of an automated system of enterprise management.[3]

At its inception, the tasks of the Institute comprised research on planning the development of the national economy of the USSR and managing the complex and differentiated economics of the country, the introduction of precise mathematical methods and modern computer technology into the planning and management of the economy, and the coordination of research in this area on a nationwide scale. A year later, the Presidium of the Academy of Sciences of the USSR reviewed the main directions of scientific research of the Institute.[7] The significance of the Institute's mission is reflected in the statements of members of the Academy made at that time. Thus, V. S. Nemchinov stated that the methods of modeling national economy processes are of extraordinary importance. Since the construction of such models must be based on a broad cybernetics approach, by the very nature of things the Central Mathematical Economics Institute will turn into a cybernetics institute.

According to a corresponding member of the Academy of Sciences, USSR, A. N. Yefimov, the Central Mathematical Economics Institute is the principal theoretical institute in the cybernetics field. Although the mission is economics, the methods and tools required by the cybernetics approach are primarily mathematical and the mathematical support of the mission is of first importance.

According to another corresponding member of the Academy of Sciences, USSR, S. N. Mergelyan, there is an urgent need to mobilize the major mathematicians of the country to help with the solution of the economics problem. This situation resembles the former situation in physics that also required large-scale mobilization of mathematicians. At the present time, there are almost no major mathematicians who are engaged in economics-mathematical research. Mergelyan was speaking on behalf of the Department of Mathematics of the Academy.[7] The Director of the Institute, however, is not a mathematician but shows a strong background in chemistry. He is also one of the most frequent contributors to the publications of the Institute and his professional interests appear to affect the activities of the Institute to an appreciable extent. It is therefore useful to review his contribution in some detail.

THE ROLE AND ACTIVITY OF N. P. FEDORENKO

According to a short biographical sketch published in his own book,[8] Academician Nikolay Prokof'yevich Fedorenko is a leading Soviet economist who has made a considerable contribution to the science of economics and to the planning and management of the national economy. He is the author of over 150 scientific works on the most important problems of the development of the national economy, especially the problem of the widespread application of chemical processes, and on the application of contemporary mathematical methods and computer technology in economic research.

He is in charge of the Institute's work on the theory of the operation of a socialist economy, and on the creation of automated management systems for the national economy. He has actively participated in studies on the theoretical and practical aspects of optimal planning and management necessary to perfect the control of the national economy and to raise the efficiency of socialist production.

Fedorenko was confirmed as (the continuing) Director of the Central Mathematical Economics Institute at the Annual Meeting of the Academy of Sciences, USSR, on March 6, 1968.[9]

In addition to his work at the Institute, Fedorenko directs the Chair of Mathematical Analysis in Economics at Moscow State University and is a professor of the Chair of the Economics of the Chemical Industry. Under his leadership, dozens of postgraduate students are conducting diversified research on the economics of different branches of the national economy.[8] He also is the Chairman of the USSR Academy of Sciences' Scientific Councils on the Complex Problems of "Optimal Planning and Management of the National Economy" (appointed in 1967)* and "Economic Problems in the Introduction of Chemical Processes into the National Economy."[10] In addition, he is the Deputy Academic Secretary of the Department of Economics of the USSR Academy of Sciences,[8] and has been a member of the Department at least from 1964.[11]

He is also a member of the following organizations:

- Rezinoproyekt Design Institute in Moscow, dealing with rubber technology[12]
- M. V. Lomonosov Institute of Fine Chemical Technology in Moscow[13]
- Scientific Council on the Complex Problems of Cybernetics.[14]

In 1965, the Presidium of the Academy of Sciences, USSR, appointed Fedorenko as Editor-in-Chief of the journal, *Economics and Mathematical Methods*.[15] He has also served since 1964 on the editorial boards of the *Journal of All Union Chemical Society*, and the *Journal of Chemical Industry*.

Besides the book, *Economics and Mathematics*, mentioned above, he is the author of *Aspects of Economics in Organic Syntheses Industry and*

---

*For description of the Scientific Council see Appendix B.

Economics of Synthetic Material Industry, published in 1968.[16] Together with A. G. Natradze, Fedorenko edited the book by N. V. Delektroskiy on *Economics of the Drug Industry*, published in 1967.[17]

Fedorenko, as the Director of the Central Mathematical Economics Institute, Academy of Sciences, USSR, was awarded the Order of Labor Red Banner by order of the Presidium of the Supreme Council of the USSR on April 17, 1967.[18]

During the period from 1964 to 1969, Fedorenko has been mentioned several times in official reports; in a report of N. M. Sisakyan, Chief Learned Secretary of the Presidium of the Academy of Sciences, USSR, on significant achievements in the fields of natural and social sciences;[19] in the discussions of the Academy on basic trends in economical and mathematical research,[20] problems of price determination in the socialist economy,[21] and present day economic cybernetics;[14] in a report from the September 1966 Session of the Social Sciences Section of the Presidium of the Academy of Sciences, USSR,[22] dealing with a discussion of questions on the economical evaluation of land and natural resources;[23] and in a report by the Moscow Institute of Fine Chemical Technology.[13]

The record of meetings and conferences in which Fedorenko was an active participant includes the General Session of the Academy of Sciences, USSR, June 22-26, 1964,[24] the International European Congress on Econometrics and Management,[25] the First All-Union Conference on the Use of Economics and Mathematical Methods in Computer Technology in Planning, Development and Location of Industry, held in Tallin, December 20-22, 1967,[26] the All-Union Scientific and Technical Conference on the Problems of Scientific Organization of Management of the Socialist Industry, Moscow, 1965,[27] and a meeting on the Problems of Developing Systems of Optimal Management and Planning for the Economy, held in Moscow, September 13-14, 1967.[28]

Fedorenko's professional background as reflected in his publications, at least beginning with the early sixties, has been in the economics of the chemical industry. As early as 1961 and up to 1964, his writings were exclusively on specialized problems of the chemical industry, such as the economics of the production of polymerization plastics,[29] economics of polyvinyl chloride in the cable industry,[30] production of vinyl acetate and related materials,[31] economics of the production of vinyl chloride polymer and monomer,[32] and production specialization at tire plants.[33] In 1964, Fedorenko began writing on economic problems of general significance to the national economy, in association with the Central Mathematical Economics Institute. At that time, he still approached the problems from the chemical point of view, as in the article on economic problems in the introduction of chemistry in the national economy,[34] economic efficiency of using plastic in the national economy,[35] and economic problems of applying chemistry to agriculture.[36] In 1965, he delivered a report on behalf of the Department of Economics of the Academy of Sciences, USSR, on the basic tasks of mechanization of the USSR national economy in the period 1966-1970. The report was presented at the meeting of the Scientific Council for Economic Problems of the Mechanization of the National Economy, held in June 1965, in Moscow.[37] Parallel with this, he was increasingly active in the main work of the Central Mathematical Economics Institute, writing papers on the current problems of price formation and the socialist economy,[38] the state of the art and prospects of the application of mathematical methods and computers to the fields of planning and management,[39] problems of the optimal development and distribution of production in a system of optimal planning and management of the national economy,[40] and econometric methods for planning and managing the national economy.[41] It is interesting to note, however, that even during this period Fedorenko devoted a larger part of his publishing activity to the problems of the chemical industry: problems of overall arrangement and distribution of chemical industry,[42] ways of increasing the octane number of gasoline,[43] methodological problems of introducing chemical processes into the national economy,[44] structural progress in chemical industry,[44] economical problems in the mechanization of agriculture,[45] development of the production of plastics and distribution of polymers in the national economy,[46] necessity for improvement in methods for calculating the economical efficiency of application of plastics and in the technique for determining the economically based demand for them,[47] and basic technical and economical problems of the application of plastics in the national economy.[48]

This heavy emphasis on chemistry by N. P. Fedorenko, as the head of an institute primarily charged with the development of cybernetics methods in the national economy, is somewhat puzzling. In fact, while the Central Mathematical Economics Institute is one of the principal research organizations officially charged with the problem of automation of economic planning, this may not necessarily be the principal area of interest within the Institute. This seems to be indicated by the background and publications of Fedorenko.

During the eight years from 1961 to early 1969, 42 papers authored by Fedorenko have been acquired. Of these, 16 deal with automation or cybernetics in relation to the national economy as a whole and the rest, as shown above, are devoted exclusively to the economics of the chemical industry. The 16 papers are distributed as follows: two in 1964, two in 1965, five in 1966, four in 1967, and three in 1968 and 1969. It would thus seem that Fedorenko was progressively drawn into the problems of national economy well after the establishment of the Institute. Fedorenko has no co-authors in his writings on the problems of cybernetics in the national economy. The only co-authorship team that is associated with Fedorenko deals with the chemical industry which, in terms of the number of publications, constitutes a major subject of activity of the Institute (see below).

THE PRINCIPAL GOALS OF THE INSTITUTE

In 1964, Fedorenko, as the Director of the Institute, delivered a comprehensive report on the first year's activities to the Presidium of the Academy of Sciences, USSR.[3]

The main impact of his report was the urgent necessity of developing advanced planning techniques and methods. Fedorenko's thesis was that while in capitalistic economies the development of industry is regulated by the market, the Soviet economy should be regulated by a scientifically based plan and not by arbitrary decisions, even if submitted by experienced specialists. Furthermore, the flow of economic information to be processed by planning and management agencies in short time periods, with high accuracy, should not entail endless proliferation of clerical workers. According to Fedorenko, in 1964 there were over 12 million persons employed in the management field.

Fedorenko's report was of interest also because it implied a considerable scope of activity apparently developed by the Institute in just its first year. In this respect, one statement made by Fedorenko is particularly striking: "The Institute also conducts work on the creation of methods of optimal planning and management of transportation in the country. Over 1,000 optimal plans for transporting freight, using various means of transportation, have been computed. The savings of this work have already reached about half a billion rubles." This claim that the Institute had managed in one year to design, introduce, and allow enough time for the operation of the system to yield this amount of savings would seem to cast some doubt on either the accuracy of this information or the actual time frame assumed.

The discrepancy between the top-level statements on the mission and accomplishments of the Institute and a reasonable conception of reality occurs again upon reviewing the body of literature that reflects the working-level research of the professional staff of the Institute. In fact, the official mission definition itself has undergone significant modifications in the subsequent years, leaving the earlier versions and their actual implementation somewhat ambiguous. A detailed review of the mission concept and its variation in the period 1963-1969 is thus of some interest.

In 1964 Fedorenko stated the main objective of the Institute was the creation of a unified system of optimal planning and management based on a unified state network of computer centers. The objective was to be reached by pursuing six avenues of attack:

1. Development of a theory of optimal planning and management to a unified mathematical model of national economy.

   This means the development of a single principle to serve as a foundation for a mathematical description of the entire national economic system as an organic whole, and of its ties to the economies of other countries.

2. Development of a unified system of economic information.

   The system should exclude any duplication of indices and should allow for an almost complete automation of the processes of collecting, transmitting, and analyzing primary data. The primary information should be collected directly at its place of origin and it should be the basis for the formation of all data. The collection of information should be based on the territorial principle in order to reduce the flow of information directed to the center.

3. Standardization and algorithmization of the planning and management processes.

   Development of standard algorithms for all levels of national economy to automate the planning and management process, thus converting large numbers of clerical workers into a smaller corps of creative planners and economists.

4. Development of mathematical methods for solving economic problems.

   Methods such as linear and nonlinear programming, heuristic programming, statistical testing, theory of games, informational searching, combinatories, etc., should solve all problems of a unified planning and management system.

5. Design and creation of a unified state network of computer centers.

   The network will consist of three levels: lower-echelon nodal centers, middle-echelon supporting centers, and the top-echelon main center, all of which will completely automate all phases of information collection, transmission, and processing, based on the territorial principle.

6. Derivation of specialized planning and management systems based on mathematical methods and computer technology.

   Each management level (enterprise, Sovnarkhoz, branch of industry, etc.) and each planning problem type (distribution, structure, etc.) will have its own specially designed system comprising a mathematical model, data report, software, and computer equipment.

Fedorenko stated that the Institute was active in all of these areas.

The Presidium of the Academy of Sciences, USSR, officially approved Fedorenko's project in all six points, even enhancing some of them, such as the development of theory (point 1), which was elevated to "one of the main directions of development of modern economic science." Furthermore, it went beyond the six-part program and granted the Institute sole authority to direct the pertinent research work of all national organizations developing such systems, and joint authority with the Scientific Council on the problem "Application of Mathematics and Computer Technology to Economic Research and Planning" to direct research and coordinate the work of all agencies engaged in the actual introduction of the completed systems in the user organizations.

The Institute was also given the technical assignment to design an electronic computer for economic calculations, planning, and management of the national economy.[7]

Two years later Fedorenko published an article[49] in which he again defined the concept of a unified optimal planning and management system. The six separate lines of development were now reduced to five by omitting standardization and algorithmization of the planning and management process. This reflected a degree of streamlining of the concept, since the omitted item was reflected in the others in the original version. The remaining five items were more or less repeated with some modifications that again reflected a further refinement of specific ideas. Thus, in 1966 Fedorenko elaborated the concept that the model should promote unity between the projected and current planning, on the one hand, and operational management on the other. The guiding principle should be continuous day-to-day planning. Each level of the system would experience the interaction of two flows of information: centralized planning-accounting, and management data and information supplied by the decentralized management mechanisms. The information flow system should include special methods of testing the reliability of information.

While the 1964 text simply described the proposed individual specialized systems, the 1966 text shifted the emphasis toward the need of experimental testing by selecting typical units of national economy to be used in debugging the appropriate systems.

In his 1966 article,[49] Fedorenko described the work of the system not as something that was actually under way, but as a set of goals that should deserve action. This nature of a mere proposal was also evident in the 1964 report to the Presidium. But just as in that report, the 1966 article ends with the statement that "The development of scientific foundations for the unified system of optimal planning and management is now being carried out by the Central Mathematical Economics Institute of the Academy of Sciences, USSR. The Institute is doing research in all the described areas. All theoretical work is being accompanied by experimental verification in the principal sectors of national economy."

In a book published in 1968,[50] L. L. Terekhov restated the set of required research projects, further reducing the number to three. The set now represented the essentials of the system, omitting the development of mathematical methods for solving economic problems and the derivation of specialized planning and management systems. In the remaining set of three projects, consisting of development of a theory for a mathematical model, an economic information system, and a unified network of computer centers, he sharpened up certain concepts, bringing them more into line with official ideology. Thus, Terekhov calls for:

1. "The development of a complex of economic mathematical models providing quantitative characteristics of all the basic laws, connections, and processes in the socialist national economy. The models must be based on our present economic laws and on the entire accumulated experience in planning and management of the socialist economy."
2. A radical improvement of the system of economic information.
3. The development of a central state network of computer centers. Like the system of information, the network of computer centers must be built on the interdepartmental principle.

In 1969 Fedorenko also published a further version of the goals of the Institute:

1. Development of systems theory for optimal national economic planning;
2. Development of automated systems of planning and management; and

3. Analysis of a specific set of problems of national economic development for 1971-1975, and forecasting economic growth for a longer period of time.[51]

The most conspicuous feature of the latest version is the absence of any reference to the unified state network of computer centers. Absent also is the proposed system of economic information. These projects, representing research on the methodology of economic analysis and organization of new operational systems, are replaced by work on economic projections, a much less innovative and more conventional activity.

Thus, it appears that through the years the primary goals of the Institute underwent a gradual and systematic shift away from a comprehensive development of cybernetic methods and technology for national economic planning. Whether this reflects a national shift of objectives in this area or is merely a problem of this Institute alone, is a matter of conjecture.

The Central Mathematical Economics Institute is not the sole research organization developing nationwide economic planning systems. The excellent paper by A. G. Aganbegyan[52] reports on the development of computer-based comprehensive economic planning, directed mainly at the Siberian regions, by the Institute of Economics and Organization of Industrial Production, Siberian Department, Academy of Sciences, USSR. The work, conducted jointly with the Institute of Mathematics and the Computer Center of the Siberian Department, is at least equal in sophistication and topical versatility to any of the proposed projects of the Moscow Institute. Nevertheless, even if reduced in scope, the latter remains the key nationwide organization in this field. A conclusive indication of this is provided by the Conference on the Establishment of Automated Budget Planning System held in Yerevan, 21-26 May 1969.[53] The Conference requested USSR Gosplan and the State Committee for Science and Technology of the USSR Council of Ministers to confirm the Central Mathematical Economics Institute as the leading organization for the preparation of a preliminary rough draft of the automated planning systems as a whole.

HIGHLIGHTS OF RESEARCH ACTIVITIES

The trend evident in the changing goals of the Institute as described above is also discernible in the activities of the Institute, as reported by the Academy of Sciences, by Fedorenko himself, and by the technical literature.

Although the principal business of the Central Mathematical Economics Institute was the introduction of cybernetics methods and technology to the management of national economy--according to the 1964 resolution of the Presidium of the USSR Academy of Sciences--this is not consistently reflected in the record of the Institute's activities during the succeeding years. The annual reports of the USSR Academy of Sciences in the years 1964-69 on the outstanding work in research and development, note only four instances of TSEMI contribution to the cybernetics area. In 1964 the Institute was cited, together with Gosplan and the Institute of Cybernetics--both of the Ukrainian SSR--for research on methods of designing models of material and equipment supply systems and the development of appropriate algorithms.[54] In 1966 its Leningrad Branch was mentioned, again for a joint effort (with the Institute of Mathematics and the Institute of Information Transmission Problems), for work on the behavioral aspects of automata theory.[55] In 1968 the Institute was cited alone for implementation of a number of projects on the optimal operation of the socialist economy, including the work "Single-Sector Dynamic Model and Analysis of Global Indices of the 1971-1975 Plan."[56] Finally, in 1969 the Institute was noted for "important research" in the field of long-range forecasting of the development of the Soviet economy.[57] Thus we see no further evidence of work on the unified models of national economy, unified systems of economic information flow, or a unified network of computer centers in the Academy accounts. In its place there is a more specialized program limited to individual aspects of economic cybernetics and also including work in the area of conventional economics. Fedorenko's own report on TSEMI activities published in 1969[51] shows a good agreement with the account of the Academy. The 1964 work on supply system modeling was being continued. The 1968 and 1969 global index analysis for long-range forecasting, noted by the Academy, was expanded beyond the next Five-

Year Plan to forecast the development of the national economy up to 1985. Other projects listed by Fedorenko reflect the same limitation to individual aspects of the national economy:

- Development of interbranch report balances for the economic areas of the country
- A project on the "Principles of Optimal Price Determination and Their Application in the Practice of Better Pricing"
- Extensive research on optimal plans for the development and distribution of individual branches of industry for the periods 1970–75 and 1975–80
- An advanced project, "Automated Systems of Planning Calculations (Principles of Development and Operation)" prepared jointly with the Sections for the Introduction of Economic-Mathematical Methods in National Economic Planning Under Gosplan of the USSR, Under the State Computer Center, Under Gosplan's Scientific Research Institute of Planning and Standards; and with the Economics Faculty of Moscow State University
- A project on "A Provisional Methodological Guide for the Development of Automated Systems of Planning, Accounting, and Management for Enterprises with a Discrete Type of Production," and "Provisional Interbranch Methodological Instructions on the Organization and Development of Branch Automated Management Systems" (referred to the appropriate ministries and departments for practical utilization)
- A project outline of an automated management system for Soyuzglavkhim (which supplies chemical and industrial rubber products)
- Solution of specific problems of optimizing deliveries of specific types of products from the chemical, paper, petroleum, and coal industries to other branches of the economy
- An advanced draft of a branch automated control system, using as a model the experience of the USSR Ministry of the Machine Building and Instrument Industry

- Participation in the design and introduction of an automated management system for the "Krasnyy Proletariy" Plant
- Extensive research on the development of an automated system for managing motor transport enterprises (using Glavmosavtotrans as a model), a large commercial enterprise (the State Department Store), and a production and trade association (using the "Moloko" Association as a model)

Fedorenko states that in 1969, scientists of the Institute were to continue research in the following basic areas: economic problems of optimal operation of the national economy; development of a set of economic-mathematical models for the compilation of medium-range plans for the development of the national economy and the economy at the branch and district levels; the methodology and methods of substantiating long-term economic decisions; theoretical problems of a multistage system of planning at the state-wide branch, and district levels; and development of a methodology for constructing control systems and systems for processing economic-statistical information based on extensive application of mathematical methods and computers.[51]

It would thus appear that the overall mission of the Institute was gradually restricted during the period from 1964 to 1969. The wide-ranging comprehensive mandate granted the Institute by the Academy of Sciences was not fully implemented, and an appreciable portion of the Institute's work has been directed to the solution of problems of individual enterprises, although this may be regarded as a necessary stepping stone towards the development of broader systems.

In this connection, it is of interest to note that this development was anticipated to some extent as far back as 1964. At that time V. M. Glushkov argued that while the main task of the Central Mathematical Economics Institute was to develop management systems, a different organization should be set up to carry out the introduction of these systems in individual enterprises. Otherwise, all the resources of the Institute would be absorbed by the introduction phase. Glushkov thus early went on record as opposed to an extensive authority for the Central Mathematical Economics Institute.

A number of participants in the 1964 discussion expressed the opinion that the range of tasks and activities of the Institute should be decreased to some extent because the Institute had neither sufficient personnel nor adequate means to carry out such a broad scope of work.[58]

A further insight into the implementation of the mission and the scope of the work is obtained by reviewing the technical publications of the Institute.

The Central Mathematical Economics Institute appears in the published literature to a moderate extent. Original papers bearing the byline of the Institute and consisting of journal articles, dissertations, symposia, and patents are limited in number, and a sizable proportion of the material concerns citations of the Institute in connection with conferences. The published papers of the Institute reflect several distinct fields of activity; these are in turn associated with a number of personalities. Individual groups of personalities associated by co-author linkages are few in number; the authors and papers, however, readily form subject categories and there is very little crossing from one subject to another by most of the identified authors in the time period covered by this review. The subject categories defined in this manner are as follows: the chemical industry, automated economic planning, agriculture and industry, mathematics, and radiobiology. These are now reviewed in turn.

The Chemical Industry

A large field of activity of the Institute is associated with the chemical industry and its economic impact. A high proportion of papers generated in this area by the Institute has been co-authored by Fedorenko; it is possible that many of these papers were written by his associates and his name was added by virtue of his position in the Institute. In any case, this indicates a considerable and continuing interest of Fedorenko in chemistry. The activity of the Central Mathematical Economics Institute in the chemical industry roughly falls into four categories: the "chemization" of the national economy (a phrasing which recalls the well-known Soviet attempts at the electrification of the country--long regarded as one of the keys to further social and economic progress); the development of the chemical industry for agricultural uses; problems of the fuel industry; and development of plastics production.

In the first category dealing with the widespread application of chemistry in the national economy, work has been going on since 1964 and has involved a group of seven authors in addition to Fedorenko. Starting in 1964 with problems of introducing chemistry into the national economy, basic directions of chemization of the light industry were spelled out in 1965. Structural progress in the chemical industry was reported on in 1966 when the group addressed itself to the problem of overall arrangement and distribution of the chemical industry. In 1967 the concern was increasing the efficiency of the development of the chemical industry; in 1968 the distribution of scarce resources in this field was examined.[59-65]

The group involved in agricultural applications of chemistry consists of four persons. Since 1965 it has been involved in the economic problems of chemization of agriculture and mathematical methods of optimization of agrochemical service.[66-68]

A distinct group of five authors worked on the economics of production of hydrocarbon fuels in 1964 and 1966.[69-71]

The largest cohesive group of persons connected by co-author linkages is evident in the area of economics of the plastics industry; it numbers 11 authors in addition to Fedorenko. Members of this group began writing in 1961, at that time without institutional affiliation, and continued steadily until 1966. The subject throughout these years was the production of vinyl acetate, vinyl chloride, and polystyrene. In addition to these fairly specialized problems, the group also considered the general problems of economic efficiency in introducing plastics into the national economy, the structure of plastics production, and the use of polymers in the national economy.[72-83]

In addition to the four areas noted above, the publications include Fedorenko's work on the economics of the production of sulfuric and phosphoric acid.[84,85]

Of all the authors of the chemical industry group associated with Fedorenko, his most frequent collaborator is Ye. P. Shchukin, who is also the only author besides Fedorenko writing on all four subdivisions of the chemical industry area. All other members of the four groups described above confined their published writings to their own group.

Research on Automated Economic Planning

The work of the Institute on the problems of economics, as reflected by the open-source publications, involves some 40 people. The bulk of this work dates from 1966 and 1967 and decreases considerably in 1968 and 1969; however, this can be ascribed to the decreased accessioning of the input material during those years.

The number of authors of research articles explicitly affiliated with the Institute is rather small; it includes a loose group of ten people without any evident co-author or team linkages.[86-95] It should be noted that with the exception of a few papers on optimal development and distribution of production, none of the research papers in this group deals with the typical problems of automation of planning and management that are the basis of the mission of the Institute. The research papers largely range from general subjects of economics, to the problems of price formation, demand for mineral resources of industrial regions, and distribution of unhomogeneous product to consumers. On the other hand, the typical problems of automation in the national economy do appear extensively in the type of papers represented by dissertations. By the nature of this type of scientific paper, no co-author or team linkages are present. The following major problems are considered by the authors of dissertations:

- Network planning, including linear programming[96-100]
- Optimal planning for industrial branches[27, 101-103]
- Construction of mathematical models[104-109]
- Algorithmic languages and algorithms for economic problems[110-113]
- Information flows in economics.[27,102,114]

Agriculture and Industry

Agriculture. The problem of introducing modern economic planning and management methods to agriculture has been actively promoted in numerous statements of prominent personalities in Soviet cybernetics. However, the published material of the Central Mathematical Economics Institute contains very little on this subject.

Papers on optimum planning of agricultural production and complex optimum organization of livestock-raising with electronic computer solutions were read at the First Scientific Technical Conference of Young Moscow Scientists in December 1964.[115]

Network analysis applied to irrigation problems was the subject of two dissertations.[116,117]

Production Control. The very small extent of visible published output of the Institute on industrial production problems appears out of line with the scope of activities reported for this area by Fedorenko in 1969. His list of continuing and accomplished projects by the Institute implies a much greater level of activity in this area than that actually reflected in the open source literature. There are 12 persons active in this field who fall into a few small groups of co-authors. Their principal topic is the development of models of petroleum refinery operation and of distribution of industrial energy supply.[118-122] One member of this group, A. S. Nekrasov, was associated with the establishment of the Section of Cybernetics and Mathematical Modeling of the Scientific Council on Complex Power Engineering Problems, Department of Physico-Technical Power Engineering Problems, Academy of Sciences, USSR.[123,124]

A more varied range of subjects is encountered in the group of dissertations: the use of computers in automating the design of machining technology; mathematical models for the fishing industry; critical-path methods of scheduling metallurgical production; and organization and methods of designing control systems at machine building plants.[104,109,125]

Transportation. The Institute research in the field of transportation is reflected in one research article by Yu. A. Oleynik,[126] who also wrote a paper on computer technology in economy and planning[127] and published four dissertations. The topics include the use of computers for scheduling urban passenger transportation, distribution of freight flow in operational and prospective network transport problems, equipment operation in automatic control systems for the merchant marine, and theory of multilinear systems for transport.[117,128-131]

Mathematics

Economics and mathematics are the two disciplines that, at least formally, are central to the mission of the Institute. In terms of research articles and dissertations, however, mathematics is much better represented in the available literature. It may be argued that such a distribution tends to confirm the avowed role of the Institute as an organization charged with the introduction of cybernetic methods into national economic planning and management, since a well-developed applied mathematical research would be highly necessary for such a mission.

The available materials indicate several distinct lines of research.

In the theory of games, four authors are in evidence, writing systematically from 1966 to 1969 and dealing with games on a unit square, equilibrium points in polymatrix games, antagonistic games played in functional space, and heuristic methods for automatic synthesis of game strategies.[132-137] The single dissertation in this area conforms topically to the rest of the material. A popular paper by N. Vorobyev on Mathematics and Theory of Games, published in 1966, has a byline of the Laboratory of Theory of Games and Operations Research, Central Mathematical Economics Institute. Research papers by G. N. Dyubin bear the byline of the Institute, Odessa Laboratories.

Linear and dynamic programming was the subject of a number of research papers and dissertations generated by eight authors between 1964 and 1967. The topics are: an iteration method of solving integer programming problems; solving problems of linear integer programming with Boolean variables; discrete problems in mathematical programming; many-index problems of linear programming; numerical solution methods of some nonlinear programming problems; and convex and fractional convex programming.[97,131,138-143]

In other cybernetics related research, small groups of authors published papers between 1965 and 1969 on systems analysis,[105,134,144-146] computer theory,[111,140,147] and theory of information.[147-149]

Finally, the Institute published a number of research papers and dissertations on theoretical and applied mathematics not directly related to any aspect of cybernetics.[106,120,144,146,150-159] Their authors do not appear in any other context.

Radiobiology

This area of research appeared in the published materials only in 1969 and is represented by a team of seven authors writing in the field of radiotherapy. L. Ya. Klepper appeared to be the most prominent member of the team.[149,160-163]

III. ANNUAL ACHIEVEMENT REVIEWS OF THE ACADEMY OF SCIENCES, USSR

SUMMARY

The material in this Section was obtained from the Soviet periodical *Vestnik Akademii Nauk SSSR* for the years from 1964 to 1969, containing the reports on the Annual Meetings of the Academy of Sciences. Each annual meeting is in part devoted to a general review of the past year's accomplishments of the member organizations in various areas of science and technology. In each specialized topic the review consists of a brief description of the activity with the names of the responsible organizations. The entries are apparently selected on the basis of greater-than-average significance and are arranged according to a hierarchical subject-heading system. The treatment of cybernetics within this system is a matter of considerable interest. Being a relatively new discipline, cybernetics has not yet found a definite niche in conventional subject classification schemes. In the reviews of the Academy, however, cybernetics has for a number of years been accorded a place of exceptional prominence. Thus, in 1964, 1965, and 1967 cybernetics was considered by the Soviet Academy of Sciences one of four major subdivisions of the entire spectrum of science and technology, on the same hierarchial level as physical-technical and mathematical sciences, chemical-technical and biological sciences, and social sciences. In terms of allotted space in the reviews, cybernetics was again comparable to the other three subjects. This situation changed in 1968 and 1969. During those years the Academy reviews were progressively reduced in overall scope and the formal subject classification was abandoned. The subject of cybernetics, moreover, suffered a drastic curtailment. The following count of entries in the cybernetics sections of the Academy reviews may be useful as a rough illustration of this process. The figures in the table are approximate because in some instances it was not possible to identify separate projects or activities clearly.

However, it may be noted that the sharp decrease of cybernetics activities reflected in the Academy reviews for the last two years is

CYBERNETICS RESEARCH AND DEVELOPMENT ACTIVITIES
REPORTED BY THE ACADEMY OF SCIENCES, USSR

Year	Number of Projects	Number of Institutes
1964	39	24
1965	29	17
1966	106	33
1967	102	29
1968	13	6
1969	11	9

contradicted by the fact that the two institutional Lenin prizes for 1969 were conferred in the field of cybernetics.

Apart from the overall level of effort in cybernetic research, it is of interest to consider its topical distribution through the years covered by the Academy reviews.

The years of 1964 and 1965 were largely dominated by theoretical research, with the Academy stressing the following subjects:

- Adaptive systems
- Relay devices and finite automata
- Applied theory of algorithms and mathematical logic
- Theory of large-system control
- Theory of information and theory of games
- Theory of mass service

In 1966, the Academy acknowledged the continuation of basic theoretical research and emphasized new topics of more applied nature:

- Reliability theory
- Pattern recognition
- Automation of intellectual labor

New technologies were also stressed at that time:

- Telemetry
- Technical cybernetics
- Technical diagnostics

In addition, the Academy for the first time noted the application of cybernetics to psychology, semiotics, and law. Economic applications were treated in detail, particularly in planning, distribution of production facilities and material supply, optimal design of long-distance transport lines, and network analysis.

In 1967 and 1968 the emphasis of the Academy included subjects more directly pertinent to computer technology, such as:

- Computer software research
- Computer simulation
- Automated programming

The 1968 meeting was also instructive in terms of criticism of the current programs. A number of participants in the discussion listed the following fields in which activity was absent or inadequate:

- Theory of machines, especially the study of dynamics of automatic machines and instruments measuring machine parameters under extreme operating conditions
- Large systems, such as automatic production lines, and the development of appropriate computer languages
- Application of digital computers to automatic design, and to the solution of stochastic problems encountered by designers
- Development of biomechanical devices for use in space, underwater, etc.

MATHEMATICAL PROBLEMS OF CYBERNETICS

During the period from 1963 to 1967, the Institute of Mathematics of the Siberian Department, Academy of Sciences, USSR, and the Institute of Physics and Mathematics of the Lithuanian Academy of Sciences accounted for the majority of projects carried out with some degree of continuity for more than one year. The most prominent of these was the development of optimal methods of analysis and synthesis of control systems, carried out by the Institute of Mathematics of the Siberian Department in 1963 and 1965 and presumably also in 1964.

Research on algorithms for automatic derivation of proof was another subject prominently displayed and pursued with considerable persistence. This activity had been concentrated in Lithuania, at first in the Institute of Energetics and Electrical Engineering at the Academy of Sciences of the Lithuanian USSR in 1963, and then in the Institute of Physics and Mathematics of the Academy of Sciences of Lithuanian SSR in 1964, 1965, and 1966. The Leningrad Department of the Mathematics Institute of the Academy of Sciences, USSR, was also reported active in this work in 1964.

Other outstanding projects in this area are:

- The construction of algorithms and tables of minimization of Boolean functions
- Functions of logic algebra
- Development of queueing theory
- Theory of optimal coding

In 1968 successful research was noted in the field of computational mathematics. Important results were obtained in numerical methods of solving differential equations in partial derivatives. The Institute of Applied Mathematics obtained a numerical method of solving problems of the elliptic type for regions with complex boundaries.

THEORY OF INFORMATION

The outstanding organization in this field is the Institute of Information Transmission Problems of the Academy of Sciences, USSR. From 1963 to 1966, the Institute worked on error reducing codes, such as the sequential decoding method reducing error probability and the number of operations; development of cyclic error-correcting codes; and the development of effective and feasible methods of coding and decoding in Gaussian channels with feedback, permitting the transmission of information at rates close to the theoretical transmission capacity of the channel and with error probability as small as desired. In 1966, the Institute submitted decoding methods that allow for the reconstruction of the transmitted information symbols with a small average number of operations (from two to four), which is considered not only a significant contribution to the theory but also of considerable practical importance for the design of modern communications systems.

The Institute of Information Transmission Problems also worked on new methods of low-cost transmission of black and white stills as a preliminary stage in the study of a global system of television transmission, providing for direct reception of artificial satellite signals by individual television receivers. In 1966, the Institute achieved results in the theory of transmitting discrete signals and messages, coding theory, methods of distributing information flows in complex networks, and transmission of information by the sense organs of man and animals.

In 1968 the Institute achieved notable results in its research on the problems of transmission, distribution, and processing of information.

Among other organizations, the Institute of Automation and Electrometry of the Siberian Department was active in the design of telemetry systems. It developed methods and equipment for artificial injection of structural redundancy to increase accuracy, speed, and reliability of measuring devices.

The Institute also submitted general methods of analyzing and synthesizing networks for the measurement of voltages and currents of complex wave forms and established the foundation for the design of new classes of networks. It advanced new principles of constructing digital measuring systems and evaluating their errors, and developed a number of instruments and automatic measuring devices which were handed over to the industry for production in 1966.

In 1968, the Institute designed new equipment for airborne electrical prospecting that does not require ground-base installations to excite the electromagnetic field. Its application sharply increases the productivity of prospecting work and yields considerable economy.

The Institute of Radio Engineering and Electronics of the Academy of Sciences, USSR, worked in 1966 on telemetry, new methods of transmission and reception of complex signals, and methods of monitoring the condition of communication channels.

The development of pattern recognition theories has been given relative prominence in the Academy reviews. The Institute of Automation and Remote Control was the major Soviet organization working on this problem in 1965. At the same time, theoretical work on pattern recognition was also pursued in Estonia, where heuristic algorithms were developed and applied to medical diagnostics, geology, and meteorology. In 1966, the Institute of Information Transmission Problems, the Institute of Automation and Remote Control, and the Institute of Physics and Mathematics of the Lithuanian Academy of Sciences developed algorithms for pattern recognition, including recognition of speech signals, medical diagnostics, acoustic diagnosis of machine defects, classification of minerals, etc. The importance of pattern recognition work was emphasized by the fact that in the 1968 review it was one of the few subjects mentioned in the very limited activity report on cybernetics.

AUTOMATIC CONTROL AND AUTOMATA

A large portion of material in this area is headed by the term, "technical cybernetics," by Soviet specialists, who define it as a study of process control systems and a search for optimal man-machine interface. In 1963, relatively little activity was reported in this area. A minimax criterion was used to develop a method of solving the problems of optimal control of a linear stationary system operating under the worst possible conditions created by the application of perturbing forces. Methods were developed to analyze systems of automatic control with variable structure and infinite order of astatism, given complete and incomplete information about the status of the system. Also, methods were developed for automatic optimization of continuous technological processes. Only two Institutes were mentioned: the Institute of Automation and Remote Control, and the Institute of Cybernetics of the Estonian Academy of Sciences. In 1964, even less was reported: a theory of universal controlled machines based on probabalistic logic; an effective method of minimizing Boolean functions; and an algorithm for network computation. The only organization mentioned in this context was the Institute of Cybernetics of the Georgian Academy of Sciences.

The two vintage years for technical cybernetics appear to be 1965 and 1966, which involved a much larger number of projects and organizations. In those years a relatively large prominence was given to work on the theory of relay systems and finite automata and, particularly, to the abstract synthesis of automata. The Soviet Union claims priority in the development of the following subdivisions of this field: theory of modular synthesis, theory of microprogram systems, mathematical models of relay systems, and behavioral aspects of automata theory. For this work, credit is given primarily to the Institute of Automation and Remote Control and the Institute of Information Transmission Problems.

In 1965, work was begun on comprehensive optimization of computer structures, simultaneously stressing miniaturization, simplification, and improvement in operating speed. A special logic language was developed to represent the synthesis algorithms and the corresponding programming system. The work of the Siberian Physical Technical Institute on statistical evaluation of various synthesis algorithms was considered very important.

In 1966, the theory of relay systems and finite automata received further development. Methods were obtained to bring the size of structures close to the absolute minimum. Significant progress was noted in the theory of microprogrammed automata that has a direct application to the design of electronic computers and control machines. A number of transformations in the microprogrammed algebras of automata were suggested and effective methods minimizing programs and miniaturizing structures of microprogrammed automata were proposed, advancing the research in design optimization problems. The principal institutes mentioned in this context are the Institute of Cybernetics of the Ukrainian Academy of Sciences, USSR, and the Institute of Information Transmission Problems. The theory and the corresponding programming for synthesizing relay systems, based on the so-called inertial semi-automata, were completed by the Institute of Electronics and Computer Technology of the Latvian Academy of Sciences. The Institute of Technical Cybernetics of the Academy of Sciences of the Byelorussian SSR developed an algorithm and a program for analyzing complex relay switching systems. The program is designed for analyzing multi-cyclic relay systems with several input sequences in which the number of input, intermediate, and actuating elements reaches 320. The stability of variable-structure systems was studied and a control algorithm was proposed for a variable-structure controller based on real elements. The principal institutes working in the area of technical cybernetics were the Institute of Automation and Remote Control, the Institute of Information Transmission Problems, and the Cybernetics Institutes of Estonian, Georgian, Ukrainian, and Byelorussian SSR.

AUTOMATIC DESIGN OF COMPUTERS

Automation of computer design is an important aim of Soviet theoretical research. In 1964 the Institute of Cybernetics of the USSR Academy of Sciences advanced new methods of formal synthesis of potential and logical structures of digital computers that served as a theoretical foundation for the comprehensive automation of computer design. The work was continued in 1965 and 1966 by the Institute of Cybernetics of the Ukrainian Academy of Sciences. The Institute carried out first experiments in machine synthesis of universal digital computer blocks. It also developed a language for the description of algorithmic structures and the principles of automatic computer design, methods of structural microprogramming of information processing algorithms, and the principles of designing information automata. The Institute also developed input and internal languages and methods of structural interpretation.

In 1965, attention was also paid to the design of high-productivity computer systems and to the study of structural reliability. The problem of achieving highly reliable relay systems in the logic module and in the delay block, assembled from less reliable internal elements and inputs, was solved. Besides the Cybernetics Institute, the organizations active in this field are the Institute of Mathematics of the Siberian Department, and the Institute of Automation and Remote Control.

COMPUTER HARDWARE

The reviews for the years 1964, 1965, and 1966 cover a fairly constant--if limited--range of hardware items in development or prototype construction, such as a photo-optical tracker for automatic tractor control, an adaptive control machine for solving differential equations, and a photoelectric polar correlator. The review for 1966 mentions for the first time the development of pneumatic and hydraulic computer elements. In only one case was a specific major computer mentioned: The account for 1967 reports on the completion of tests with a new Minsk-222 model, which is a combination of two Minsk-22 and one Minsk-2 computers. It is noted that the capacity of the new system was increased from 2 to 38 times in comparison to the capacities of the individual machines. The Institutes credited with the reported items of computer and automatic machine hardware are the Institute of Cybernetics of the Ukrainian Academy of Sciences, the Institute of Cybernetics of the Georgian Academy of Sciences, the All-Union Institute of Scientific and Technical Information, the Institute of Automation and Electrometry of the Siberian Department, the Institute of Electronics and Computer Technology of the Latvian Academy of Sciences, the Institute of Mathematics of the Siberian Department, and the Institute of Automation and Remote Control.

PROGRAMMING LANGUAGES

Throughout the years covered, very little is reported on the development of software for specific computer types. In 1963 the Institute of Cybernetics of the Estonian Academy of Sciences developed a system of automatic programming of arithmetic operators for the M-3 machine; with this system programs for the solution of engineering and technical problems can be written in a form close to the usual mathematical notation. In 1964, a programming language for the synthesis of algorithms (LYaPAS) was developed. This language increases the effectiveness of computer technology in the solution of complex problems. In 1966, translators from the LYaPAS language were developed for the majority of Soviet computers. The institutes credited with this work are the Siberian Physical-Technical Institute of the Tomsk University and the Institute of Mathematics with its Computer Center of the Moldavian Academy of Sciences. In 1967, software was developed for the Dnepr-2 system. In connection with this system, the Academy claims that a time-sharing program was implemented and operated for the first time in the Soviet Union.

SYSTEMS ANALYSIS

Systems analysis is defined as the area of Soviet cybernetics dealing with research on large complex systems and computer installations serving a larger user audience. Information pertinent to this area is fairly limited in the Academy reviews. In 1963, the Computer Center of the Academy of Sciences of the Azerbaydzhan SSR investigated a large network of instruments with inhomogeneous demand pattern using the phase-space method. The work yielded a generalization of the classic problem of the so-called "mass-service," which in Soviet computer terminology is related to the time-sharing concept. Specifically, non-stationary time-sharing problems were solved for the case of the failure of one processor and for the case of two demand flows. An algorithm of a mathematical model and a computer simulation of the time-sharing system were proposed. The Academy review of 1966 reported on the development over several years of the theory of organization and management of large systems. Such systems are established for single-purpose complex operations that are identical in character but have different modes of information collection. Network analysis programs were constructed and debugged. Systems for multi-purpose complex operations were in the development and introduction stage. Considerable importance was attached to the problems of managing large systems that are applicable not only to individual machine sets, but also to all plant departments, enterprises, branches of national economy, and even the national economy as a whole.

RELIABILITY THEORY

Reliability theory is regarded as a distinct branch of cybernetics and was given a relatively wide coverage in the 1966 and 1967 reviews. In 1965 new results were obtained in systems duplication and analysis of self-restoring detection systems. The analysis of standby equipment with a limited number of restoring cycles yielded more rational methods of quantitative evaluation of the necessary resources. The organizations credited for this work are: the Moscow State University, the Institute of Automation and Remote Control, and the Scientific Council of Cybernetics of the USSR Academy of Sciences. In 1966, reliability studies were extended to the products of radio-electronic, automation, and machine-building industry. Substantial results were obtained in the area of structural reliability. Methods of synthesizing structures of relay systems with a given reliability level by introducing a structural redundancy, asymmetry, and unequal failure probability were developed. Particular attention was paid to the physical processes occurring in failures. Exceptional importance was attached to economic problems of reliability. Methods of determining optimal lifetime of products based on cost-effectiveness criteria were developed. The practical results of reliability analysis are new electronic elements; in particular, thin film elements, broader use of redundancy, and the utilization of codes for detecting and correcting errors were developed. The Moscow Power Institute created a method of predicting reliability from a sequence of failures, allowing for a significant reduction of prediction time and an increase in precision of the obtained results. A semi-automatic machine was designed and built to realize the method.

MACHINE TRANSLATION AND INFORMATION STORAGE AND RETRIEVAL

In 1963, a mathematical language was created for programming machine translation problems, and a program for translation from the English language was described in detail by the Institute of Mathematics, Siberian Department. 1964 results include an algorithm and system of programs for word-by-word machine translation from English into Russian, using the Ural-4 computer, development of methods for semantic translation of scientific and technical texts from various languages into Russian, and the application of the results to prepare thesauri based on textual analysis. An algorithm of translation from Russian into Armenian was prepared and considerable work done on the design of a specialized computer for automatic translation.

In 1966, an experimental system of automatic translation of publications in the American patent journal, *The Official Gazette*, was being debugged. Several texts with a total volume of about 10,000 words were translated by the Ural-4 machine with a satisfactory quality. The development of experimental algorithms for a Japanese-into-Russian automatic translation was completed. The algorithm was to be programmed for the BESM-6 computer. The organizations active in this field are the Institute of Mathematics of the Siberian Department, the All-Union Institute of Scientific and Technical Information, the Computer Center of the Armenian Academy of Sciences and the Yrevan University, and the Central Scientific Research Institute of Patent Information. In the field of information storage and retrieval, the All-Union Institute of Scientific and Technical Information developed a project to establish an automated information reference center for electrical engineering. The Scientific Research Institute of Economic Information designed algorithms and built an operating system for subject-based document search, using a data base of 20,000 entries in computer technology. A search language, coding system, and a descriptor thesaurus for a mechanized search system to operate on perforated cards for a data base of 70,000 documents were developed.

TRAINING

The ever-increasing demand for a large number of well-trained personnel for industry, agriculture, and science calls for new advanced training methods. Work began in 1964 on programmed teaching methods that would make a broad use of various technical devices and computers and specially prepared programmed textbooks. This work was being carried out in a number of universities, institutes, and schools. In 1964, a number of programmed textbooks was prepared and a variety of simple training devices were built. In some academic institutions computers were drawn into the training work. However, work on programmed teaching is not considered to be on a satisfactory level. A scientific establishment specializing in research in this field is needed.

NATIONAL ECONOMY

Soviet cybernetics activities in the field of national economy were reported quite extensively by the Academy of Science, particularly for the years 1965, 1966, and 1967. The cybernetic work in this field falls into the following categories:

- Planning and analysis of national economy

- Industrial automation
- Production plans
- Power systems
- Transportation
- Chemical industry
- Agriculture
- Unified network of computer centers.

Planning and Analysis of National Economy

In spite of the widely expressed and insistent views on the urgent needs to apply cybernetic methods and equipment to the problems of national economy planning and analysis, there is no evidence in the accounts of the Academy of Science of any systematic effort in this direction. There is only a number of disconnected statements through the years concerning various geographic areas and various problems of economic planning. These, however, may be merely the highlights considered worthy of mention by the Academy of Sciences, while the unreported related activity may have a much greater degree of cohesion and purpose.

In 1963, the Byelorussian and the Lithuanian Republics prepared their interbranch budgets using the Minsk-2 computer. The computer program matrix models of budget plans were being introduced in the State Committee of Lumber, Paper, and Wood-processing Industries and Forestry, attached to the Gosplan, USSR. A new and interesting method of solving large-scale economic planning problems dealing with the maximization of specific production plans was submitted. The results of experimental computation of demand for material resources in the individual departments of the Ukrainian SSR was analyzed by the Scientific Research Institute of Gosplan of the Ukrainian SSR. In 1963 and 1964, the methods of modeling systems of supply were being developed and the corresponding algorithms were being worked out by the Central Mathematical Economics Institute of the Academy of Sciences of the USSR, the Gosplan of the Ukrainian SSR, and the Cybernetics Institute of the Ukrainian Academy of Sciences. In the same year, supply indices prepared by the method developed by the Institute of Cybernetics of the Ukrainian Academy of Sciences were introduced for the first time in the national economy plan of the Ukrainian SSR.

In 1966, a dynamic model of national economy planning was adapted for the input of standardized economic information. The Central Mathematical Economics Institute prepared a number of papers on the problems of optimal functioning of the Socialist economy and developed a single-sector dynamic model and a computation of global indicators for the plan for 1971-75.

In 1969 the Central Mathematical Economics Institute and the Institute of Economics and Organization of Industrial Production of the Siberian Department were noted for important research in the field of long-range forecasting of the Soviet economy. The investigation concerned the effect of the main parameters of economic development, such as supply of material, capital, labor, and others, on the growth of the economy.

Industrial Automation

Production Plans. From 1963 to at least 1966, the Institute of Mathematics and Computer Technology and the Institute of Technical Cybernetics of the Academy of Sciences of the Byelorussian SSR were particularly active in this field. Their tasks consisted of designing algorithms and mathematical models for a number of technological processes, such as the reliability of automatic conveyor belts in industrial enterprises, design of machines and technological base for production, and design of technological processes. These institutes were also active in development of the theory of large systems. The research consisted of designing models for controlling operational complexes, and programming algorithms for analyzing network models for optimal planning problems.

In 1965 and 1966 the concept of mass-servicing, or time-sharing, was the task of the Institute of Mathematics of the Siberian Department. During the two years, the Institute also carried out a number of projects for the steel industry, modeling automatic systems involving rolling mills. The L'vov television plant work of the Institute of Cybernetics of the Ukrainian Academy of Sciences was also noted for the years 1965-1967. While the steel plant research of the Institute of Mathematics centered around process control, the television plant project involved the automation of management and accounting operations. In 1967, the Cybernetics Institute completed and put into operation the first section of an automated control system for planning, accounting, and operational management of the prefabricated parts shop and the television set assembly shop of the L'vov plant.

In 1965 and 1966, cybernetics development of direct industrial significance pursued the following major objectives:

- Network planning that reached the stage of control of operation complexes in a number of plants, such as the Vilnius Calculating-Machine Plant, Lipetskstroy, and the VEF Plant of Radio and Telegraphic Equipment
- Modular information-control systems
- Mass-servicing systems such as an automatic airline reservations system
- Remote-control systems for management and process control of beneficiation plants and mines (BTA-2)
- Universal modular systems for control of complex electro-and-radio-engineering installations
- Solid-state remote-control systems for programmed control of large distributed hierarchical structures (such as a system of ten regional establishments consisting of a total of 5,000 economic units)
- Theory of large systems
- Algorithms for determining optimal control strategies for discrete systems with a large number of variables, particularly applicable for the solution of problems of organizing production and computing technological processes in power plants, oil-well operation, etc.

The organization particularly active in this work is the Institute of Automation and Remote Control. The Institute is also noted for applying the theory of relay systems and finite automata to the synthesis of complex machines for technical diagnosis, such as the *Puma-E* machine for servicing electric locomotives.

A system of collecting, transmitting, and storing technical and economic production data was installed in the Barnaul radio plant by the

Computer Center of the Siberian Department. The Moscow Engineering Physics Institute developed an automated system of designing building construction work.

In 1969 a number of major achievements was noted in the field of industrial cybernetics. The Institute of Automation and Remote Control designed methods of optimizing complex systems of control for operation of oil wells, oil processing, chemical reactors, and complex power systems.

The Institute of Cybernetics of the Ukrainian Academy of Sciences developed a number of new systems and elements, including systems for planning, accounting, and management of the Zaporozhstal' Plant; an automatic machine for making drawings, graphs, charts, and other graphics in automated designing and processing of scientific research; rapid-action, small-size logical elements for discrete computing devices; micro-modules of metal oxide semi-conductors; and a series of cathode-ray tube devices for displaying information from computers. This work involved the participation of the Institute of Automation and Remote Control, Institute of Electronics and Computer Technology of the Latvian Academy of Sciences, Institute of Technical Cybernetics of the Byelorussian Academy of Sciences, the Moscow Power Institute, and others.

Power Systems. The principal organization in this field was the Institute of Energetics and Electrical Engineering of the Lithuanian Academy of Science. In 1964, the Institute developed methods, algorithms, and programs for synthesizing economic networks as applied to the production and distribution of a single product type such as electrical energy. Specifically, algorithms were developed for automatic optimization of the operation of power plants and transmission stations. In 1965, the algorithms were tested on a digital control computer and optimization systems were run through electronic analog computers. In 1966, the software was handed over to the Siberian Power Institute of the Siberian Department and to the Energoset'proyekt Institute and other organizations for further development. The Siberian Power Institute used the automated power system plants as a model to study the nature and properties of large developing economic systems; it proposed a number of approximate methods of optimizing the development of such systems.

Similar work was applied to the 1970 plans for the power grid of the Moldavian Power System. This was done by the Department of Power Cybernetics of the Academy of Sciences of the Moldavian USSR, together with the L'vov Department of Energoset'proyekt.

The Moscow Power Institute also worked on automated optimization of power system operation. It developed a nonlinear theory of simulation and methods for evaluating the reliability of the individual elements of power systems.

Transportation. A relatively fair amount of attention has been paid to the application of cybernetics research to the problems of transportation. In this work, the emphasis was placed upon railroads.

Two major projects have been discussed under the code names of Avtomashinist (automatic train operator) and Avtodispetcher (automatic train dispatcher). In 1963, the first stage of the Avtomashinist system was completed. Experimental units were installed in three trains of the subway, and in electric trains on the Moscow-Kalinin line. In 1965, an experimental Avtodispetcher system for automatic control of long rail lines was completed. In 1966, Avtodispetcher system equipment was assembled on the Lyubertsy-Chelyusti line. An experimental operation of this system and introduction into other lines was scheduled for 1967. The economic effectiveness of the system was expected to amount to 200 to 300 thousand rubles per year. The work was concentrating the efforts of a large number of railroad organizations, such as the Central Research Institute of the Ministry of Transportation, the Leningrad and Moscow Subway Systems, the Leningrad Institute of Railroad Transportation Engineers, the Moscow Institute of Transportation Engineers, the Computer Center of the Moscow Railroad Administration, the Dnepropetrovsk and Khabarovsk Institutes of Railroad Transportation, and others. The Institute of Automation and Remote Control was also active in this work.

In 1963, an overall evaluation of railroad operations in a local economy was carried out in Uzbek, USSR, in the computer center of the Institute of Mechanics of the Uzbek Academy of Sciences. In 1965, the Mining Institute of the Siberian Department investigated various systems of automating electrical transportation in mines. This work resulted in the construction of an experimental 14-KR type locomotive with automatic control.

In 1963, cybernetic research was applied to the control of river transportation. The Central Scientific Research Institute of Electronics and Computer Technology of the Ministry of River Fleet of the RSFSR developed a system of automatic traffic control to be used by the Volga River steamer system. The operation of the system in 1963 gave positive economic results. The Institute also solved the problem of fleet expansion for 1965-70, and completed a project of dry goods transportation in the Caspian Sea.

In the motor-freight transportation area, a new method was developed and was being introduced in twelve major cities by the Scientific Research Institute of Motor Transport in its Leningrad branch in 1963. In 1964, transportation was noted in the petroleum industry. In 1965, motor-transport planning was applied to the major cities of the Ukraine by the Cybernetics Institute of the Academy of Sciences of the Ukrainian SSR.

Chemical Industry. The chemical industry is one of the major industries slated for cybernetic development. Throughout the years from 1963 to 1966, a considerable amount of work was noted in the creation of general principles of mathematical modeling of chemical processes and also methods of optimal control and design of chemical production. In 1963, automatic data processing for chemistry was carried out on a large scale, based on perforated-card systems.

In 1965, a number of methods for automatic and semi-automatic indexing of chemical information was developed and programmed on a Ural-4 machine; the results obtained were used in a project for a Reference and Information Center of the Academy of Sciences of the USSR. The experience with perforated reference cards in metallurgy was generalized and a prototype of a standardized perforated card approved. A subscription to 22 perforated-card libraries in metallurgy and associated chemical problems was initiated. The author index of the Abstract Journal in chemistry was converted to a microfiche mode and an organization of a Reference Information Center in chemistry was being completed.

The activity most consistently reported on in the Academy of Science's meetings was the mathematical modeling of chemical processes. Of these, particular attention was paid to the model of catalytic processes; in 1963, such a model was constructed for the production of sulfuric acid, ethylene oxide, and nitril-acrylic acid. In 1965, the modeling was expanded to two and three-dimensional contact reactions involving a fixed catalyst layer and a boiling catalyst layer. The construction of mathematical models of processes included, in 1963, the modeling of the separation of multi-component systems. In 1964, this work concerned increasing the precision of such models as could be described by ordinary differential equations. In 1965, mathematical modeling involved the use of kinetic equations of mass and heat transfer; in 1966, a method of "extremal imitation" of sensing system status by noise was developed.

Another major subject of chemical cybernetics worked on was optimal production control, which was noted in 1963, 1965, and 1966. This included the development of high-quality automatic process control systems, optimal process control systems, and methods of evaluating the quality of measuring and monitoring systems to be applied to the chemical industry.

The third major topic was the mathematical theory of experimentation. In 1963, it was applied to the optimization of the separation and extraction of rare metals. The mathematical approach to planning of experiments was again noted in 1965.

A project of several years standing involved the production of synthetic rubber by the Voronezh Synthetic Rubber Plant. An algorithm for controlling a complex process that does not have a mathematical description and depends on a large number of factors was developed by the Moscow Power Institute in 1963. In 1965, the Moscow Engineering Economics Institute developed for this plant a preliminary methodology for computing financial plans using a computer-based matrix method. In the same year, a number of mass-produced adaptive optimizing machines were introduced in synthetic rubber plants.

An atlas of mathematical models and algorithms was prepared in 1965 by the Department of Cybernetics of Chemical and Technological

Processes of the Moscow Chemical and Technological Institute, with the participation of the Siberian Department of the Academy of Sciences.

The organizations active in this work are the Institute of Catalysis of the Siberian Department, the Institute of Mathematics of the Siberian Department, the Computer Center of the Azerbaydzhan Academy of Sciences, the Problem Laboratory of the Mathematical Statistical Methods of the Moscow State University, the Computing Center of the Siberian Department, the Institute of Automation and Remote Control, the Experimental Design Bureau for Automation, the Central Scientific Research Institute for Complex Automation, the Moscow Chemical Technological Institute, the All-Union Institute of Scientific and Technical Information, and a number of industrial organizations. It is interesting to note that the Central Mathematical Economics Institute is not mentioned in the annual Academy reviews for the area, although it has been involved in this work.

Agriculture. Very little data have been reported by the Academy in this area. In 1965, within the framework of planning agricultural production by mathematical and computer methods, previously obtained economical mathematical methods of planning the structure of sowing acreages and building cattle herds was improved by the Institute of Physics and Mathematics, together with the Institute of Agricultural Economics of the Lithuanian USSR. Methods of planning and computation for the Siberian regions were reported in 1966. The Institute of Cybernetics of the Georgian SSR was also reported active in agriculture.

Unified Network of Computer Centers. Although the idea and plans for a unified network of computer centers were the subject of numerous statements, speeches, and articles in the Soviet literature for a number of years, the actual work--if any--done in this area has not been reflected to a significant extent in the reviews. The reviews only note that in 1963 work was begun and the first results obtained in the creation of basic principles for the technical equipment necessary to consolidate the electronic computers and computer centers into a single informational system. The Institute of Cybernetics of the Ukrainian Academy of Sciences was credited with this work. In 1966, the design principles for automated systems of planning and management were being developed. The Scientific Research Institute of Economic Information on Radio Electronics, together with the Scientific Research Institute of the Central Statistical Administration, submitted general principles for designing a state network of computer centers designed for the collection and processing of economic information intended for the solution of problems of management and planning in national economy. During the same year, the Institute of Information Transmission Problems achieved some results in the theory of distribution of informational flows in a single communication system. The Institute also submitted the principles to achieve automated optimization of information flow distribution with varying configurations of the communications network.

BIOLOGY AND MEDICINE

Bionics was represented in the Academy reviews for the years 1964, 1965, and 1966. In 1964, the mechanism of nervous activity was studied on the physical, chemical, cellular, and structural levels. New results were obtained by the Institute of Information Transmission Problems in the research on the transmission and processing of information in the nervous system. In 1966, the Institute was again noted for continuing work in this field and particularly for the unique methods of analyzing the operation of visual organs, investigation of the properties of the visual analyzer, and the role of eye movement in the process of vision. The study involved insects and vertebrates. The eye-movement mechanism and its control system was also the subject of work by the computer center of the Academy of Sciences in the same year. Other types of movements, such as breathing and stance control, were studied by the Institute of Biophysics of the Academy of Sciences. Other physiological control systems studies involving computer simulation were carried out by the Institute of Surgery of the Academy of Medical Sciences of the USSR, and the Institute of Cybernetics of the Ukrainian Academy of Sciences. In 1966, the Institute of Cybernetics was noted for work on the informational processes in the brain. The reliability of information transmission in the central nervous system was the subject of a study that led to the conclusion that nerve fibers are not passive elements but have definite tasks in processing information. The study was performed by the Laboratory of Neurobionics of the Armenian Academy of Sciences.

The Institute of Mathematics of the Siberian Department built classical models of the survival theory. For the first time, stable models were constructed for this theory. The Institute of Automation and Electrometry of the Siberian Department studied the functions of olfactory receptors and indicated the feasibility of designing devices to monitor vapors of a given material in a medium. The Institute has developed and built a prototype of such a device distinguished by high speed of operation. Automatic recognition of characteristic signals of speech was developed and tested experimentally by the Institute of Physics and Mathematics of the Lithuanian Academy of Sciences. Recognition of visual patterns by living organisms showed that the primary processing of information is carried out by the receptor fields of the visual system. An electronic model of the receptor field of the retina was built by the Institute of Physiology of the Academy of Sciences.

Most of the medical cybernetics research was started in the early sixties and the first results were noted in 1963. The central topic of this research was the automation of the diagnostic process. The Institute of Surgery developed a program for diagnosing diseases of the liver. A special device was built for mathematical processing of biological and physiological information and was applied to the analysis of the cardio-vascular system and particularly to the analysis of dynamocardiograms. The device was built by the All-Union Scientific Research Institute of Medical Instruments and Equipment. Automated diagnosis was pursued in 1965 and 1966 by the Institute of Surgery, based on the recognition algorithm. In 1965, an adaptive computer system was used for this purpose. The Leningrad Scientific Research Institute of Neurosurgery and the Institute of Information Transmission Problems also pursued this work. In 1965, significant results were obtained in the development of systems of bioelectric control of machines. It is claimed that the priority of Soviet science in this field has been recognized by the entire world.

BIBLIOGRAPHY FOR SECTION III

Vestnik AN SSSR, No. 3, 1964, pp. 38-42
Vestnik AN SSSR, No. 3, 1965, pp. 40-43
Vestnik AN SSSR, No. 3, 1966, pp. 32-39
Vestnik AN SSSR, No. 3, 1967, pp. 42-50
Vestnik AN SSSR, No. 5, 1968, pp. 13-36
Vestnik AN SSSR, No. 5, 1969, pp. 5-13

Appendix A

INSTITUTE OF AUTOMATION AND REMOTE CONTROL

LEADING RESEARCH AND DEVELOPMENT SPECIALISTS

Name	Period of Activity	Profile of Activity
Ya. Z. Tsypkin	1946-1968	Linear and nonlinear pulse systems, discrete optimal systems, self-learning systems
M. A. Ayzerman	1951-1963	Stability problems, theory of finite automata
M. V. Meyerov	1947-1961	Stability problems, regulation theory, machine-tool control
V. S. Pugachev	1957-1964	Linear control systems, optimal systems, stochastic control theory
A. A. Fel'dbaum	1949-1966	Stochastic control theory, optimal process theory, adaptive systems, automatic optimizers, computer software theory, automatic synthesis of control systems
A. Ya. Lerner	1952-1966	Optimal control systems, pattern recognition, modular design of control systems, electric drive systems, blast furnace control systems
L. I. Rozonoer	1959-1964	Optimal control systems, invariance theory, adaptive systems, theory of finite automata
B. N. Petrov	1947-1967	Invariance theory, adaptive systems
S. V. Yemel'yanov	1962-1966	Invariance theory, variable-structure systems, regulator design
L. N. Fitsner	1958-1964	Automatic optimization systems, extremal regulation theory, automatic optimizers, automatic synthesis, machine-tool control

Name	Period of Activity	Profile of Activity
E. M. Braverman	1960-1964	Pattern recognition, learning machines
M. A. Gavrilov	1952-1963	Relay systems, finite automata
P. P. Parkhomenko	1957-1969	Relay systems analysis and synthesis, theory of finite automata, bridge network synthesis, universal testing machines, logic machines
V. A. Il'in	1955-1968	Remote control systems, reliability theory, large telemechanical systems, electric drive systems
V. A. Zhozhikashvili	1955-1969	Remote control systems, contactless remote control devices, telemetry systems, reliability analysis
B. Ya. Kogan	1955-1964	Mathematical modeling, computer software, analog computer design
Ye. V. Krug	1956-1964	Standardization of control equipment, contactless actuators, analog and digital regulators
G. P. Katys	1959-1969	Pattern recognition devices, optical scanning systems
I. V. Prangishvili	1959-1969	Contactless remote control systems, integrated solid-state logic circuits
D. I. Ageykin	1957-1967	Automatic monitoring systems, sensor and measuring instrument design
V. Yu. Kneller	1958-1968	Automatic measuring bridges
D. Ye Polonnikov	1955-1968	Analog computers, electronic amplifier design
M. A. Rozenblat	1958-1968	Magnetic amplifier design
S. P. Khlebnikov	1959-1968	Digital computer elements, computer peripheral equipment, digital instrument design

SPECIALIZED CO-AUTHOR GROUPS

Subject	Period of Activity	Number of Authors
Nonlinear Pulse Systems	1946-1966	5
Theory of Invariance	1955-1967	13
Coding Theory	1963-1968	4
Relay Networks	1958-1963	9
Mathematical Modeling	1959-1968	5
Mathematical Analysis	1967-1969	6
Contactless Actuator	1950-1968	10
Variable-Structure Regulator	1960-1964	6
Pattern Recognition	1968-1969	4
Teleautomatic Systems	1955-1969	8
Radioactive Isotope	1959-1962	6
Automatic Measuring Bridge	1958-1968	6
Measuring Instruments and Indicators	1957-1967	6
Optical Systems	1959-1968	12
EMU Simulator	1955-1964	14
Solid-State Electronics	1959-1966	3
Magnetic Logic Elements	1959-1964	2
Electrochemistry	1965-1969	3
Solid-state Logic	1967-1969	10
Peripheral Digital Equipment	1959-1968	8
Magnetic Amplifier and Logic	1955-1969	16
Hydro-automatic	1958-1968	2
Industrial Pneumo-automatic	1958-1968	14
Pneumatic Devices I	1958-1968	10

Subject	Period of Activity	Number of Authors
Pneumatic Devices II	1958-1968	3
Measuring Devices	1968-1969	7
Adapter Systems	1958-1960	8
Oxygen Converter	1968-1969	22
Control Optimization	1963-1968	6
Metal Casting	1968-1969	6
Blast Furnace	1968	16
Aluminum Processing	1968-1969	5
Materials Handling	1967-1969	15
Blasting Machine	1968	6
Coal Beneficiation	1968	10
Mining Machine	1968	4
Neuron Information Processing	1964-1967	6

DISSERTATIONS

Doctoral Dissertations

Name	Year of Publication
A. F. Beletskiy	1959, 1968
V. K. Chichinadze	1968
E. L. Itskovich	1968
P. P. Parkhomenko	1968
D. Ye. Polonnikov	1965, 1968
I. V. Prangishvili	1968
N. S. Raybman	1966, 1968
E. M. Braverman	1967
A. G. Butkovskiy	1965, 1967

Name	Year of Publication
A. Ya. Sochneve	1959, 1966, 1967
A. A. Talem	1967
R. R. Varshamov	1966, 1967
V. I. Varshavskiy	1966, 1967
A. D. Zakrevskiy	1967
L. A. Zalmanzon	1963, 1967
D. I. Golenko	1964, 1965
Ye. L. Orlovskiy	1965
D. I. Ageykin	1963
L. N. Fitsner	1963
Ya. B. Kadymov	1961
D. V. Svecharnik	1961
N. P. Vlasov	1961
Yu. I. Neymark	1957, 1960
S. P. Pivovarov	1960
L. A. Bessonov	1958
N. N. Bautin	1957
A. A. Fel'dbaum	1956

Candidate of Sciences Dissertations

A. Kh. Abramov	1968
A. L. Abrukin	1959
Yu. V. Aksenov	1968
G. N. Alyabyeva	1958
G. G. Ananiashvili	1966
Ch. I. Askerov	1965

Name	Year of Publication
G. Kh. Babich	1965
V. V. Bardizh	1964
V. M. Baykovskiy	1965
V. G. Belyakov	1963
R. G. Berulava	1968
N. O. Biryukov	1959
M. A. Boyarchenkov	1964
E. M. Braverman	1963
O. I. Bronshteyn	1965, 1968
O. A. Budko	1958
V. N. Burkov	1969
A. G. Butkovskiy	1963, 1966
A. B. Chelyustkin	1957, 1959
A. G. Cherkashina	1966
Ye. I. Chernov	1958
M. K. Chernyshev	1967
J. Chi	1961
Yu. I. Chugin	1963
L. E. Degtyar	1968
V. P. Didenko	1964
V. N. Dmitriyeve	1960, 1961
Ye. Ye. Dudnikov	1964
A. R. Dzhelyalov	1964
V. L. Epshteyn	1961
B. I. Filipovich	1964
A. I. Galaktionov	1966, 1968

Name	Year of Publication
M. A. Gavrilov	1964
V. A. Gayskiy	1968
M. B. Gendler	1965
E. I. Germ	1968
Ye. G. Gladyshev	1967
V. G. Gogolevskiy	1966, 1968
V. R. Gorov	1968
N. S. Gorskaya	1958
V. V. Gorskiy	1957, 1966, 1967
V. G. Grishin	1965, 1967
N. V. Grishko	1964
D. E. Gukovskiy	1966
A. M. Gurevich	1967
I. S. Gurevich	1966, 1968
I. S. Ibragimov	1968
V. M. Ilinskiy	1966
V. V. Imedadze	1958
G. G. Iordan	1957, 1959
Yu. F. Itkis	1968
E. L. Itskovich	1967
V. I. Ivanov	1959, 1963, 1966
I. D. Karasev	1958
O. G. Kasatkin	1964
V. A. Kashirin	1962
O. I. Khaseyev	1963, 1965
Yu. G. Khvalov	1968

Name	Year of Publication
I. N. Kichin	1959
L. S. Kirillova	1965, 1966
V. Yu. Kneller	1959, 1961, 1964, 1965, 1967
I. V. Koban	1964
Ye. S. Kochetov	1968
I. V. Kogan	1966
L. G. Kogan	1958
P. V. Kokotovich	1965
V. A. Kolemayev	1965
N. I. Komov	1968
A. I. Koyekin	1966
G. V. Kreynin	1961, 1962
Ye. Krug	1956, 1958
V. I. Kikhtenko	1959
A. I. Kulakovskiy	1966
V. N. Kulibanov	1967
N. A. Kuznetsov	1966
O. P. Kuznetsov	1965
M. I. Lanin	1964
O. I. Larichev	1965
Yu. P. Leonov	1959, 1961
M. Ye. Limonova	1969
V. A. Lutskiy	1964, 1968
Yu. F. Maksimenko	1965
V. D. Malyugin	1967, 1968
Yu. D. Mamikonov	1964

Name	Year of Publication
Ye. P. Maslov	1965, 1969
I. L. Medvedev	1966
R. P. Megrelishvili	1966, 1968
Ya. I. Mekler	1963
L. V. Meltser	1957
S. M. Meyerkov	1968
P. F. Merabishvili	1964
L. A. Milovidov	1959
O. M. Minina	1962, 1963
K. G. Mityushkin	1964
P. V. Nadezhdin	1969
N. D. Nanobashvili	1966
V. V. Naumchenko	1967, 1968
B. N. Naumove	1959
V. Yu. Nevrayev	1959
K. B. Norkin	1963
Ye. L. Orkina	1968
L. M. Osovskiy	1964
V. M. Ostianu	1964
Yu. I. Ostrovskiy	1959
V. M. Ozernyy	1964
L. G. Palevich	1964
P. P. Parkhomenko	1959, 1963
Ts. Ts. Paulauskas	1963
D. P. Petelin	1966
V. V. Petrov	1958

Name	Year of Publication
B. P. Petrukhin	1966
Ye. P. Petrushinin	1968
D. Ye. Polonnikov	1957, 1958, 1962
V. M. Pomazan	1967
G. N. Povarov	1957, 1964
I. V. Pozin	1964
I. V. Prangishvili	1964
N. L. Prokhorov	1966
A. I. Propoy	1966
V. M. Pustylinikov	1963
G. G. Rakhimov	1968
V. K. Rayev	1966
A. L. Raykin	1968
Ya. A. Rips	1968
A. A. Romashchev	1968
Ye. N. Rosenvasser	1961
Yu. D. Rozental	1965
V. Yu. Rutkovskiy	1958, 1959
M. V. Rybashov	1964
Z. M. Salikhov	1964
E. P. Sarkisyan	1964
O. A. Sedykh	1959
V. A. Semenenko	1968
I. B. Semenov	1964, 1966
V. N. Shadrin	1964
A. G. Shashkov	1957, 1958

Name	Year of Publication
B. S. Shkrabov	1968
E. K. Shpilevskiy	1967
V. N. Silayev	1965
Ye. S. Sogomonyan	1965
R. A. Stakhovskiy	1959
V. L. Stefanyuk	1969
V. A. Strokov	1967
T. H. Tai	1961, 1963
A. I. Teyman	1967
P. P. Timokhovich	1967
Yu. L. Tomfeld	1964
E. A. Trakhtengerts	1966
G. N. Tsertsvadze	1964, 1968
E. L. Tsikovich	1964
Yu. M. Tsodikov	1965, 1967
V. V. Tsokanov	1964, 1966
A. D. Tsvirkin	1968
Ya. Z. Tsypkin	1956
G. B. Tumanyan	1964
Ye. N. Turta	1967
V. I. Utkin	1964, 1967
V. N. Vapnik	1966
R. R. Vasiliyev	1957, 1963
M. G. Vitkov	1963, 1967
T. M. Vorobyeva	1958
G. V. Voronin	1964

Name	Year of Publication
B. A. Vvlasyuk	1968
R. T. Yanushevskiy	1967
V. Z. Yarin	1965
S. V. Yemel'yanov	1959, 1960, 1964, 1968
E. B. Yershova	1965
V. P. Zhivoglyadov	1965
V. A. Zhozhikashvili	1964
V. P. Zinkevich	1967
V. D. Zotov	1969

TABULAR SUMMARY OF SECTION I PUBLICATION DATA

Subject Code for Table 1*

1. Theoretical Research

   1.1 Linear and Nonlinear Automatic Control Systems

   1.2 Optimal and Adaptive Systems

   1.3 Relay Systems and Finite Automata

   1.4 Remote Control

   1.5 Mathematical and Physical Modeling Methods and Applied Mathematics

2. Design and Construction

   2.1 Automatic Regulation and Control

      2.11 Modular Systems Design

      2.12 Automatic Control of Electric Drive

      2.13 Adaptive and Optimizing Systems for Automatic Regulation and Control

   2.2 Remote Control and Telemetry Systems

   2.3 Automatic Monitoring Systems and Devices

   2.4 Computers and Computing Devices

   2.5 Components and Units

   2.6 Hydraulic and Pneumatic Control Systems

*The method of identifying a specialized group by co-author correlation is shown in Fig. 5.

Table 1

DISTRIBUTION OF AUTHORS, TECHNICAL PAPERS, AND PATENTS
(by year and subject)

Subject	Year																				
	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	Totals
Authors																					
1.1		1	1			6	1	3	3	9	9	9	9	8	7	2	6	1	2		77
1.2			1	1	1	3	1	1		9	9	6	11	19	20	2	7	8	5		104
1.3			1			4	2	1	4	8	1	7	2	14	6	4			4	1	59
1.4						10				9	3	2	4	5	3	2	1	5	4		48
1.5				1		7	1	1	1	5	2	2	1	4	2	7	3	9	12	2	60
2.11	1					1	5				3		4	4	2		2	2	2		26
2.12		1			2	2	1	2	5	11	1				5	1		6	1	1	39
2.13									1		4	1	1		6	1	3		8	2	27
2.2						3		2	1	5			4	2	7	1		1	10		36
2.3								6	2	12	3	6	6	9	5	6		21	25		101
2.4						2	6	4	4	8	5	4	1	1	7	5		4	3		54
2.5			2			6	3		4	10		3	6	7	16	8	25	23	40	13	166
2.6						1			11	3	1	1		4		3	6	15	25		70
3.1									7		5				2			12	7		33
3.2														3	1	3	2	3	37	17	66
3.3						2								1		3	3	11	56	19	95
3.4															3	2	1	8	3	4	21
Totals	1	2	5	2	3	45	20	20	43	91	46	41	49	81	92	50	59	129	244	59	1,082
Technical Papers																					
1.1		1	1			5	1	2	4	10	13	11	10	10	9	1	5	1	2		87
1.2			1	1	1	3	1	1		8	11	6	10	18	18	2	5	4	3		93
1.3			2			10	3	1	.4	4	1	3	2	22	6	3			1	1	63
1.4						12				3	2	2	3	4	5	2	1	3	4		41
1.5				1		4	1	1	1	6	2	3	2	3	1	3	2	7	6	1	44
2.11	1					2	2				2		2	3	1		1	1	1		16
2.12		1				2	2	4	10	7	1				6	1		2		1	37
2.13									1		2	1	1		3	2	1				11
2.2						7		2	1	4			3	2	3	1		1	1		25
2.3								4	1	12		3	6	8	4	3		4	1		46
2.4						2	3	2	1	7	4	2	1	1				1			24
2.5						7	2		4	11		2	2	5	11	4	8	5	3	1	65
2.6						1			13	3	1	1		2		3	1	2			27
3.1									2		2				2			1			7
3.2														1	1	2	2	1	2		9
3.3										2				1		1	1	2			7
3.4															1	2	1	5	2	1	12
Totals	1	2	4	2	1	55	15	17	42	77	41	34	42	80	71	31	28	40	26	5	614
Patents																					
1.1																					
1.2																					
1.3																			2		2
1.4																					
1.5																					
2.11																	1	2	1		4
2.12					1	1												1	1		4
2.13											1								7	1	9
2.2																			7		7
2.3											3	1						11	13		28
2.4									1		1				1	1		2	1		7
2.5			1										3			1	8	10	31	6	60
2.6																	1	8	9		18
3.1																			5		5
3.2																			5	4	9
3.3																		3	18	7	28
3.4																		1			1
Totals	0	0	1	0	1	1	0	0	1	0	5	1	3	0	1	2	10	38	100	18	182

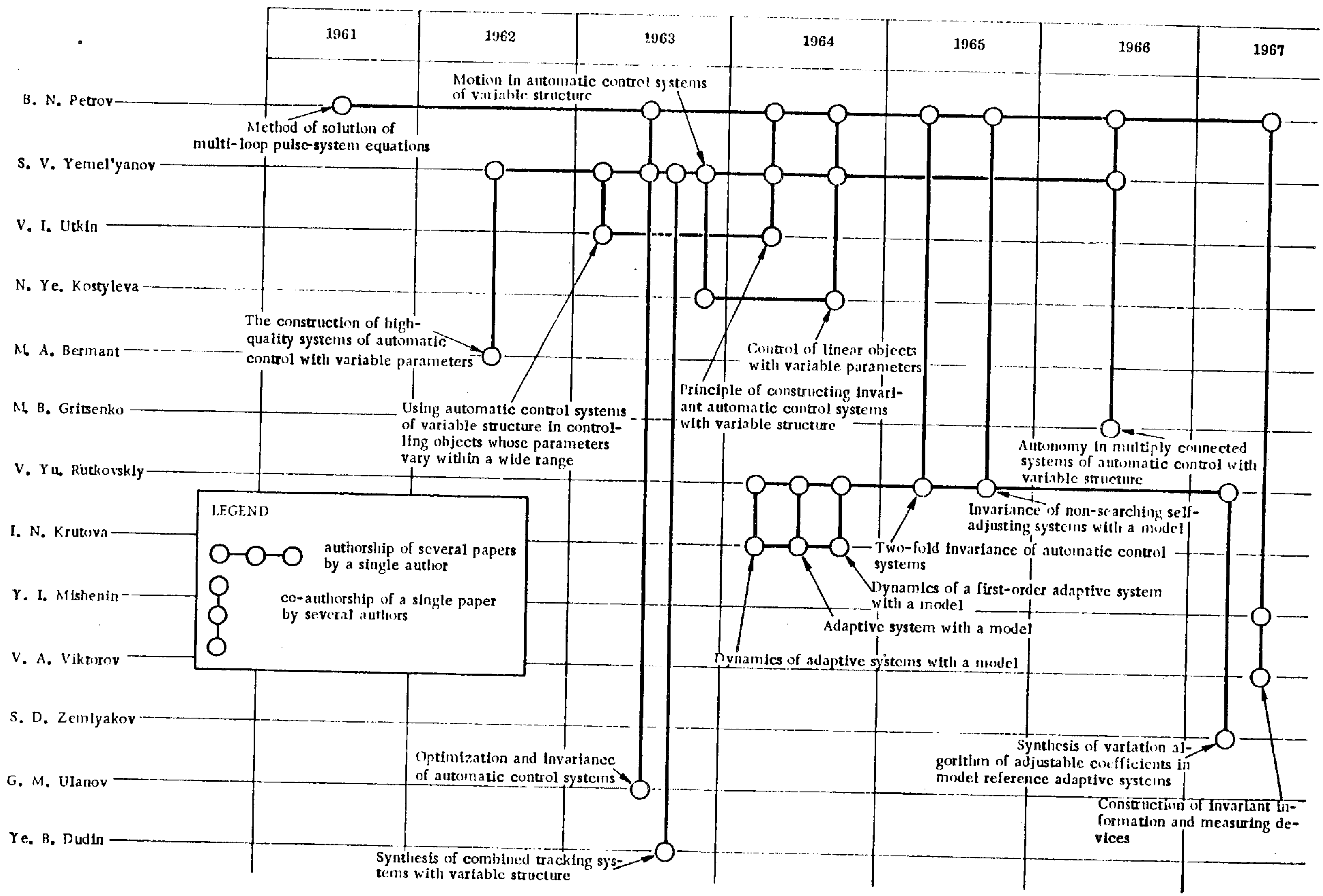


Fig. 5--Method of identifying a specialized group by co-author correlation
(Theory of Invariance Group)

3. Industrial and Research Applications

   3.1 Machine-tool Control

   3.2 Smelters

   3.3 Other Industries

   3.4 Biocybernetics

REFERENCES FOR SECTION I

Key to Abbreviations of Soviet Periodical Titles

Abbreviation	Expansion
ARU	Avtomaticheskaye Regulirovaniye i Upravleniye, Izd-vo AN SSSR
AVT	Avtomatika i Telemekhanika
BIP	Byulleten' Izobreteniy i Tovarnhkh Znakov
DAN	AN SSSR. Doklady
DAS	Dopovidi ANUkr SSR
ETE	Pribory i Tekhnika Eksperimenta
FAP	Funktsional'nyy Analiz i Yego Prilozheniya
FIS	Fermentnaya i Spirtovaya Promyshlennosti
FIZ	Inzhenerno-Fizicheskiy Zhurnal
IAU	Izvestiya AN Uzbek SSR
IFT	AN Est SSR. Izvestiya, Seriya Fiziko-Mathematichesikh i Tekhnicheskikh Nauk
IPO	Izobreteniya Promyshlennyye Obraztsy Tovarnyye Znaki
ITE	Izvestiya AN SSSR. Otdel Teknicheskikh Nauk, Energetika i Avtomatika
IZE	Ivuz. Elektromekhanika
KAT	Kinetika i Kataliz
KTT	Khimiya i Tekhnologiya Topliv i Masel

Abbreviation	Expansion
LAB	Zavodskaya Laboratoriya
LUR	Ivuz. Tsvetnaya Metallurgiya
MAP	Mekhanizatsiya i Avtomatizatsiya Proizvodstva
MAZ	Matematisheskiye Zametki
NAY	Izmeritel'naya Tekhnika
NER	Zhurnal Vysshey Nervnoy Deyatel'nosti
OTT	AN SSSR Izvestiya. Otdeleniye Teknicheskikh Nauk
PMM	Prikladnaya Matematika i Mekhanika
PRI	Priborostroyeniye
PUP	Pribory i Sistemy Upravleniye
SOB	AN Gruz SSR. Sobshcheniya
TKK	Tekhnicheskaya Kibernetika
TOT	Teoreticheskiye Osnovy Khmicheskoy Tekhnologii
UMN	Uspekhi Matematicheskikh Nauk
UZB	AN Uzb SSR. Izvestiya, Seriya Tekhnicheskikh Nauk
VEM	Vechernaya Moskva
VES	Vestnik Mashinostroyeniya
VVS	Vestnik Vysshey Shkoly
VZT	Moscow. Vsesoyuznyy Mauchno-I Issledovatel'skiy Institut Zheleznodorozhnogo Transporta. Vestnik
ZAT	Za Teknicheskiy Progress

References

1. Ya. Z. Tsypkin. AVT, v. 7, no. 2, 3 (1946).

2. Ya. Z. Tsypkin. AVT, v. 8, no. 3 (1946).

3. M. A. Ayzerman. AVT, v. 12, no. 2 (1951).

4. M. V. Meyerov. AVT, v. 8, no. 4 (1947).

5. M. V. Meyerov. DAN, v. 139, no. 4 (1961).

6. Ya. Z. Tsypkin. Proc. VEEI, Electrical Eng., no. 6 (1955).

7. A. M. Popovskiy. Proc. II, All Union Conf. on Auto. Control Theory v. 1 (1955).

8. M. V. Meyerov. Proc. II, All Union Conf. on Auto. Control Theory, v. 1 (1955).

9. M. V. Meyerov. AVT, v. 17, no. 5 (1956).

10. S. V. Yemelyanov and M. A. Bermant. DAN, v. 145, no. 4, p. 748 (1962).

11. N. Ye. Kostyleva and S. V. Yemelyanov. DAN, v. 153, no. 4, p. 776 (1963).

12. Ya. Z. Tsypkin. DAN, v. 145, no. 1, p. 52 (1962).

13. Ya. Z. Tsypkin. DAN, v. 152, no. 2, p. 302 (1963).

14. B. N. Petrov. AVT, v. 22, no. 12, p. 1689 (1961).

15. M. A. Ayzerman and F. R. Gantmakher, Absolute Stability of Control Systems, Moscow, Izd-vo AN SSSR (1963).

16. V. V. Solovodnikov. Introduction to Static Dynamics of Automatic Control Systems, Izd-vo Gostekhizdat (1952).

17. V. V. Solovodnikov and P. S. Matveyev. AVT, v. 16, no. 3 (1955).

18. Yu. P. Leonov. AVT, v. 17, no. 2 (1956).

19. Yu. P. Leonov and L. Z. Tel'ksnis. AVT, v. 18, no. 11 (1957).

20. Ya. A. Tsypkin. AVT, v. 14, no. 4 (1958).

21. V. S. Pugachev. AVT, v. 18, no. 11 (1957).

22. V. S. Pugachev. PMM, v. 23, no. 1 (1959).

23. V. S. Pugachev. Proc. of the All-Union Conf. on the Theory of Probability and Mathematical Statistics held in Vilnyus on 5-4 Sept. (1960) Vilnyus (1962).

24. Yu. P. Leonov. AVT, v. 20, no. 8 (1959).

25. Yu. P. Leonov. AVT, v. 21, no. 6 (1960).

26. Ye. S. Kochetkov. Proc. of the Seventh Conf. of Young Scientists from IAT, Izd-vo AN SSSR (1962).

27. Ye. S. Kochetkov. Proc. of the Third Prague Conf. on Info. Theory, Statistically Solvable Functions and Random Processes. Izd-vo Check SSR (1964).

28. V. S. Pugachev. AVT, v. 19, no. 6 (1958).

29. V. S. Pugachev. ITE, no. 2 (1960).

30. V. S. Pugachev. Proc. of the Second Prague Conf. on Info. Theory, Statistically Solvable Functions and Random Processes. Prague, Izd-vo Check SSR (1960).

31. V. S. Pugachev. Theory of Random Functions and its Applc. to Auto. Control Problems, 2nd Edition (1960), 3rd Edition (1962).

32. V. S. Pugachev. Proc. of the First Info. Congress of the International Federation on Automatic Control, v. 3, Izd-vo AN SSSR (1961).

33. V. S. Pugachev. ITE, no. 5 (1961).

34. V. S. Pugachev. Proc. of the Third Prague Conf. on Info. Theory, Statistically Solvable Functions and Random Processes, Prague, Izd-vo Check SSR (1964).

35. V. S. Pugachev. Proc. of the 4th All-Union Mathematical Meeting held in July 1961, Izd-vo AN SSSR (1964).

36. L. P. Sysoyev. Proc. of the 7th Conf. of Young Scientists from IAT, Izd-vo AN SSSR (1962).

37. Ye. L. Nappel'baum. Proc. of the 7th Conf. of Young Scientists from IAT, Izd-vo AN SSSR (1962).

38. M. Yu. Gadzhiyev. Proc. of the Sixth Conf. of Young Scientists from IAT, Izd-vo AN SSSR (1960).

39. Yu. P. Leonov and L. N. Lipatov. AVT, v. 20, no. 9 (1959).

40. Yu. P. Leonov and L. N. Lipatov. PRI, no. 11 (1960).

41. Yu. P. Leonov and L. N. Lipatov. AVT, v. 21, no. 3 (1960).

42. Yu. P. Leonov and L. N. Lipatov. AVT, v. 22, no. 5 (1961).

43. Yu. P. Leonov. Proc. of the First International Congress of the International Federation of Automatic Control, v. 3, Izd-vo AN SSSR (1961).

44. Yu. P. Leonov. AVT, v. 23, no. 7 (1962).

45. S. Ya. Rayevskiy and N. S. Raybman. AVT, v. 22, no. 11 (1961).

46. S. Ya. Rayevskiy and N. S. Raybman. AVT, v. 23, no. 7 (1962).

47. S. Ya. Rayevskiy and N. S. Raybman. Proc. of the 4th All-Union Mathematical Meeting held in July 1961, Izd-vo AN SSSR (1964).

48. N. S. Raybman. ITE, no. 1 (1961).

49. N. S. Raybman. ITE, no. 2 (1962).

50. N. S. Raybman. TKK, no. 2 (1963).

51. E. Payziyev. UZB, no. 5, p. 3 (1968).

52. A. A. Fel'dbaum. AVT, v. 20, no. 8 (1959).

53. T. I. Tovstukha. AVT, v. 21, no. 5 (1960).

54. T. I. Tovstukha. Proc. of the 7th Conf. of Young Scientists from IAT, Izd-vo AN SSSR (1962).

55. V. S. Pugachev. ITE, no. 3 (1961).

56. Ya. Z. Tsypkin. AVT, v. 9, no. 2 (1948).

57. Ya. Z. Tsypkin. AVT, v. 10, no. 5 (1949).

58. I. V. Pyshkin. Sbornik Avtomatika i Telemekhanika, Izd-vo AN SSSR (1958).

59. I. V. Pyshkin. AVT, v. 24, no. 10 (1963).

60. Ya. Z. Tsypkin and I. V. Pyshkin. ITE, no. 5 (1961).

61. G. G. Rakhimov. TKK, v. 20, no. 5, p. 683 (1964).

62. I. V. Pyshkin. AVT, v. 5, no. 3 (1959).

63. Ya. Z. Tsypkin, AVT, v. 25, no. 3 (1964).

64. Ya. Z. Tsypkin. AVT, v. 24, no. 12 (1963).

65. M. M. Simkin. AVT, v. 22, no. 11 (1961).

66. I. V. Pyshkin. Proc. of a Conf. on the Theory and Applc. of Discrete Automatic Systems, Izd-vo AN SSSR (1960).

67. Ya. Z. Tsypkin. Collection of articles entitled: "Goldfarb Method in Control Theory," Izd-vo gosyenergoizdat (1962).

68. M. M. Simkin. DAN, v. 149, no. 3, p. 586 (1963).

69. Ya. Z. Tsypkin. ITE, no. 4 (1960).

70. A. I. Propoy. AVT, v. 22, no. 7 (1963).

71. L. I. Rozonoer. AVT, v. 20, no. 12 (1959).

72. A. G. Butkovskiy. AVT, v. 24, no. 8 (1963).

73. V. N. Novosel'tsev. AVT, v. 21, no. 5 (1960).

74. Ya. Z. Tsypkin. Proc. of the 1st International Congress of the International Federation on Automatic Control, v. 2, Izd-vo AN SSSR (1961).

75. V. M. Baykovskiy. AVT, v. 21, no. 3 (1960).

76. Ya. Z. Tsypkin. DAN, v. 155, no. 6, p. 1272 (1964).

77. Ya. Z. Tsypkin. DAN, v. 55, no. 5, p. 1029 (1964).

78. M. S. Epelman. DAN, v. 165, no. 1, p. 51 (1965).

79. Ya. Z. Tsypkin. DAN, v. 165, no. 1, p. 51 (1965).

80. M. M. Simkin. DAN, v. 159, no. 6, p. 1284 (1964).

81. M. M. Simkin. DAN, v. 168, no. 4, p. 800 (1966).

82. Ya. Z. Tsypkin and A. I. Propoy. DAN, v. 175, no. 6, p. 1, 242 (1967).

83. Ya. Z. Tsypkin. VVS, no. 5, p. 69 (1966).

84. Ya. Z. Tsypkin. AVT, no. 9, p. 205 (1968).

85. Ya. Z. Tsypkin and R. G. Faradzhev. DAN, v. 166, no. 3, p. 570 (1966).

86. I. V. Pyshkin. AVT, v. 24, no. 4 (1963).

87. A. I. Propoy. DAN, v. 159, no. 6, p. 1, 232 (1964).

88. A. A. Fel'dbaum. AVT, v. 10, no. 4 (1949).

89. A. Ya. Lerner. AVT, v. 13, no. 2, 4 (1952).

90. A. A. Fel'dbaum. AVT, v. 14, no. 6 (1953).

91. A. A. Fel'dbaum. AVT, v. 16, no. 2 (1955).

92. A. A. Fel'dbaum. Computing Devices in Automatic Systems, Izd-vo Fizmatgiz (1959).

93. A. A. Pavlov. ITE, no. 2 (1963).

94. A. G. Butkovskiy and A. Ya. Lerner. AVT, v. 21, no. 6 (1960).

95. A. G. Butkovskiy. AVT, v. 22, no. 1 (1961).

96. L. I. Rozonoer. AVT, v. 20, nos. 10-12 (1959).

97. L. I. Rozonoer. Proc. of the 1st International Congress of the International Federation on Automatic Control, Izd-vo AN SSSR (1961).

98. I. S. Ibragimov. IZE, no. 3, p. 310 (1967).

99. A. M. Letov. AVT, v. 23, no. 11 (1962).

100. A. M. Letov. AVT, v. 21, nos. 4-6 (1960), v. 22, no. 4 (1961).

101. M. Ye. Salukvadze. AVT, v. 22, no. 10 (1961), v. 23, no. 6 (1962), v. 23, no. 12 (1962).

102. L. S. Kirillova. AVT, v. 23, no. 12 (1962), v. 24, no. 8 (1963).

103. I. A. Litovchenko. AVT, v. 22, no. 12 (1961).

104. Ya. Z. Tsypkin. DAN, v. 134, no. 2 (1960).

105. V. N. Novosel'tsev. AVT, v. 21, no. 5 (1960).

106. V. S. Pugachev. Theory of Random Functions and its Application to the Automatic Control Problems, Izd-vo Fizmatgiz, 1st edition (1957), 2nd edition (1960), 3rd edition (1962).

107. L. P. Sysoyev. AVT, v. 24, no. 5 (1963).

108. A. A. Fel'dbaum. AVT, v. 21, no. 9, 11 (1960), v. 22, no. 1, 2 (1961).

109. A. A. Fel'dbaum. Lectures presented at the 2nd International Congress of the International Federation on Automatic Control, VINITI (1963).

110. V. P. Zhivoglyadov. AVT, v. 25, no. 1 (1964).

111. V. S. Kulebakin. Proc. Conf. on Invariance Theory Applications in Auto. Systems, Publ. Acad. Sc. Ukr. SSR (1959).

112. V. S. Kulebakin. Proc. of the All-Union Conf. on Theory of Auto. Control, Publ. Acad. Sc. USSR, v. 2 (1955).

113. B. N. Petrov. Proc. II, All-Union Conf. on Auto. Control Theory, v. 2, Publ. Acad. Sc. USSR (1955).

114. G. M. Ulanov. DAN, v. 96, no. 5 (1954).

115. G. M. Ulanov. Proc. Conf. on Invariance Theory Application in Auto. Systems, Publ. Acad. Sc. Ukr. SSR (1959).

116. B. N. Petrov. Proc. Conf. on Invariance Theory Application in Auto. Systems, Publ. Acad. Sc. Ukr. SSR (1959).

117. B. N. Petrov, G. M. Ulanov and S. V. Yemel'yanov. Report to 2nd International Conf. of International Federation of Auto. Control, VINITI (1963).

118. B. N. Petrov, S. V. Yemel'yanov and Ye. B. Dudin, DAN, v. 153, no. 6 (1963).

119. L. I. Rozonoer. AVT, v. 24, nos. 6, 7 (1963).

120. B. N. Petrov, S. V. Yemel'yanov and V. I. Utkin. DAN, v. 154, no. 6 (1964).

121. B. N. Petrov and V. Yu. Rutkovskiy. DAN, v. 161, no. 4, p. 789 (1965).

122. V. Yu. Rutkovskiy and B. N. Petrov, DAN, v. 161, no. 3, p. 544 (1965).

123. A. A. Fel'dbaum. AVT, v. 17, no. 11 (1956).

124. I. S. Morosanov, AVT, v. 18, no. 11 (1957).

125. L. N. Fitsner. Proc. of a Conf. on the Theory and Application of Discrete Automatic Systems, Izd-vo AN SSSR (1960).

126. L. N. Fitsner. AVT, v. 21, no. 8 (1960).

127. L. N. Fitsner. AVT, v. 22, nos. 1, 7, 8 (1961), v. 23, no. 2 (1962).

128. L. N. Fitsner. AVT, v. 25, no. 5 (1964).

129. A. A. Fel'dbaum. Proc. of a Conf. on the Theory and Application of Discrete Automatic Systems, Izd-vo AN SSSR (1960).

130. A. A. Fel'dbaum. AVT, v. 21, no. 2 (1960).

131. T. I. Tovstukha. AVT, v. 21, no. 5 (1960).

132. Ts. Ts. Paulauskas. AVT, v. 23, no. 1 (1962).

133. S. A. Doganovskiy. AVT, v. 21, no. 8 (1960).

134. M. V. Meyerov. Report to 2nd International Conf. of the International Fed. of Auto. Control, VINITI (1963).

135. L. M. Osovskiy. AVT, v. 24, no. 2 (1963).

136. L. M. Osovskiy. AVT, v. 24, no. 2 (1963).

137. Ye. P. Maslov. AVT, v. 24, no. 10 (1963).

138. Ye. P. Maslov. AVT, v. 25, no. 1 (1964).

139. Ye. P. Maslov and V. P. Zhivoglyadov. TKK, no. 1 (1964).

140. V. Yu. Rutkovskiy and S. D. Zemlyakov. DAN, v. 174, no. 1, p. 47 (1967).

141. I. I. Perel'man. AVT, v. 24, no. 10 (1963).

142. I. N. Krutova and V. Yu. Rutkovskiy. TKK, nos. 1, 2 (1964).

143. I. N. Krutova and V. Yu. Rutkovskiy. AVT, v. 25, no. 2 (1964).

144. I. N. Krutova and V. Yu. Rutkovskiy. AVT, v. 25, no. 4 (1964).

145. Yu. I. Shmukler. DAN, v. 182, no. 6, p. 1290 (1968).

146. V. A. Viktorov, B. N. Petrov and V. I. Mishenin. DAN, v. 177, no. 1, p. 52 (1967).

147. S. V. Yemel'yanov and V. I. Utkin. DAN, v. 152, no. 2, p. 299 (1963).

148. N. Ye. Kostyleva, B. N. Petrov and S. V. Yemel'yanov. DAN, v. 155, no. 1, p. 61 (1964).

149. M. B. Gritsenko, B. N. Petrov and S. V. Yemel'yanov. DAN, v. 169, no. 1, p. 52 (1966).

150. A. A. Fel'dbaum. AVT, v. 25, no. 4 (1964).

151. Ye. M. Braverman. AVT, v. 21, no. 10 (1960).

152. Ye. M. Braverman. AVT, v. 23, no. 3 (1962).

153. M. A. Ayzerman. Biological Aspects of Cybernetics, Izd-vo AN SSSR (1962).

154. O. A. Bashirov, Ye. M. Braverman and I. B. Muchnik. AVT, v. 25, no. 5 (1964).

155. M. A. Ayzerman, Ye. M. Braverman and L. I. Rozonoer. AVT, v. 25, no. 6 (1964).

156. V. N. Vapnik and A. Ya. Lerner. IAU, no. 5 (1962).

157. V. P. Vapnik and A. Ya. Lerner. AVT, v. 24, no. 6 (1963).

158. L. M. Dronfort. Encyclopedia of Modern Technology, v. 2 (1963).

159. Ye. M. Braverman. Encyclopedia of Modern Technology, v. 2 (1963).

160. V. P. Vapnik and A. Ya. Chervonenkks. AVT, v. 25, no. 1 (1964).

161. R. S. Rutman and M. S. Epel'man. DAN, v. 159, no. 4, p. 764 (1964).

162. L. Ye. Chirkov. IPO, no. 34, p. 120 (1968).

163. Yu. P. Leonov. DAN, v. 167, no. 3, p. 538 (1966).

164. M. A. Gavrilov. Proc. of Theory of Switching. The Annals of the Computation Laboratory of Harvard University, v. 29 (1959).

165. M. A. Gavrilov. DAN, v. 87, no. 3 (1952).

166. G. N. Povarov. Proc. of the 2nd and 3rd Scientific-Technical Conf. of Young Specialists from IAT, Izd-vo AN SSSR (1956).

167. G. N. Povarov. UMN, v. 11, no. 5(71) (1956).

168. G. N. Povarov. AVT, v. 16, no. 2, p. 212 (1955).

169. G. N. Povarov. DAN, v. 100, no. 5 (1955).

170. G. N. Povarov. DAN, no. 2 (1955).

171. M. A. Gavrilov. Structural Theory of Relay Devices. Izd-vo VZYEI (1956).

172. M. A. Gavrilov. AVT, Theory of Relay Networks. Lecture on Automatics and Telemechanics, Izd-vo VZYEI (1952).

173. V. M. Ostianu. DAN, v. 103, no. 5 (1955).

174. V. I. Ivanov. DAN, v. 104, no. 2 (1955).

175. P. P. Parkhomenko. Abstracts of papers presented at the All-Union Conf. on the Theory of Devices Utilizing Relays, Izd-vo AN SSSR (1957).

176. M. A. Ayzerman, L. A. Gusev, L. I. Rozonoer, I. M. Smirnova and A. A. Tal'. AVT, v. 22, no. 6 (1961).

177. A. A. Tal'. AVT, v. 25, no. 6 (1964).

178. P. P. Parkhomenko. DAN, v. 184, no. 1, p. 51 (1969).

179. O. P. Kuznetsov. Structural Theory of Relay Devices, Izd-vo AN SSSR (1963).

180. O. P. Kuznetsov and Ye. D. Stotskaya. Abstracts of papers presented at the Colloquium on the Language of Finite Automata, Izd-vo, Siberskogo fiziko teknicheskogo instituta (1964).

181. Yu. L. Tomfel'd. Structural Theory of Relay Devices, Publ. Acad. Sc. USSR (1963).

182. P. P. Parkhomenko and Yu. L. Tomfel'd. Structural Theory of Relay Devices, Publ. Acad. Sc. USSR (1963).

183. M. A. Gavrilov. Proc. of the 1st International Congress of the International Fed. on Auto. Control, v. 2, Izd-vo AN SSSR (1961).

184. M. A. Gavrilov. Lectures presented at the 2nd International Congress of the International Fed. on Auto. Control, VINITI (1963).

185. R. R. Varshamov and V. M. Ostianu. Report IAT (1963).

186. R. R. Varshamov. DAN, v. 157, no. 3, p. 546 (1964).

187. R. R. Varhsamov. DAN, v. 164, no. 4, p. 757 (1965).

188. R. R. Varshamov. DAN, v. 156, no. 6, p. 1308 (1964).

189. R. R. Varshamov. DAN, v. 161, no. 3, p. 540 (1965).

190. R. R. Varshamov, G. M. Tenengolts and V. A. Arakelov. IPO, no. 31, p. 95 (1968).

191. V. M. Ostianu. AN SSSR, Strukturnaya teoria releynykh ustroystv, (Structural Theory of Relay Devices), p. 226 (1963).

192. V. M. Ostianu. Candidate's disseration, IAT (1963).

193. V. P. Didenko. Candidate's dissertation, IAT (1964).

194. V. D. Kazakov. Avtomaticheskaye upravleniye, Izd-vo AN SSSR (1960).

195. V. D. Kazakov. Structural Theory of Relay Devices, Izd-vo AN SSSR (1963).

196. V. P. Didenko. Structural Theory of Relay Devices, Izd-vo AN SSSR (1963).

197. V. D. Kazakov. Proc. of the 2nd Hungarian Mathematical Conf., Budapest (1961).

198. V. D. Kazakov and V. B. Naúmchenko. ARU (1962).

199. V. D. Kazakov. ARU (1962).

200. V. D. Kazakov. AN SSSR, Strukturnaya teoria releynykh ustroystv (Structural Theory of Relay Devices), p. 163 (1963).

201. P. P. Parkhomenko and Yu. L. Tomfel'd. AN SSSR, Strukturnaya teoria releynykh ustroystv (Structural Theory of Relay Devices), p. 128 (1963).

202. B. L. Timofeyev. AN SSSR, Strukturnaya teoria releynykh ustroystv (Structural Theory of Relay Devices), p. 242 (1963).

203. G. B. Tumanyan. DAN, v. 156, no. 3, p. 525 (1964).

204. M. A. Gavrilov. AVT, v. 16, no. 2, p. 209 (1955).

205. B. L. Timofeyev. Structural Theory of Relay Devices, Izd-vo AN SSSR (1963).

206. P. P. Parkhomenko, Yu. L. Tomfel'd, V. R. Gorovoy and V. M. Kucherov. Proc. IAT (1963).

207. V. P. Didenko. AN SSSR, Strukturnaya teoria releynykh ustroystv (Structural Theory of Relay Devices), p. 212 (1963).

208. M. A. Gavrilov. AN SSSR, Strukturnaya teoria releynykh ustroystv (Structural Theory of Relay Devices), p. 5 (1963).

209. O. P. Kuznetsov and Yu. L. Tomfel'd. AN SSSR, Strukturnaya teoria releynykh ustroystv (Structural Theory of Relay Devices), pp. 74, 100, 110 (1963).

210. V. V. Vorzheva. AN SSSR, Strukturnaya teoria releynykh ustroystv (Structural Theory of Relay Devices), p. 170 (1963).

211. Ye. S. Sogomonyan, P. P. Parkhomenko and V. V. Karibskiy. DAN, v. 161, no. 1, p. 59 (1965).

212. V. V. Devyatkov. ZAT, no. 12, p. 7 (1968).

213. V. A. Il'in. AVT, v. 16, no. 4 (1955).

214. V. A. Il'in. Publ. State Publ. House for Power (1963).

215. V. A. Il'in. EIKA, Entsiklopediya izmereniy, kontrolya i avtomatizatsii (Enclyclopeida of Measurement, Control, and Automation), no. 10, p. 29 (1968).

216. V. A. Kashirin. AVT, v. 20, no. 2 (1959).

217. P. P. Vasil'yev and G. A. Shastova. Publ. State Publ. House for Power (1960).

218. Yu. I. Chugin. AVT, v. 22, no. 5 (1961).

219. G. G. Rakhimov. UZB, no. 4, p. 8 (1966).

220. Yu. I. Chugin, AVT, v. 23, no. 2 (1962).

221. V. V. Kashirin. AVT, v. 16, no. 2, p. 216 (1955).

222. G. A. Shastova. AVT, v. 16, no. 2, p. 212 (1955).

223. L. B. Venchkovskiy. AVT, v. 21, no. 8 (1960).

224. L. B. Venchkovskiy. ETE, no. 1, p. 140 (1961).

225. P. P. Vasil'yev and G. A. Shastova. AVT, v. 24, no. 1 (1963).

226. G. A. Shastova. MAP, no. 1, p. 51 (1964).

227. G. A. Shastova. EIKA, Entsiklopediya izmereniy, kontrolya i avtomatizatsii (Encyclopedia of Measurement, Control, and Automation), no. 5, p. 57 (1965).

228. E. O. Vasil'yev. FIS, no. 5, p. 25 (1967).

229. N. V. Pozin. AVT, v. 20, no. 10 (1959).

230. A. I. Novikov. AVT, v. 23, no. 10 (1962).

231. V. A. Il'in. AVT, v. 16, no. 2, p. 216 (1955).

232. V. A. Il'in. AVT, v. 16, no. 2, p. 210 (1955).

233. V. A. Il'in. AN SSSR Vestnik, no. 9, p. 68 (1964).

234. V. A. Il'in. MAP, no. 1, p. 52 (1964).

235. V. A. Il'in. AN SSSR Vestnik, no. 5, p. 72 (1965).

236. A. L. Raykin and V. A. Zhozhikashvili. AN SSSR, Strukturnaya teoriya releynykh ustroystv (Structural Theory of Relay Devices), p. 237 (1963).

237. V. A. Il'in. MAP, no. 1, p. 51 (1964).

238. V. A. Lutskiy. Computation of Reliability and Effectiveness of Microwave Instrumentation, IZD-vo AN Ukr. SSR (1963).

239. V. A. Zhozhikashvili and A. L. Raykin. AVT, v. 23, no. 3 (1962).

240. K. K. Abramov and L. I. Gusyatinskiy. IPO, no. 13, p. 193 (1967).

241. M. P. Kostenko. Electrodynamic Modeling of Power Systems, Izd-vo AN SSSR (1959).

242. M. P. Kostenko and I. D. Urusov. Elektrichestvo, no. 8, p. 11 (1955).

243. B. Ya. Kogan. AVT, v. 16, no. 6, p. 557 (1955).

244. B. Ya. Kogan. Electronic Modeling Devices and Their Utilization for Investigation of Automatic Control Systems, State Publ. House for Phys. and Math. (1959).

245. M. A. Shnaydman. AVT, v. 14, no. 2 (1953).

246. A. A. Fel'dbaum. Computing Devices in Automatic Systems. State Publ. House for Phys. and Math. (1959).

247. N. S. Sosenskiy. AVT, v. 20, no. 10 (1959).

248. B. Ya. Kogan. ITE, no. 6 (1961).

249. V. A. Trapeznikov. Mathematical Modeling of Dynamic Systems, Elektrichestvo, no. 8 (1955).

250. B. Ya. Kogan. AVT, v. 17, no. 1 (1956).

251. B. Ya. Kogan. AVT, v. 21, no. 1 (1960).

252. M. A. Shnaydman. Proc. Conf. on Theory and Application of Discrete Auto. Syst., Publ. Acad. Sc. USSR (1960).

253. M. V. Rybashov. AVT, v. 22, no. 1 (1961).

254. M. V. Rybashov. AVT, v. 22, no. 12 (1961).

255. M. V. Rybashov. AVT, v. 23, no. 2 (1962).

256. M. V. Rybashov, B. I. Kizovskiy, A. P. Kravchenko, Ye. Ye. Dudnikov and V. O. Chinakal. KTT, no. 12, p. 26 (1968).

257. N. N. Karimskaya and M. V. Rybashov. AVT, v. 24, no. 3 (1963).

258. G. L. Polyak and M. Kh. Dorri. AN BSSR, Inst. teplo i massoobmena. Issledovaniye teplo i massoobmena v tekhnologicheskikh protsessakh i apparatakh. (Acad. of Byelorussian SSR. Institute of Heat and Mass Exchange. Investigation of Heat and Mass Exchange in Technological Processes and Equipment) Minsk, Izd-vo Nauka i tekhnika, p. 281 (1966).

259. L. G. Pliskin. TOT, v. 2, no. 6, p. 946 (1968).

260. V. S. Beskov, V. Ye. Goryushko, M. G. Slinko and G. S. Yablonskiy. KAT, v. 6, no. 4, p. 773 (1965).

261. F. B. Gul'ko and B. Ya. Kogan. Lectures presented at the 2nd International Congress of the International Fed. on Auto. Control, VINITI (1963).

262. F. B. Gul'ko. TKK, no. 1 (1963).

263. N. N. Mikhailov and Zh. A. Novosel'tseva. TKK, no. 1 (1964).

264. M. A. Krasnoselskiy. MAZ, v. 2, no. 6, p. 599 (1967).

265. P. P. Zabreyko. MAZ, v. 2, no. 6, p. 593 (1967).

266. M. A. Krasnoselskiy. DAN, v. 181, no. 5, p. 1058 (1968).

267. P. P. Zabreyko, V. Ya. Stetsenko and M. A. Krasnoselskiy. MAZ, v. 1, no. 4, p. 461 (1967).

268. M. A. Krasnoselskiy and V. M. Gershteyn. DAN, v. 183, no. 2, p. 267 (1968).

269. V. V. Strygin and M. A. Krasnoselskiy. FAP, v. 1, no. 3, p. 33 (1967).

270. V. A. Chernyatin. DAN, v. 10, no. 11, p. 821 (1966).

271. Yu. N. Andreyev and V. M. Orkin. FIZ, v. 12, no. 6, p. 736 (1967).

272. M. K. Chernyshev. VEM, no. 37, p. 4 (1967).

273. A. Yu. Levin and M. V. Vishnyakov. MAZ, v. 1, no. 6, p. 659 (1967).

274. Ye. A. Livshits and B. N. Sadovskiy. DAN, v. 183, no. 2, p. 278 (1968).

275. Yu. V. Pokornyy and M. A. Krasnoselskiy. MAZ, v. 5, no. 2, p. 253 (1969).

276. M. V. Rybashov. AVT, v. 20, no. 5, p. 685 (1959).

277. M. V. Rybashov. AVT, v. 20, no. 5, p. 685 (1959).

278. M. V. Rybashov. DAN, v. 147, no. 6, p. 1304 (1962).

279. M. V. Rybashov and Ye. Ye. Dudnikov. DAN, v. 161, no. 6, p. 1289 (1965).

280. V. A. Trapeznikov and A. Ya. Lerner. AVT, v. 11, no. 4 (1950).

281. V. A. Trapeznikov. AVT, v. 16, no. 6, p. 559 (1955).

282. V. V. Karibskiy and B. S. Sotskov. Standardizatsiya, no. 10 (1962).

283. Ye. K. Krug. EIKA, Entsiklopediya izmereniy, kontrolya i avtomatizatsii (Encyclopedia of Measurement, Control and Automation), no. 8, p. 3 (1967).

284. O. I. Aven, S. M. Domanitskiy and A. Ya. Lerner. AVT, v. 17, no. 8 (1956).

285. O. I. Aven and S. M. Dominitskiy. Publ. State Publ. House for Power (1960).

286. O. I. Aven, E. D. Demidenko, S. M. Domanitskiy and Ye. K. Krug. AVT, v. 17, no. 3 (1956).

287. D. E. Polonnikov. Publ. State Publ. House for Phys. and Math. (1960).

288. Ye. K. Krug and O. M. Minina. Publ. State Publ. House for Power (1962).

289. O. M. Minina. Publ. Acad. Sc. USSR (1963).

290. T. M. Aleksandridi, S. N. Diligenskiy and Ye. K. Krug. Report to 2nd International Congress of International Fed. for Auto Control, VINITI (1963).

291. O. M. Minina. Opredeleniye dinamicheskikh kharakteristik i parametrov tipovykh reguliruyemykh ob'yektov (Determining Dynamic Characteristics and Parameters of Typical Objects of Control), Moscow, Izd-vo AN SSSR, p. 44 (1963).

292. Ye, K. Krug and O. M. Minina. EIKA, Entsiklopediya izmereniy, kontrolya i avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, Izd-vo Energiya, no. 3, pp. 65, 47 (1964).

293. V. A. Khokhlov. IPO, no. 24, p. 153 (1966).

294. I. L. Medvedev. IPO, no. 20, p. 57 (1967).

295. Ye. K. Krug. EIKA, Entsiklopediya izmereniy, kontroyla i avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, Izd-vo Energiya, no. 6, p. 59 (1966).

296. I. L. Medvedev. IPO, no. 1, p. 40 (1967).

297. V. S. Kulebakin. Proc. Conf. Acad. Sc. USSR on Scient. Problems of Production Automation. Publ. Acad. Sc. USSR (1957).

298. V. S. Kulebakin and V. V. Gorskiy. Proc. Conf. Acad. Sc. USSR on Scient. Problems of Production Automation, Publ. Acad. Sc. USSR (1957).

299. V. S. Kulebakin. DAN, v. 77, no. 2 (1951).

300. D. P. Petelin. Proc. Conf. on Automated AC Electric Drive, Publ. Acad. Sc. USSR (1958).

301. A. A. Bulgakov. Electronic Automatic Control Devices, Publ. State Publ. House for Power (1958).

302. A. A. Bulgakov. Frequency Control of Asynchronous Motors, Publ. Acad. Sc. USSR (1955).

303. A. A. Bulgakov. Proc. Conf. on AC Electric Drive, Publ. Acad. Sc. USSR (1959).

304. I. B. Semenov and V. Z. Yarina. AVT, v. 20, no. 8 (1959).

305. V. A. Il'in. AVT, v. 25, no. 6 (1964).

306. Ye. K. Krug. AVT, v. 16, no. 6, p. 559 (1955).

307. V. B. Gogolevskiy. AVT, v. 20, no. 5, p. 686 (1959).

308. V. N. Bogoyavlenskiy. AVT, v. 19, no. 8, p. 809 (1958).

309. V. N. Bogoyavlenskiy. Elektrichestvo, no. 1, p. 95 (1958).

310. D. P. Petelin. AVT, v. 19, no. 8, p. 811 (1958).

311. D. P. Petelin. Elektrichestvo, no. 1, p. 95 (1958).

312. Ye. L. Orkina. IPO, no. 36, p. 54 (1968).

313. A. Ya. Lerner, B. G. Volik, A. F. Baryshev and S. I. Bernshteyn, no. 11, p. 44 (1967).

314. Ye. L. Orkina. IZE, no. 5, p. 559 (1965).

315. Ye. L. Orkina. IZE, no. 1, p. 86 (1969).

316. A. R. Kazbekov and I. M. Krassov. Vestnik mashinostroyeniya, no. 3, p. 88 (1967).

317. A. M. Agafonnikov and A. A. Bulgakov, Author's Cert. no. 126521 (1954).

318. A. A. Bulgakov. Author's Cert. no. 113516 (1955).

319. A. A. Bulgakov. Programmed machine-tool control, Publ. State Publ. House for Power (1956).

320. Ye. D. Demidenko. AN SSSR, Vestnik, no. 1, p. 36 (1964).

321. V. V. Tsokanov. IZE, no. 7, p. 889 (1964).

322. L. N. Fitsner. Theory and Application of Discrete Auto. Systems, Publ. Acad. Sc. USSR (1960).

323. L. N. Fitsner. AVT, v. 22, nos. 1, 7, 8 (1961), v. 23, no. 2 (1962).

324. A. A. Fel'dbaum. AVT, v. 19, no. 8 (1958).

325. A. B. Shubin. AVT, v. 21, no. 5 (1960).

326. S. B. Yemel'yanov and I. A. Burovoy. Author's Cert. no. 130350, B-12, no. 14 (1960).

327. I. A. Burovoy, S. B. Yemel'yanov and B. V. Lunkin. Proc. State Inst. Non-ferrous Met., no. 21, Publ. State Scient-Techn. Publ. House for Ferrous and Non-ferrous, Met. (1964).

328. I. A. Burovoy, S. B. Yemel'yanov, M. S. Lodyseva and A. A. Rassmotrov. Proc. State Inst. Non-ferrous Met. no. 21, Publ. State Scient-Techn. Publ. House for Ferrous and Non-ferrous, Met. (1964).

329. I. A. Burovoy, S. B. Yemel'yanov, R. I. Rapoport and A. A. Rassmotrov. Proc. State Inst. Non-ferrous Met. no. 21, Publ. State Scient-Techn. Publ. House for Ferrous and Non-ferrous Met. (1964).

330. L. N. Fitsner. EIKA, Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, Izd-vo energiya, no. 5, p. 73 (1965).

331. L. N. Fitsner. EIKA, Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, Izd-vo energiya, no. 5, p. 71 (1965).

332. Ye. N. Dubrovskiy and A. V. Kortnev. IPO, no. 22, p. 50 (1968).

333. V. A. Putintsev. IPO, no. 27, p. 43 (1968).

334. M. A. Rozenblat, V. A. Semenko and A. A. Romashchev. IFT, v. 15, no. 4, p. 629 (1966).

335. S. Ye. Zdor and G. P. Katys. Author's Cert. no. 236870, Sept. 19 (1967).

336. G. P. Katys, V. D. Zotov, V. B. Shirokov and N. V. Kravtsov. IPO, no. 27, p. 53 (1968).

337. V. D. Zotov and G. P. Katys. IPO, no. 9, p. 48 (1968).

338. V. B. Shirokov, V. D. Zotov and G. P. Katys. IPO, no. 11, p. 60 (1968).

339. G. P. Katys, A. M. Tishin, V. I. Lalabekov, N. V. Kravtsov, S. M. Konovalov and Ye. P. Shubarov. IPO, no. 30, p. 39 (1968).

340. V. A. Zhozhikashvili. AVT, v. 16, no. 1 (1955).

341. V. A. Zhozhikashvili and K. G. Mityushkin. Izv, AN SSSR, no. 4 (1955).

342. V. N. Tutevich. Contactless Remote Control System for Coal Mines, Publ. House for Coal Technology (1957).

343. R. V. Bilik, V. A. Zhozhikashvili, I. B. Prangishvili and K. G. Mityushkin. Contactless Remote Control Elements and Systems with Time-sequenced Signals, "Nauka," Publ. House (1969).

344. V. A. Zhozhikashvili. AVT, v. 16, no. 4, p. 402 (1955).

345. V. M. Kharlamov. VINITI, Telemechanization Systems, no. 4, Topic no. 29 (1962).

346. V. A. Zhozhikashvili and Yu. I. Shmukler. AVT, v. 23, no. 7 (1962).

347. V. A. Il'in. Remote monitoring and control of distributed objects, State Publ. House for Power (1963).

348. N. V. Pozin. AVT, v. 20, no. 10 (1959).

349. V. G. Kozhushko. IPO, no. 6, p. 40 (1968).

350. B. P. Petrukhin and I. V. Prangishvili. AVT, v. 20, no. 5, p. 686 (1959).

351. I. V. Prangishvili. MAP, no. 1, p. 53 (1964).

352. I. V. Prangishvili. EIKA, Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, Izd-vo energiya, no. 5, p. 67 (1965).

353. I. V. Prangishvili. PUP, no. 6, p. 61 (1968).

354. V. A. Zhozhikashvili. IPO, no. 28, p. 35 (1968).

355. N. B. Grinberg, A. A. Zak, L. A. Levin and I. V. Prangishvili. Prib., no. 5 (1964).

356. N. P. Vasil'yev. EIKA, Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Encyclopedia of Measurement, Control and Automation), no. 7, p. 51 (1967).

357. V. Yu. Kneller. AVT, v. 23, no. 4 (1962).

358. E. L. Itskovich. Prib. i sredstva avtomatizatsii (Instruments and Means of Automation), nos. 1, 1 (1963).

359. E. A. Trakhtengerts and V. Ye. Yurchenko. Prib. i sredstva avtomatizatsii (Instruments and Means of Automation), no. 2 (1964).

360. D. E. Gukovskiy. Application of Cybernetics to Electrical Measurement Technology, Priborelektroprom (1964).

361. E. L. Itskovich. AVT, v. 24, no. 2 (1963).

362. E. L. Itskovich. AVT, v. 22, no. 2 (1961).

363. M. V. Rybashov. AVT, v. 24, no. 1 (1963).

364. P. P. Parkhomenko. AVT, v. 20, no. 4 (1959).

365. P. P. Parkhomenko. Structural Theory of Relay Devices, Publ. Acad. Sc. USSR (1963).

366. E. L. Itskovich, I. N. Vorobyev and D. I. Ageykin. LAB, v. 23, no. 7, p. 852 (1957).

367. D. I. Ageykin. Magnetic Gas Analyzers, State Publ. House for Power (1963).

368. D. I. Ageykin. Proc. I Internat. Congress of the International Federation Auto. Control, v. 1, Publ. Acad. Sc. USSR (1961).

369. I. A. Tsaturova, I. N. Panasenko and M. V. Rybashov. AVT, v. 20, no. 5, p. 684 (1959).

370. D. I. Ageykin, B. E. Galkin and A. A. Desova. VINITI, Topic 34, Moscow (1957).

371. G. P. Katys. Elements of Automatic Monitoring Systems for Non-stationary flows. Publ. Acad. Sc. USSR (1959).

372. V. N. Skugorov. Priborostroyeniye, no. 8 (1959).

373. N. N. Shumilovskiy and L. V. Mel'tser. Foundation of the Theory of Automatic Monitoring Devices Using Radioactive Isotopes. Publ. Acad. Sc. USSR (1959).

374. I. M. Panasenko, A. S. Seryakov and D. I. Ageykin. IPO, no. 1, p. 148 (1967).

375. N. N. Kuznetsova, D. I. Ageykin and Yu. T. Knopov. IPO, v. 1, p. 146 (1967).

376. N. N. Kuznetsova, D. I. Ageykin and Yu. T. Knopov. IPO, v. 1, p. 146 (1967).

377. V. A. Torgonenko, V. N. Tikhonravov, V. V. Pechnikov and T. D. Gagina, IPO, no. 20, p. 38 (1968).

3781 G. I. Koretskiy, M. P. Kostogryz and N. Ye. Zacharchenko. IPO, no. 34, p. 93 (1968).

379. G. I. Kotlyar. IPO, no. 28, p. 146 (1968).

380. V. A. Glazyev, N. T. Sivakov and N. D. Topchiyeva. IPO, no. 8, p. 90 (1967).

381. A. A. Desova. AVT, v. 20, no. 5, p. 684 (1959).

382. A. A. Desova. EIKA Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, Izd-vo energiya, no. 3, pp. 65, 3 (1964).

383. I. A. Tsaturova. AVT, v. 20, no. 5, p. 684 (1959).

384. Yu. A. Kalnin, N. Salakhutdinov, A. A. Kalmakov and Yu. V. Gushchin. LUR, no. 5, p. 144 (1965).

385. Yu. V. Gushchin. Automatic Control and Regulation, Publ. Acad. Sc. USSR (1962).

386. Yu. V. Gushchin. LUR (1962).

387. L. V. Mel'tser and N. N. Shumilovskiy. PRI, v. 2, no. 4, p. 137 (1959).

388. L. V. Mel'tser and N. N. Shumilovskiy. Atomnaya energiya, v. 12, no. 3, p. 254 (1962).

389. N. N. Shumilovskiy, V. N. Pozdnikov, V. A. Yanushkovskiy and V. D. Kiryukhin. Atomnaya energiya, v. 11, no. 5, p. 468 (1961).

390. N. A. Pivovarov and A. A. Naumov. AVT, v. 20, no. 5, p. 684 (1959).

391. D. I. Ageykin. Prib i sredstva avtomatizatsii (Instruments and Means of Automation), no. 11 (1962).

392. D. I. Ageykin and N. N. Kuznetsova. Author's Cert. no. 150040, Nov. 1 (1961).

393. D. I. Ageykin. Author's Cert. no. 139455, Nov. 26 (1960).

394. D. I. Ageykin. Author's Cert. no. 141079, Nov. 26 (1960).

395. D. I. Ageykin, G. G. Yarmol'chuk and E. N. Kostina. Author's Cert. no. 147004, Nov. 3 (1960).

396. G. P. Katys. Automatic Monitoring of Nonstationary Parameters and Parametric Fields, Publ. Acad. Sc. USSR (1962).

397. G. P. Katys and R. N. Blaut-Blachev. Scanning pyrometers, VINITI, Moscow (1963).

398. R. N. Blaut-Blachev. IPO, no. 13, p. 55 (1967).

399. R. N. Blaut-Blachev. IPO, no. 17, p. 92 (1968).

400. N. V. Kravtsov, L. Ye. Chirkov and G. P. Katys. IPO, no. 20, p. 81 (1968).

401. G. P. Katys. Izmer. Tekh., no. 2, p. 72 (1967).

402. V. Yu. Kneller and L. N. Sokolov. Izmer. Tekh., no. 6 (1963).

403. N. N. Shumilovskiy and V. Yu. Kneller. PRI, no. 3 (1958).

404. V. Yu. Kneller. Izmer. Tekh., no. 3 (1959).

405. V. Yu. Kneller. AVT, v. 20, no. 9 (1959).

406. A. P. Pilipenko. Elektrichestvo, no. 5, p. 59 (1965).

407. A. I. Galaktionov. Encyclopedia of Measurement, Control and Automation, no. 2, State Publ. House for Power (1964).

508. B. Ya. Kogan. Proc. All-Union Conf. on Theory of Automatic Regulation, v. 3, Publ. Acad. Sc. USSR (1955).

409. V. V. Gurov, B. Ya. Kogan, A. D. Talantsev and V. A. Trapeznikov. AVT, v. 17, no. 1 (1956).

410. V. A. Trapeznikov, B. Ya. Kogan, V. V. Gurov and A. A. Maslov. EMU-5 Electronic Simulator, ITEIN, Acad. Sc. USSR (1956).

411. V. V. Gurov, V. M. Yevseyev, B. Ya. Kogan and A. A. Maslov. EMU-8 Electronic Simulator, VINITI (1957).

412. B. Ya. Kogan, A. A. Maslov and D. Ye. Polonnikov. EMU-8A, Electronic Simulator Vest. AN SSSR, no. 7 (1958).

413. B. Ya. Kogan. Electronic Simulators and Their Application in the Study of Automatic Regulation Systems, Publ. House for Phys. and Math. (1959).

414. A. D. Talantsev. Proc. 2 All-Union Conf. on Theory of Auto. Regulation, v. 3, Publ. Acad. Sc. USSR (1955).

415. V. M. Yevseyev. AVT, v. 18, no. 5 (1957).

416. D. Ye. Polonnikov. AVT, v. 21, no. 12 (1960).

417. D. Ye. Polonnikov. AVT, v. 22, no. 6 (1961).

418. A. A. Fel'dbaum and L. N. Fitsner. Author's Cert. no. 104137, Sept. 3 (1952).

419. L. N. Fitsner. AVT, v. 20, no. 1 (1959).

420. V. V. Gurov. IPO, no. 4, p. 67 (1967).

421. I. L. Medvedev. IPO, no. 19, p. 109 (1968).

422. L. P. Afinogenov, S. D. Altshul and G. I. Gilman. IPO, no. 24, p. 90 (1966).

423. S. M. Domanitskiy, B. B. Buyanov, A. F. Volkov, V. A. Vedeshenkov and V. A. Trapeznikov. IPO, no. 24, p. 90 (1966).

424. A. M. Shubladze. IPO, no. 4, p. 139 (1967).

425. A. M. Shubladze. IPO, no. 19, p. 107 (1968).

426. V. I. Utkin, V. B. Yezerov and A. M. Shubladze. IPO, no. 28, p. 110 (1968).

427. I. V. Prangishvili and N. Yu. Shaipov. Author's Cert. no. 236856, Feb. 21 (1968).

428. I. V. Prangishvili and N. Yu. Shaipov. Author's Cert. no. 236858, March 15 (1968).

429. K. B. Norkin and O. B. Suslova. IPO, no. 30, p. 125 (1968).

430. G. A. Lutskevich. IPO, no. 22, p. 52 (1967).

431. A. M. Petrovskiy. IPO, no. 3, p. 63 (1968).

432. K. B. Norkin. AVT, v. 20, no. 5, p. 685 (1959).

433. K. B. Norkin. IPO, no. 1, p. 97 (1967).

434. V. P. Zinkevich and M. A. Rozenblat. IFT, v. 15, no. 4, p. 629 (1966).

435. M. A. Rozenblat. ITE, v. 15, no. 4, p. 629 (1966).

436. V. P. Zinkevich. IPO, no. 5, p. 133 (1968).

437. V. P. Zinkevich. Author's Cert. no. 236865, no. 7, p. 121, June 26 (1969).

438. A. A. Shulepov and S. P. Khlebnikov. IPO, no. 30, p. 44 (1968).

439. N. S. Raybman, L. V. Gigineyshvili, V. M. Chadeyev, Yu. L. Romanov, S. P. Khlebnikov and A. A. Shulepov. IPO, no. 23, p. 103 (1966).

440. S. B. Kleybanov and E. S. Eykelman. IPO, no. 8, p. 89 (1967).

441. E. V. Yevreinov, M. A. Korolev, A. I. Mishin, I. V. Prangishvili, Ye. S. Selkov, Ye. V. Babicheva, V. M. Gusakov and M. A. Uskach. Author's Cert. no. 236530, no. 7, p. 33, Feb. 21 (1968).

442. D. Ye. Polonnikov. Hybrid Computers, Publ. Acad. Sc. USSR (1962).

443. R. A. Tamrazov. Proc. Computer Center, v. 2, Publ. Acad. Sc. Azerbaydzhan SSR (1963).

444. A. V. Shileyko. AVT, v. 22, no. 12 (1959).

445. S. P. Adamovich. AVT, v. 20, no. 5, p. 684 (1959).

446. N. N. Mikhaylov and A. V. Shileyko. AVT, v. 20, no. 5, p. 685 (1959).

447. M. P. Sakharov. Elektrichestvo, no. 11, p. 56 (1966).

448. S. L. Gurevich, S. P. Khlebnikov and A. A. Shulepov. IPO, no. 1, p. 84 (1967).

449. Ye. N. Artamonov. ETE, no. 3, p. 87 (1968).

450. Yu. L. Tomfel'd. IPO, no. 9, p. 106 (1968).

451. S. P. Khlebnikov and A. Ya. Biryukov. IPO, no. 22, p. 107 (1968).

452. G. P. Batukhtin and V. L. Shinkarenko. IPO, no. 15, p. 49 (1968).

453. S. P. Khlebnikov. AVT, v. 20, no. 5, p. 686 (1959).

454. B. N. Strelkov. AVT, v. 20, no. 5, p. 685 (1959).

455. B. Ya. Kogan, A. A. Maslov, A. V. Shileyko, G. M. Kozyreva, V. P. Nazarova, A. Ya. Biryukov and A. I. Kaz'min. Patent Registration no. 42211, Jan. 21 (1964).

456. V. A. Vedeshnikov, V. A. Trapeznikov, A. F. Volkov, T. A. Turkovskaya and V. D. Zenkin. BIP, no. 18, p. 91 (1965).

457. G. Kh. Babich, V. T. Lysikov and F. V. Mayorov. IPO, no. 26, p. 128 (1968).

458. O. I. Semenkov and E. E. Zulfugarzade. AN BSSR, Institut Teknicheskoy kibernetiki, Vychislitel'naya tekhnika v. mashinostroyenii (Academy of Sciences, Byelorussian SSR, Institute of Technical Cybernetics, Computer Technology in Machine Building), Minsk, p. 183 (1967).

459. A. A. Fel'dbaum. Izv. AN SSSR, Energ. Auto., no. 4 (1960).

460. R. P. Stakhovskiy, L. N. Fitsner and A. V. Shubin. Proc. I Intern. Congress of Intern. Fed. of Auto. Control, v. 4, Publ. Acad. Sc. USSR (1961).

461. A. A. Fel'dbaum. AVT, v. 17, no. 11 (1956).

462. L. N. Fitzner. Author's Cert. no. 14644, March 19 (1960).

463. L. N. Fitsner. Author's Cert. no. 116680, July 22 (1958).

464. P. P. Parkhomenko. Theory and Application of Discrete Auto. Systems, Publ. Acad. Sc. (1960).

465. B. L. Timofeyev. Auto. Control, Ya. Z. Tsypkin. ed., Publ. Acad. Sc. USSR (1960).

466. M. A. Rozenblat and O. A. Sedykh. Standardization, no. 6 (1958).

467. M. A. Rozenblat. State Publ. House for Power (1963).

468. N. P. Vasilyeva. Elektrichestvo, no. 2, p. 79 (1955).

469. N. P. Vasilyeva. AVT, v. 16, no. 4, p. 404 (1955).

470. O. A. Sedykh. AVT, v. 16, no. 4, p. 404 (1955).

471. G. V. Subbotina. AVT, v. 16, no. 4, p. 405 (1955).

472. O. A. Sedykh and N. P. Vasilyeva. AVT, v. 17, no. 10, p. 944 (1956).

473. M. A. Rozenblat. PRI, no. 6, p. 114 (1958).

474. M. A. Rozenblat. Elektrichestvo, no. 2, p. 86 (1959).

475. I. S. Gashkovets. Elektrichestvo, no. 10, p. 92 (1959).

476. M. A. Boyarchenko, F. I. Kerbnikov and M. A. Rozenblat. Elektrotekhnika, no. 1, p. 62 (1964).

477. O. A. Sedykh and N. P. Vasilyeva. Vestnik Elektropromyshlennosti, no. 8, p. 80 (1965).

478. M. A. Rozenblat. IFT, v. 15, no. 4, p. 629 (1966).

479. Yu. V. Chernikhov and V. I. Stakhno. IPO, no. 21, p. 38 (1968).

480. V. A. Shabanov, A. I. Pavlov and V. M. Chernyshev. IPO, no. 13, p. 31 (1968).

481. O. A. Kossov. AVT, v. 20, no. 7 (1959).

482. M. A. Rozenblat. AVT, v. 20, no. 9 (1959).

483. O. A. Kossov and O. I. Khasayev. Elektrichestvo, no. 12, p. 69 (1961).

484. D. Ye. Polonnikov. IPO, no. 4, p. 48 (1968).

485. D. Ye. Polonnikov and R. N. Chernyshev. IPO, no. 1, p. 54 (1968).

486. D. Ye. Polonnikov. AVT, v. 16, no. 6, p. 559 (1955).

487. D. Ye. Polonnikov. Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Encyclopedia of Measurement, Control and Automation), no. 3, Moscow, Izd-vo energiya, p. 65, 33 (1964).

488. V. D. Averbukh. IPO, no. 13, p. 112 (1966).

489. V. D. Averbukh. IPO, no. 11, p. 42 (1968).

490. N. P. Vasil'yeva and I. Gashkovets. State Publ. House for Power (1962).

491. N. P. Vasil'yeva and T. M. Vorob'yeva. Contactless Elements of Automation, Publ. Acad. Sc. USSR (1963).

492. S. M. Domanitskiy and B. P. Petrukhin. PRI, no. 4 (1964).

493. N. L. Prokhorov and I. M. Gorin. Author's Cert. no. 150299, March 5 (1960), Byull. Izobret. no. 18 (1962).

494. I. M. Gorin and N. L. Prokhorov. Author's Cert. no. 152122, March 2 (1962), Byull. Izobret. no. 23 (1962).

495. N. L. Prokhorov and I. M. Gorin. Author's Cert. no. 150300, March 5 (1962), Byull, no. 18 (1962).

496. N. L. Prokhorov. Auto. Regulation and Control, Ya. Z. Tsypkin, ed., Publ. Acad. Sc. USSR (1961).

497. V. S. Matorina and O. A. Sedykh. AVT, v. 23, no. 1 (1962).

498. N. P. Vasil'yeva and O. A. Sedykh. PRI, no. 4 (1964).

499. N. P. Vasil'yeva and I. Gashkovets. AVT, v. 25, no. 6 (1964).

500. B. S. Sotskov. AVT, v. 19, no. 1, p. 99 (1958).

501. S. F. Stepanov. AVT, v. 20, no. 5, p. 686 (1959).

502. O. A. Kossov. Elektrichestvo, no. 5, p. 60 (1959).

503. S. N. Diligenskiy and Ye. I. Artamonov. ETE, no. 6, p. 82 (1963).

504. Yu. D. Rozental and M. A. Rozenblat. DAN, v. 153, no. 1, p. 90 (1963).

505. D. Ye. Polonnikov. ETE, no. 1, p. 67 (1963).

506. N. L. Prokhorov. Promyshelennaya energetika, no. 4, p. 51 (1964).

507. O. A. Kossov and V. V. Tsokanov. Elektrichestvo, no. 5, p. 34 (1964).

508. V. S. Khitruk. BIP, no. 23, p. 29 (1965).

509. N. D. Nanobashvili. SOB, v. 38, no. 1, p. 161 (1965).

510. V. V. Vasilyev and A. M. Kasimov. IPO, no. 16, p. 109 (1966).

511. O. A. Kossov. EIKA, Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Encyclopedia of Measurement, Control and Automation), no. 10 (1968).

512. V. G. Mashlykin. IPO, no. 21, p. 56 (1967).

513. T. M. Aleksandridi and Yu. S. Legovich. IPO, no. 2, p. 114 (1967).

514. V. Ye. Solodilov, N. Salakhutdinov and A. A. Kalmakov. UZB, no. 5, p. 10 (1967).

515. Yu. V. Aksenov, R. S. Kasimov and M. A. Rozenblat. IPO, no. 22, p. 36 (1967).

516. V. G. Mashlykin. IPO, no. 21, p. 35 (1968).

517. V. G. Mashylkin. IPO, no. 7, p. 44 (1968).

518. S. N. Diligenskiy and Ye. I. Artamonov. IPO, no. 23, p. 101 (1968).

519. I. V. Bizin, V. A. Kamenev and V. P. Shchupov. IPO, no. 4, p. 129 (1968).

520. R. S. Kasimov. IPO, no. 23, p. 28 (1968).

521. V. P. Zinkevich. IPO, no. 13, p. 105 (1968).

522. M. A. Rozenblat. IPO, no. 19, p. 110 (1968).

523. D. I. Ageykin. IPO, no. 20, p. 38 (1968).

524. V. F. Khalchev and M. F. Karavay. IPO, no. 18, p. 52 (1968).

525. V. P. Nosenko, V. Ye. Petrukha and L. I. Sorokin. IPO, no. 10, p. 52 (1968).

526. V. P. Nosenko and L. I. Sorokin. IPO, no. 21, p. 52 (1968).

527. N. V. Pozin and D. I. Kirvelis. IPO, no. 22, p. 111 (1968).

528. A. Ya. Biryukov. IPO, no. 33, p. 55 (1968).

529. L. Ye. Epshteyn and Yu. N. Fedin. Author's Cert. no. 237465, no. 8, p. 91, Feb. 20 (1969).

530. R. N. Blaut-Blachev. Author's Cert. no. 238869, no. 10, p. 96, Oct. 26, 1966 (1969).

531. I. Ye. Dekabrun. AVT, v. 19, no. 1, p. 100 (1958).

532. Ye. P. Svitina. AVT, v. 20, no. 5, p. 684 (1959).

533. L. V. Sentyurina. AVT, v. 20, no. 5, p. 684 (1959).

534. V. S. Borovkov and V. V. Treyer. Elektrokhimiya, v. 1, no. 9, p. 1130 (1965).

535. V. S. Borovkov and V. V. Treyer. Elektrokhimiya, v. 2, no. 9, p. 1092 (1966).

536. A. P. Shorygin. Elektrokhimiya, v. 3, no. 1, p. 110 (1967).

537. A. P. Shorygin. Elektrokhimiya, v. 4, no. 12, p. 1475 (1968).

538. A. P. Shorygin. Elektrokhimiya, v. 5, no. 3, p. 371 (1969).

539. T. K. Berends, T. K. Yefremova, A. A. Tagayevskaya and A. A. Tal' PRI, no. 11 (1963).

540. AVT, v. 24, no. 8 (1963).

541. V. A. Trapeznikov. Izv. AN SSR, Techn. Sciences Div. no. 12 (1945).

542. M. A. Ayzerman. AVT, v. 16, no. 6, p. 559 (1955).

543. V. N. Dmitriyev. AN SSR, Otdeleniye Teknicheskikh nauk, no. 6, p. 156 (1958).

544. V. N. Dmitriyev. AVT, v. 19, no. 10, p. 989 (1958).

545. V. N. Dimitriyev, V. I. Polyakov, M. K. Soms, I. B. Krishtul and V. G. Gradetskiy. IPO, no. 23, p. 102 (1966).

546. V. N. Dmitriyev, V. G. Gradetskiy, V. I. Polyakov, M. K. Soms and I. B. Krishtul. IPO, no. 7, p. 87 (1967).

547. V. N. Dmitriyev, V. G. Gradetskiy, I. S. Mezin and V. M. Yarol. IPO, no. 22, p. 134 (1967).

548. V. N. Dmitriyev and V. V. Vasilyev. IPO, no. 11, p. 124 (1967).

549. V. N. Dmitriyev, N. P. Uvarov, V. M. Yarol, V. G. Gradetskiy and T. M. Koltsova. IPO, no. 30, p. 120 (1968).

550. L. N. Zalmanzon, AN SSR, Otdeleniye teknicheskikh nauk, no. 6, p. 156 (1958).

551. A. I. Semikova and L. A. Zalmanzon. AVT, v. 19, no. 10, p. 989 (1958),

552. A. I. Semikova and L. A. Zalmanzon. AN SSR, Otdeleniye tekhnicheskikh nauk, no. 6, p. 156 (1958).

553. A. I. Semikova and L. A. Zalmanzon. AVT, v. 19, no. 10, p. 989 (1958).

554. A. I. Semikova. AVT, v. 20, no. 5, p. 685 (1959).

555. L. A. Zalmanzon. AN SSSR, Vestnik, no. 2, p. 108 (1965).

556. L. A. Zalmanzon. EIKA, Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Enclyclopedia of Measurement, Control and Automation), no. 7, p. 33 (1967).

557. Yu. V. Lutsuk and L. A. Zalmanzon. IPO, no. 14, p. 113 (1967).

558. L. A. Zalmanzon. IPO, no. 28, p. 98 (1968).

559. L. A. Zalmanzon. IPO, no. 28, p. 98 (1968).

560. A. A. Tal'. AN SSSR, Otdeleniye tekhnicheskikh nauk, no. 6, p. 156 (1958).

561. A. A. Tal'. AVT, v. 19, no. 10, p. 989 (1958).

562. T. K. Berends. AVT, v. 20, no. 5, p. 685 (1959).

563. T. K. Berends. Nauka I Zhizn', no. 4, p. 96 (1965).

564. T. K. Berends. EIKA, Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Encyclopedia of Measurement, Control and Automation), no. 7, p. 27 (1967).

565. L. Ye. Arkhipov, V. A. Zharinov, S. A. Yuditskiy, T. K. Yefremova, A. A. Tal', A. A. Tagayevskaya, V. S. Sushkin, V. I. Pershenkov, A. M. Kasimov, I. R. Iskra, V. V. Cherni, T. K. Berends, V. I. Belov and P. M. Atlas, IPO, no. 20, p. 102 (1968).

566. V. M. Dvoretskiy and V. P. Temnyy. AVT, v. 19, no. 10, p. 990 (1958).

567. V. M. Dvoretskiy. AVT, v. 20, no. 5, p. 685 (1959).

568. V. P. Temnyy. EIKA, Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, Izd-vo energiya, no. 5, p. 63 (1965).

569. V. M. Dvoretskiy. IPO, no. 11, p. 122 (1967).

570. V. M. Dvoretskiy. IPO, no. 20, p. 103 (1968).

571. E. M. Nadzhafov. AN SSSR, Otdelenye tekhnicheskikh nauk, no. 6, p. 156 (1958).

572. E. M. Nadzhafov and Yu. I. Ivlichev. AVT, v. 19, no. 10, p. 988 (1958).

573. V. V. Petrov. AVT, v. 21, no. 1, p. 63 (1960).

574. V. G. Sholokhov and T. I. Telauridze. IPO, no. 19, p. 46 (1968).

575. A. N. Shubin and M. M. Belyayev. Author's Cert. no. 234752, Sept. 5, 1967 (1969).

576. Ye. V. Fudim. DAN, v. 169, no. 6, p. 1293 (1966).

577. Ye. V. Fudim. Author's Cert. no. 224894, no. 26, p. 123 (1968).

578. Ye. V. Fudim. IPO, no. 4, p. 132 (1968).

579. Ye. V. Fudim. Author's Cert. no. 234751, July 14, 1966, no. 4, p. 114 (1969).

580. L. N. Fitsner, V. Yu. Kaganov, Yu. Ye. Yefroymovich, D. T. Vasilyev, A. B. Chelyustkin, P. N. Kopay-Gory and Ya. A. Khetagurov. AVT, v. 19, no. 2, p. 194 (1958).

581. A. B. Chelyustkin and V. A. Ivanov. Elektrichestvo, no. 2, p. 13 (1960).

582. L. N. Zagalskiy, S. M. Domanitskiy and B. B. Buyanov. Elektrichestvo, no. 1, p. 27 (1960).

583. L. N. Fitsner. EIKA, Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, no. 3, p. 45 (1964).

584. B. I. Andreychikov. AN SSSR, Institut Nauchoy Informatsii, Obshchaya Geologiya, Strategrafiya, 1963-1964, Itogi nauki, Moscow, VINITI, 1966 (1964).

585. A. B. Chelyustkin. Stal', no. 12, p. 1103 (1958).

586. V. I. Gromov and V. B. Yefimov. Author's Cert. no. 236021, no. 6, p. 87, May 28, 1966 (1969).

587. Yu. A. Yashchuk, Ye. T. Darov and Ye. I. Meybaum. IPO, no. 13, p. 112 (1968).

588. Ye. I. Meybaum. IPO, no. 13, p. 112 (1968).

589. V. M. Burdin, M. V. Meyerov, A. I. Krylov, V. I, Kiryukhin, S. Ye. Khusid, O. G. Muzalevskiy, I. I. Perel'man, G. B. Zinovyev, A. G. Shesterkin, M. A. Shvartsgorn, Yu. I. Samokhin and S. A. Leontyev. Stal', no. 9, p. 818 (1967).

590. A. G. Butkovskiy, A. Ya. Lerner and S. A. Malyy. DAN, v. 153, no. 4, p. 772 (1963).

591. A. G. Butkovskiy and Yu. N. Andreyev. FIZ, v. 8, no. 1, p. 87 (1965).

592. S. A. Malyy. EIKA, Entsiklopediya izmereniy, kontrolya I avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, Izd-vo energiya, no. 5, p. 75 (1965).

593. S. A. Malyy. Ivuz. Chernaya Metallurgiya, no. 9, p. 175 (1966).

594. A. G. Butkovskiy. AN BSSR, Inst. Teplo-I massoobmena (Academy of Sciences, Byelorussian SSR, Institute of Heat and Mass exchange), Minsk, Nauka ITekhnika, p. 135 (1966).

595. A. G. Butkovskiy, E. M. Goldfarb and E. S. Geskin. Ivuz. Chernaya Metallurgiya, no. 3, p. 173 (1967).

596. S. A. Malyy and A. Ya. Lerner. DAN, v. 183, no. 6, p. 1278 (1968).

597. P. P. Tartakovskiy, Yu. N. Khotimchenko, V. P. Dubrinskiy and A. V. Vedrak. IPO, no. 38, p. 124 (1968).

598. Yu. V. Postrichev, A. V. Vedrak, D. Kh. Yakimenko and P. P. Tartakovskiy. Author's Cert. no. 233182, no. 2, p. 78, Sept. 15, 1964 (1969).

599. M. I, Korobko, P. Ya. Vavulin, S. M. Serdyuk, V. Ye. Pronkin and P. I. Ostashevskiy. Author's Cert. no. 238825, no. 10, p. 96, Oct. 30, 1967 (1969).

600. V. S. Bogushevskiy, V. Ya. Bushnev, G. N. Kozin, G. T. Kuts, S. M. Serdyuk, S. K. Sobolev, Ye. Ya. Suprunyuk, Yu. M. Talalayevskiy, I. G. Zeltzer, V. V. Karnaukhov and G. F. Gulyev. IPO, no. 4, p. 41 (1968).

601. G. T. Kuts, I. S. Kikuruznyak, V. V. Karnaukhov, G. F. Gulyev, V. S. Bogushevskiy, A. M. Ravdel, Yu. M. Talalayevskiy and S. K. Sobolev. Author's Cert. no. 234434, no. 4, p. 41, Nov. 13, 1967 (1969).

602. Yu. V. Bashmakov, V. S. Bogushevskiy, G. N. Pozin, G. T. Kuts, S. K. Sobolev, Yu. M. Talalayevskiy, I. S. Kukuruznyak and V. V. Karnaukhov. IPO, no. 36, p. 35 (1968).

603. Yu. F. Akhonin, V. D. Kolesnik, G. F. Gulyev, O. S. Sakhnovskaya, A. S. Sizenko, S. K. Sobolev and V. V. Karnaukhov. Author's Cert. no. 236103, no. 6, p. 109, July 12, 1966 (1969).

604. A. G. Astakhov, N. V. Fedorovskiy, V. I. Kirillov, L. R. Migutskiy, V. I. Pleskach and O. Ya. Zhedenko, IPO, no. 1, p. 40 (1968).

605. M. V. Venediktov, V. I. Kirillov, A. G. Astakhov, N. V. Fedorovskiy, V. V. Arikhbayev, V. P. Grechanovskiy, I. L. Kondrashov, I. I. Lavrentik, V. N. Moskovkin, L. U. Shevchenko, V. N. Shelestov, N. A. Sumskoy, V. T. Zelinskiy and L. V. Zelenetskaya. IPO, no. 34, p. 101 (1968).

606. V. A. Orlov. IZE, no. 9, p. 1120 (1964).

607. B. P. Dovgalyuk. Ministerstvo vysshego I srednego spetsial'nogo obrazovaniya Metallurgiya i koksokhimiya (Ministry of Higher and Secondary Specialized Education, Ukrainian SSR, Metallurgy and Coke Chemistry), no. 13, p. 79 (1968).

608. V. I. Izmaylova. Za Tekhnicheskiy Progress, no. 2, p. 14 (1967).

609. V. P. Shut, S. Sh. Tverskoy, V. Ya. Mayevskiy, M. I. Marder, I. I. Klodnitskiy, A. N. Khlebnikov, S. K. Ivanov, Ye. V. Dyachenko, D. I. Buznitskiy and V. P. Alekseyev. IPO, no. 14, p. 35 (1968).

610. A. P. Kravchenko, B. I. Kusovskiy and V. O. Chinakal. Author's Cert. no. 234358, no. 4, p. 28, Feb. 8, 1967 (1969).

611. A. S. Bruk, F. Z. Yelenskiy, B. Ya. Livshits, A. Ye. Eydelman and V. I. Donkov. IPO, no. 13, p. 101 (1968).

612. I. A. Mikhil. AVT, v. 20, no. 5, p. 683 (1959).

613. K. B. Norkin, V. D. Spiridonov and O. N. Karpukhin. KAT, v. 6, no. 4, p. 772 (1965).

614. B. A. Pereverzev. AVT, v. 20, no. 5, p. 684 (1959).

615. N. A. Smirnov. AN BSSR, Izvestiya, Seriya fiziko-tekhnicheskikh nauk, no. 4, p. 5 (1967).

616. V. F. Zarechnyy, I. Ye. Manokha, I. I. Balashov, Yu. I. Georgiyevskiy and V. N. Boyko. IPO, no. 31, p. 80 (1968).

617. Yu. I. Georgiyevskiy. IPO, no. 32, p. 79 (1968).

618. V. F. Zarechnyy, I. I. Balashov, Yu. I. Georgiyevskiy and I. Ye. Manokha. IPO, no. 31, p. 40 (1968).

619. V. F. Zarechnyy, I. Ye. Manokha, Yu. I. Georgiyevskiy and I. I. Balashov, no. 12, p. 83 (1969).

620. L. A. Vereshchagin, V. S. Yatsenko, and P. S. Kuznetsov.

621. V. S. Yatsenko. Author's cert. no. 36054, no. 6, p. 96 (1969).

622. N. M. Rudnyy, N. V. Gelashvili, A. G. Lakhtionov and Yu. Ye. Kirichenko. IPO, no. 8, p. 98 (1968).

623. N. M. Rudnyy, R. S. Stankevich and R. Y. Nesterchuk. IPO, no. 3, p. 129 (1967).

624. N. M. Rudnyy, V. L. Tatiyevskiy, M. V. Venediktov and A. Ye. Sogin, IPO, no. 13, p. 142 (1967).

625. P. S. Kuznetsov, R. A. Bakhteyev and L. A. Vereshchagin. Author's Cert. no. 236055, Oct. 9, 1967, no. 6, p. 96 (1969).

626. N. M. Rudnyy and T. L. Kofanova. IPO, no. 6, p. 90 (1968).

627. N. M. Rudnyy and V. V. Maslovskiy. IPO, no. 26, p. 66 (1968).

628. N. M. Rudnyy and R. S. Stankevich. IPO, no. 14, p. 104 (1968).

629. N. M. Rudnyy, Yu. Ye. Kirichenko and M. I. Kuznetsova. IPO, no. 34, p. 111 (1968).

630. N. M. Rudnyy and R. A. Bakheteyev. IPO, no. 28, p. 127 (1968).

631. N. A. Gozhenko, N. A. Krinitsyna, B. F. Rudko and Ye. I. Tishchenko. Author's Cert. no. 234743, Apr. 8, 1967, no. 4, p. 112 (1969).

632. E. I. Shkuta, A. K. Alekseyev, B. I. Kaul, Yu. A. Khvatov, B. Koryakov-Savoyskiy, V. I. Lopatin and G. M. Marchenko. IPO, no. 6, p. 41 (1968).

633. T. I. Akhtyrskaya, V. G. Rakogon, V. D. Pepenko, I. R. Levitan, B. I. Fedyanin and L. A. Bocharov. IPO, no. 10, p. 82 (1968).

634. T. I. Akhtyrskaya, V. G. Rakogon, V. D. Pepenko, I. R. Levitan, B. I. Fedyanin and L. A. Bocharov. IPO, no. 31, p. 68 (1968).

635. A. S. Ruppo, K. B. Norkin, Yu. E. Sagalov, A. D. Shkolnikov, S. D. Slavutskiy, P. I. Gandelsman, B. G. Gershteyn, A. I. Geyshes, L. G. Melkumov and V. V. Brantov. IPO, no. 24, p. 41 (1968).

636. K. B. Norkin, A. I. Geyshes, P. I. Gandelsman, V. V. Brantov, A. D. Shkilnikov, Yu. E. Sagalov and A. S. Ruppo. IPO, no. 13, p. 37 (1968).

637. L. A. Shoykhet, I. V. Kaplenko and R. V. Shpakovskiy. IPO, no. 26, p. 16 (1968).

638. E. I. Snezhko and L. A. Shoykhet. IPO, no. 32, p. 28 (1968).

639. Yu. L. Bezusyak, A. Z. Grishchenko and L. V. Saulova. Author's Cert. no. 237106, Mar. 6, 1967, no. 8, p. 13 (1969).

640. E. L. Itskovich, Yu. P. Savitskiy and L. A. Girshov. Tsement, no, 5, p. 5 (1966).

641. N. V. Pozin and I. A. Lyubinskiy. AN SSSR, Obyedinennyy nauchnyy Sovet fiziologiya cheloveka i zhivotnykh. Mekhanizmy slukha (Academy of Sciences, USSR, United Scientific Council on Human and Animal Physiology, Auditory Mechanisms), Leningrad, Izd-vo nauka, v. 6, p. 209 (1967).

642. I. A. Lyubinskiy and N. V. Pozon. Biofizika, v. 12, no. 2, p. 272 (1967).

643. N. V. Pozin, Ye. N. Sokolov and D. I. Kirvelis. Biofizika, v. 12, no. 1, p. 148 (1967).

644. Sh. Tott, G. V. Voronin and Ye. N. Sokolov, Biofizika, v. 9, no. 1, p. 94 (1964).

645. F. B. Gulko, B. I. Khodorov, Ye. N. Timin and S. Ya. Vilenkin, Biofizika, v. 14, no. 2, p. 304 (1969).

646. F. B. Gulko. Biofizika, v. 13, no. 2, p. 370 (1968).

647. N. G. Proskuryakova and A. R. Shakhnovich. Biofizika, v. 13, no. 1, p. 117 (1968).

648. A. I. Lauringson and L. P. Shchedrovitskiy. Biofizika, v. 10, no. 1, p. 137 (1965).

649. V. M. Krol. Khimiya i zhizn', no. 2, p. 17 (1967).

650. I. M. Panasenko and L. V. Fatkin. IPO, no. 19, p. 110 (1967).

651. G. P. Katys and V. B. Shirokov. IPO, no. 21, p. 122 (1968).

652. G. P. Katys, V. I. Lalabekov and Ye. P. Chubarov. IPO, no. 32, p. 27 (1968).

653. L. Ye. Chirkov and N. V. Kravtsov. ETE, no. 6, p. 95 (1967).

654. B. I. Filipovich. EIKA, Entskilopediya izmereniy, kontrolya i avtomatizatsii (Encyclopedia of Measurement, Control and Automation), no. 10, p. 15 (1968).

655. V. Yu. Kneller. AVT, v. 20, no. 5, p. 684 (1959).

656. V. Yu. Kneller and L. N. Sokolov. IPO, no. 34, p. 61 (1968).

657. V. Yu. Kneller, A. A. Desova and Yu. R. Agamalov. IPO, no. 14, p. 62 (1968).

658. B. S. Razumikhin. DAN, v. 167, no. 6, p. 1234 (1966).

659. H. Wang. AVT, v. 20, no. 5, p. 683 (1959).

660. V. I. Shadrin. AVT, v. 20, no. 5, p. 686 (1959).

661. L. A. Telksnis. AVT, v. 20, no. 5, p. 685 (1959).

662. A. M. Letov. PMM, v. 19, no. 3, p. 257 (1955).

663. Ye. P. Maslov. Elektrichestvo, no. 8, p. 5 (1966).

664. V. S. Pugachev. AVT, v. 20, no. 5, p. 682 (1959).

665. V. M. Kharlamov. BTI ORGES no. 3, State Publ. House for Power (1963).

666. A. G. Butkovskiy. DAN, v. 180, no. 5, p. 1056 (1968).

667. M. A. Boyarchenkov, A. A. Yanshin, A. G. Cherkashin, Ch. Chao and O. A. Kossov. AVT, v. 20, no. 5, p. 687 (1959).

668. A. B. Chelyustkin. Elektrichestvo, no. 5, p. 86 (1960).

669. E. E. Zulfugarzade. ZAT, no. 6, p. 7 (1967).

670. V. V. Shulpekov. IPO, no. 6, p. 40 (1968).

671. V. A. Trapeznikov. AVT, v. 16, no. 4, p. 403 (1955).

672. A. A. Bulgakov. Elektrichestvo, no. 10, p. 29 (1956).

673. B. G. Volik. AVT, v. 20, no. 5, p. 687 (1959).

674. V. Yu. Nevrayev. Elektrichestvo, no. 1, p. 95 (1958).

675. V. Yu. Nevrayev. AVT, v. 19, no. 8, p. 810 (1958).

676. V. Yu. Nevrayev. Elektrichestvo, no. 1, p. 95 (1958).

677. L. A. Milovidov. Elektrichestvo, no. 2, p. 87 (1959).

678. V. S. Volodin. AVT, v. 20, no. 5, p. 687 (1959).

679. A. G. Cherkashin. Elektrichestvo, no. 12, p. 18 (1964).

680. S. P. Khlebnikov and A. A. Shulepov. IPO, no. 9, p. 104 (1966).

681. A. A. Shulepov and S. P. Khlebnikov. IPO, no. 17, p. 113 (1967).

682. A. A. Shulepov and S. P. Khlebnikov. IPO, no. 1, p. 110 (1966).

683. L. N. Fitsner. EIKA, Entsiklopediya izmereniy, kontrolya i avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, Izd-vo energiya, no. 3, p. 43, 65 (1964).

684. L. N. Fitsner. Elektrichestvo, no. 8, p. 61 (1960).

685. L. I. Rozonoer and A. G. Butkovskiy. AVT, v. 20, no. 5, p. 682 (1959).

686. A. Ya. Lerner. EIKA, Entsiklopediya izmereniy, kontrolya i avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, Izd-vo energiya, no. 6, p. 51 (1966).

687. A. A. Fel'dbaum. Leningradskaya Pravda, no. 42, p. 3 (1966).

688. V. A. Trapeznikov. AN SSSR, Vestnik, no. 4, p. 164 (1964).

689. V. A. Ivanov. AVT, v. 20, no. 5, p. 682 (1959).

690. V. Yu. Nevrayev. Elektrichestvo, no. 4, p. 94 (1959).

691. A. A. Fel'dbaum. EIKA, Entsiklopediya izmereniy, kontrolya i avtomatizatsii (Encyclopedia of Measurement, Control and Automation), Moscow, Izd-vo energiya, no. 3, p. 57, 65 (1964).

692. A. V. Lanshin, P. A. Ilyukhin and K. K. Zhiltsov. DAN, v. 181, no. 2, p. 298 (1968).

693. K. B. Norkin. AVT, v. 23, no. 8 (1962).

694. Yu. S. Popkov. AVT, v. 24, no. 11 (1963).

695. N. F. Cherenkova and I. V. Prangishvili. EIKA, Entsiklopediya izmereniy, kontrolya i avtomatizatsii (Encyclopedia of Measurement, Control and Automation), no. 7, p. 55 (1967).

696. A. A. Maslov and Yu. G. Purlov, AVT, v. 20, no. 5, p. 685 (1959).

697. M. A. Rozenblat. Elektrotekhnika, no. 1, p. 62 (1964).

698. M. A. Rozenblat and O. G. Kasatkin. DAN, v. 155, no. 5, p. 1066 (1964).

699. M. A. Boyarchenkov, R. S. Kasimov and V. P. Zinkevich. IPO, no. 19, p. 42 (1968).

700. M. A. Rozenblat and A. S. Zinkevich. IPO, no. 23, p. 31 (1968).

701. M. A. Rozenblat, M. A. Boyarchenkov and V. K. Rayev. IPO, no. 28, p. 110 (1968).

702. O. G. Kasatkin and M. A. Rozenblat. IPO, no. 4, p. 80 (1966).

703. M. A. Rozenblat. AN SSSR, Vestnik, no. 11, p. 47 (1964).

704. M. A. Rozenblat. IFT, v. 15, no. 4, p. 630 (1966).

705. F. I. Kerbnikov. AVT, v. 16, no. 4, p. 405 (1955).

706. M. A. Rozenblat. DAN, v. 181, no. 6, p. 1375 (1968).

707. M. A. Gavrilov. AN SSSR, Strukturnaya teoriya releynykh ustroystv, Moscow, p. 180, 170 (1963).

708. A. D. Talantsev. AVT, v. 20, no. 5, p. 685 (1959).

709. M. A. Gavrilov. AVT, v. 19, no. 9, p. 896 (1958).

710. M. A. Gavrilov. Elektrichestvo, no. 2, p. 79 (1955).

711. M. A. Gavrilov. AVT, v. 16, no. 4, p. 402 (1955).

712. M. A. Gavrilov. AVT, v. 16, no. 2, p. 211 (1955).

713. V. I. Ivanov. AVT, v. 19, no. 9, p. 899 (1958).

714. V. I. Ivanov. AVT, v. 16, no. 2, p. 213 (1955).

715. V. M. Ostianu. AVT, v. 19, no. 9, p. 898 (1958).

716. P. P. Parkhomenko. AN SSSR, Strukturnaya teoriya releynykh ustroystv, Moscow, pp. 250, 270 (1963).

717. V. A. Zhozhikashvili. AVT, v. 19, no. 10, p. 987 (1958).

718. V. S. Matorina, O. A. Sedykh and O. A. Vasil'yev. Elektrotekhnika, no. 1, p. 63 (1964).

719. P. P. Parkhomenko. AVT, v. 19, no. 9, p. 899 (1958).

720. V. P. Didenko, V. D. Kazakov, V. M. Kharlamov, B. L. Timofeyev, P. P. Parkhomenko, A. D. Talantsev and O. P. Kuznetsov. AVT, v. 20, no. 5, p. 687 (1959).

721. V. D. Kazakov. AN SSSR, Strukturnaya teoriya releynykh ustroystv, Moscow, pp. 145, 270 (1963).

722. V. P. Didenko. AN SSSR, Strukturnaya teoriya releynykh ustroystv, Moscow, pp. 148, 270 (1963).

723. V. A. Tantsyura. VZT, no. 5, p. 35 (1966).

724. N. S. Anishin and G. G. Rekus. PRI, v. 8, no. 5, p. 68 (1965).

725. E. M. Mamedli, V. T. Lysikov and O. I. Semenkov. AN BSSR. Institut Tekhnicheskoy Kibernetiki, Vychislitel'naya Tekhnika V. Mashinostroyenii (Academy of Sciences Byelorussian SSR. Institute of Technical Cybernetics Computer Technology in Machine building), Minsk, p. 159, July (1967).

726. R. R. Varshamov, G. M. Tenengolts and V. A. Arakelov. IPO, no. 28, p. 107 (1968).

727. P. P. Parkhomenko. ITE, no. 3, p. 179 (1959).

728. N. V. Pozin, S. N. Diligenskiy, L. B. Venchkovskiy, M. Yu. Gadzhiyev, S. I. Ogandzhanyants, Yu. I. Chugin, V. M. Vaykovskiy and V. D. Zenkin. AVT, v. 20, p. 686 (1959).

729. Ya. G. Genis and E. M. Mamedli. AN BSSR, Institut Tekhnicheskoy Kibernetiki, Vycheslitel'naya Tekhnika V Mashinostroyenii Nauch, Tekhn, Sbornik, Minsk, (Academy of Sciences Byelorussian SSR, Institute of Technical Cybernetics, Computer Technology in Machine Building), p. 200 (1967).

730. V. A. Il'in. EIKA, Entsiklopediya izmereniy, kontrolya i avtomatizatsii (Encyclopedia of Measurement, Control and Automation), no. 9, p. 13 (1968).

731. M. A. Rozenblat. DAN, v. 171, no. 4, p. 814 (1966).

732. S. M. Yakovlev. AVT, v. 16, no. 2, p. 213 (1955).

733. V. P. Demeshin. AVT, v. 16, no. 2, p. 216 (1955).

734. R. V. Bilik. AVT, v. 16, no. 4, p. 402 (1955).

735. R. V. Bilik. MAP, no. 1, p. 53 (1964).

736. V. L. Bakhrakh. IPO, no. 28, p. 175 (1968).

737. V. I. Stepanov. AVT, v. 16, no. 2, p. 215 (1955).

738. A. M. Petrovskiy. AVT, v. 16, no. 2, p. 211 (1955).

739. A. V. Khramoy. AVT, v. 16, no. 2, p. 211 (1955).

740. V. N. Tutevich. AVT, v. 16, no. 2, p. 213 (1955).

741. Ya. G. Genis and E. M. Mamedli. IPO, no. 36, p. 108 (1968).

742. M. N. Gubanov. AVT, v. 16, no. 4, p. 404 (1955).

743. M. I. Gubanov. Elektrichestvo, no. 10, p. 53 (1956).

744. A. P. Shorgin. EIKA, Entsiklopediya izmereniy, kontrolya i avtomatizatsii (Encyclopedia of Measurement, Control and Automation), no. 10, p. 29 (1968).

745. Yu. V. Novikov. AVT, v. 19, no. 2, p. 194 (1958).

746. A. Ya. Chervonenkis and V. N. Vapnik. DAN, v. 181, no. 4, p. 781 (1968).

747. V. N. Dmitriyev. IPO, no. 1, p. 94 (1967).

748. Yu. I. Ostrovskiy. OTT, no. 6, p. 156 (1958).

749. V. A. Khokhlov. AVT, v. 19, no. 10, p. 990 (1958).

750. V. A. Khokhlov. VES, no. 12, p. 75 (1961).

751. V. A. Khokhlov. IPO, no. 13, p. 66 (1967).

752. B. S. Shkrabov. IPO, no. 5, p. 110 (1967).

753. V. I. Lezin. IPO, no. 36, p. 106 (1968).

754. I. N. Kundyrevich, Yu. F. Titov, Ye. I. Meybaum and Yu. A. Yashchuk. IPO, no. 13, p. 112 (1968).

755. M. V. Meyerov. DAN, v. 165, no. 4, p. 780 (1965).

756. P. F. Merabishvili. Elektrichestvo, no. 7, p. 74 (1963).

757. M. G. Grudin, F. A. Lantsberg, A. M. Litvinov. Yu. D. Lukomskiy and M. V. Pashkovskiy. IPO, no. 21, p. 165 (1967).

758. N. V. Kravtsov. IPO, no. 34, p. 120 (1968).

759. I. I. Perel'man and B. G. Zinovyev. IPO, no. 1, p. 86 (1967).

760. I. I. Perel'man and B. G. Zinovyev. IPO, no. 1, p. 92 (1967).

761. Ya. Z. Tsypkin. ITE, no. 2, p. 98 (1960).

762. V. S. Kulebakin. Elektrichestvo, no. 1, p. 95 (1958).

763. V. V. Gorskiy. Elektrichestvo, no. 1, p. 92 (1957).

764. V. V. Gorskiy. Elektrichestvo, no. 3, p. 14 (1957).

765. B. S. Sotskov. Elektrichestvo, no. 2, p. 79 (1955).

766. V. A. Zhozhikashvili. AVT, v. 16, no. 2, p. 212 (1955).

767. A. A. Bulgakov. DAN, v. 174, no. 1, p. 45 (1967).

768. M. P. Sakharov. IPO, no. 12, p. 60 (1967).

769. Ya. Z. Tsypkin. PRI, no. 6, p. 114 (1958).

770. V. K. Nesnov. IPO, no. 6, p. 40 (1968).

771. Ye. V. Kartuzov. IPO, no. 28, p. 35 (1968).

772. V. S. Krutenko and V. N. Silayev. IPO, no. 28, p. 35 (1968).

773. V. Ya. Ruban and V. F. Oseledko. IPO, no. 6, p. 40 (1968).

774. S. N. Dilegenskiy. IZE, no. 2, p. 148 (1968).

775. A. A. Tal'. Teploenergetika, no. 10, p. 69 (1957).

776. G. E. Shleyer. IPO, no. 33, p. 68 (1968).

777. V. N. Silayev and Ch. Chao. AVT, v. 20, no. 5, p. 685 (1959).

778. B. S. Sotskov. OTT, no. 1, p. 158 (1957).

779. B. S. Sotskov. AVT, v. 16, no. 2, p. 212 (1955).

780. B. S. Sotskov. AVT, v. 16, no. 6, p. 557 (1955).

781. V. N. Shadrin. IZE, no. 11, p. 1381 (1964).

782. V. N. Shadrin. IZE, no. 8, p. 991 (1964).

783. V. I. Ivanov. AN SSSR. Strukturnaya teoriya releynykh ustroystv, Moscow, pp. 259, 270 (1963).

784. V. I. Ivanov, P. I. Ryzhov and V. K. Sirotko. OTT, no. 3, p. 150 (1955).

785. B. I. Kaznozhan, M. P. Vukalovich and R. N. Chernyshev. Teploenergetika, no. 6, p. 70 (1967).

786. Yu. M. Tsodikov. PRI, v. 8, no. 5, p. 103 (1965).

787. V. P. Grabovetskiy. AVT, v. 20, no. 5, p. 684 (1959).

788. V. N. Shadrin. Elektrichestvo, no. 12, p. 78 (1957).

789. V. M. Ilyinskiy. NAY, no. 2, p. 72 (1967).

790. V. Yu. Kneller and Yu. R. Agamalov. IPO, no. 31, p. 46 (1968).

791. V. Yu. Kneller. IPO, no. 21, p. 64 (1968).

792. Vestnik AN SSSR, no. 5, pp. 13-36 (1968).

793. Vestnik AN SSSR, no. 3, pp. 42-50 (1967).

794. Ye. I. Meybaum. IPO, no. 13, p. 112 (1968).

795. Vestnik AN SSSR, no. 3, pp. 32-35 (1966).

796. Vestnik AN SSSR, no. 3, pp. 38-43 (1964).

797. Yu. Ye. Kirichenko. Author's Cert. no. 233273, no. 2, p. 103, Aug. 23, 1967 (1969).

798. A. I. Lauringson and L. P. Shchedrovitskiy. Biofizika, v. 10, no. 2, p. 369 (1965).

799. L. A. Tenenbaum. VEM, no. 273, p. 4 (1967).

800. V. U. Degtyar. NER, v. 16, no. 1, p. 82 (1966).

801. Vestnik AN SSSR, no. 3, pp. 40-43 (1965).

802. AVT, v. 25, no. 6, p. 747 (1964).

803. AVT, v. 25, no. 6, p. 753 (1964).

804. AVT, v. 25, no. 6, p. 763 (1964).

805. AVT, v. 25, no. 6, p. 807 (1964).

806. Directory of selected Scientific Institutions in the USSR, Charles E. Merrill Books, Inc., Columbus, Ohio, p. 312 (1963).

807. Vestnik AN SSSR, no. 4, p. 7 (1969).

808. Vestnik AN SSSR, no. 10, p. 113 (1964).

809. Moscow News, no. 3, p. 8, Jan. 27 (1968).

810. G. P. Katys, Yu. D. Mamikonov, Ye. P. Chuvarov and V. M. Ilinskiy. IPO, no. 36, p. 110 (1968).

Appendix B

THE CENTRAL MATHEMATICAL ECONOMICS INSTITUTE

AUTHORS ASSOCIATED WITH THE CENTRAL MATHEMATICAL ECONOMICS INSTITUTE

The Chemical Industry

a. Chemistry in national economy

N. P. Fedorenko
I. V. Rakhlin
L. M. Girshovich
L. F. Semina
V. M. Ioffe
I. Ye. Krichevskiy
G. F. Borisovich
Ye. P. Shchukin[59-65]

b. Agricultural applications

N. P. Fedorenko
Ye. P. Shchukin
V. A. Yedemskiy
E. S. Savinskiy
A. A. Smirnov[66-68]

c. Hydrocarbon fuels

N. P. Fedorenko
Ye. P. Shchukin
O. B. Braginskiy
L. A. Fridman
I. V. Kondratyev
E. L. Khmelnitskaya[69-71]

d. Plastics production

N. P. Fedorenko
T. L. Bakumenko
Ye. P. Shchukin
A. S. Vayn

Yu. T. Lipshits

N. M. Anichkina

N. P. Kocherov

N. S. Kosheleva

D. Andreytsev

N. M. Markosova

V. M. Ioffe

A. Aleshin[72-83]

e. Inorganic chemistry

N. P. Fedorenko

E. I. Tsypina

S. G. Lipkina[78,79]

Research on Automated Economic Planning

a. General

N. P. Fedorenko

B. S. Verkhovskiy

Yu. Brykin

V. Krynkov

B. Milhalevskiy

V. A. Mash

F. Diderikhs

Z. F. Baranov

V. P. Dyachenko

Yu. G. Lipets

A. Korbut[39-41,86-95]

b. Network planning including linear programming

V. Ya. Altayev

I. A. Radchik

K. V. Kim[96-100]

c. Optimal planning for industrial branches

Ye. Yu. Fayerman

Yu. V. Ovsiyenko

V. G. Mednitskiy

A. K. Pitelin

A. Kh. Tkhaytsukov[27,101-103]

d. Construction of mathematical models

L. S. Glyazer

S. K. Rayevich

L. A. Nakhamkin

B. A. Shcheninkov

Yu. N. Tyurin[104-109]

e. Algorithmic languages and algorithms for economic problems

V. I. Franchuk

F. F. Shiller[110-113]

f. Information flows in economics

I. Ye. Mayzlin

I. S. Zinger[27,101,114]

Agriculture and Industry

a. Agriculture

B. Ishakov-Plyukhin

A. Gusev

L. Belova

O. S. Gorbacheva

V. S. Chernyavskiy[115-117]

b. Production control

Kh. Sh. Margulis

G. Ya. Fridman

A. G. Vigdorchik

Yu. V. Sinyak

Yu. D. Kononov

A. S. Nekrasov

A. B. Mandel

N. P. Buslenko

Yu. Yu. Kess

V. O. Zhuravkov

S. L. Zhurzhenko

I. M. Ratner[96,104,109,118-125]

c. Transportation

Yu. A. Oleynik

M. R. Kogalovskiy

G. N. Kovshov

D. G. Polyak

V. K. Kulyagin[117,126-131]

Mathematics

a. Theory of games

G. N. Dyubin

Kh. K. Brutyan

Ye. B. Yanovskaya

N. Vorobyev[132-137]

b. Linear and dynamic programming

I. Pitayevskiy-Shapiro

V. A. Volkonskiy

L. V. Levina

A. Pomanskiy

Yu. Yu. Finkel'shteyn

B. S. Verkhovskiy

Ye. G. Gol'shteyn

V. Z. Belenkiy

R. A. Polyak

B. L. Leonas[97,131,138-143]

c. Other cybernetics-related research

S. N. Kashcheyev
V. R. Khachaturov
V. A. Starosel'skiy
V. P. Salakatov
L. A. Kasselman
I. P. Vorontsova
M. Ye. Deza
B. I. Aleynikov
V. I. Arkin[105,111,134,140,144-149]

d. General

L. M. Simuni
I. B. Vapniyarskiy
G. M. Khenkin
Ye. A. Larionov
V. L. Levin
B. S. Mityagin
L. A. Rukhovets
G. N. Tyurina
B. Yefimov
L. A. Oganesyan
A. K. Kelmans
R. Yu. Yasilionis[106,120,144,146,150-158]

Radiobiology

L. Ya. Klepper
N. Ye. Futerman
Yu. A. Oleynik
T. G. Pavlova
A. N. Krongauz
M. A. Fadeyeva
L. A. Karp[149,160-163]

CONFERENCES PARTICIPATED IN BY THE CENTRAL MATHEMATICAL ECONOMICS INSTITUTE

International Conferences

International Seminar on Planning, Moscow, July 1964[164]

The Sixth European Congress of the Regional Sciences Association, Vienna, August 29 to September 4, 1966.[165]

Fifth Conference on the Industrial Power Engineering, Prague, September 4-9, 1967[123]

International Meeting on Economic Zoning[166]

International European Congress on Econometrics and Management[25]

All-Union Conferences

All-Union Scientific and Technical Conference on the Problems of Scientific Organization of Socialist Industry Management, Moscow, 1965[27]

Expanded Conference of the Science Council of the All-Union Scientific Research Institute of the Gas Industry, 1966[167]

The First All-Union Conference on Optimization and Modeling of Transport Networks, Kiev, 29 to 31 May 1967[168]

First All-Union Conference on the Use of Economic and Mathematical Methods and Computer Technology in the Planning Development and Location of Industry, Tallin, 20 to 22 December 1967[26]

All-Union Meeting Devoted to Quantitative Methods in Social Studies[169]

All-Union Conference on the Improvement of Planning in the National Economy[170]

Second All-Union Conference on Operational Control of Production Process[171]

All-Union Summer School Course on Mathematical Programming[172]

All-Union Scientific Conference on Application of Econometrics Methods and Computers in Planning and Controlling the National Economy, Moscow, November 1968[173]

General Conferences

Scientific Conference on the Problems of Reproduction of Common Product and National Income in Soviet Republic, Kiev, February 1964[94]

Conference of the Division of Economics of the Academy of Sciences of USSR, Moscow, 25, 26 January 1966[174]

Seminar on the Dynamics of Neuron Nets in the Vilnyus State University[175]

The Interuniversity Scientific Conference on Problems of Statistics Textbook Publication and Improvement, Kiev, 31 May to 2 June 1966[176]

All-Union Symposium on Quantitative Methods in Sociological Investigation, Sukhumi, April 1967[177]

Scientific Technical Conference on Operation of Electric Power Distribution Networks, Leningrad, June 1967[178]

Second Intercollegiate Conference on the Scientific Organization of Labor, Tallin, May 1968[179]

Interscholastic Conference on the Teaching of Economico Mathematical Methods[180]

Session of General Meeting held at the Estonian Academy of Sciences, Tallin, 16 and 17 October 1968[181]

The Summer School Mathematics in Geography 1968[182]

SCIENTIFIC COUNCIL ON THE COMPLEX PROBLEM "OPTIMAL PLANNING AND MANAGEMENT OF NATIONAL ECONOMY"

The Council established in 1967 by the Academy of Sciences, USSR, was based on three former scientific councils for "The Application of Mathematics and Computer Technology to Economic Research and Planning," "Improvements in the Methods and Indices of National Economy Planning," and "Scientific Foundations for Planning and Organization of Social Production."

Members of the Council include:

L. Z. Kantorovich and T. S. Khachaturov on behalf of the Academy of Sciencies, USSR,

M. E. Rakovskiy and L. B. Al'ter on behalf of Gosplan, USSR,

L. Ya. Berri on behalf of the Moscow State University, and

A. Ya. Boyarskiy on behalf of the Central Statistical Administration, USSR.

The Council consists of eleven sections:

Modeling of the Process of National Economy and Planning,

Long-range National Economy Forecasting,

National Consumer Demand and Commerce,

Territorial Systems of Planning and Management,

Automated Systems of Planning and Management of Industrial Branches,

Automated Systems of Managing Industrial Enterprises,

Optimal Planning of Agricultural Production,

Transport Problems,

Utilization of Computer Technology and Systems of Mathematical Support and Economics,

Mathematical Programming, and the

Study of Economical and Mathematical Models of Foreign Countries.

The Council also has 16 territorial sections:

Leningrad, Novosibirisk, Ukrainian, Byelorussian, Latvian,

Estonian, Lithuanian, Armenian, Uzbek, Georgian, Kazakh,

Azerbaydzhan, Kirghiz, Moldavian, Turkmen, and Tadzhik.

REFERENCES FOR SECTION II

1. Vestnik Akademii Nauk, SSSR 10, 3-14 (64).
2. Izvestiya 8/17/67, 6.
3. Vestnik Akademii Nauk, SSSR 10, 3-14 (64).
4. Ek. Gaz. 27, 12 (68).
5. Ek. Gaz. 8, 17 (68).
6. Mosk. Pravda 9/24/69, 2.
7. Vestnik Akademii Nauk, SSSR 10, 10-11 (64).
8. N. P. Fedorenko, Economics and Mathematics, Znaniye Publishing House, Moscow, 1967, 2.
9. Vestnik Akademii Nauk, SSSR 5, 43 (68).
10. Vestnik Akademii Nauk, SSSR 1, 107-109 (68).
11. Vestnik Akademii Nauk, SSSR 3, 13 (64).
12. Kauchuk i rezina 5, 45 (64).
13. Khimiya v shkole 2, 85 (69).
14. Voprosy ekonomiki 9, 148 (66).
15. Vestnik Akademii Nauk, SSSR 6, 130 (65).
16. Plasticheskiye massy 10, 72 (68).
17. Khimiko-farmatsevticheskiy zhurnal 9, 58 (67).
18. Vestnik Akademii Nauk, SSSR 7, 82-97 (67).
19. Vestnik Akademii Nauk, SSSR 3, 13 (64).
20. Vestnik Akademii Nauk, SSSR 7, 118 (64).
21. Vestnik Akademii Nauk, SSSR 2, 62 (66).
22. Voprosy ekonomiki 12, 151 (66).
23. Vestnik Akademii Nauk, SSSR 2, 9 (68).
24. Vestnik Akademii Nauk, SSSR 8, 3 (64).
25. Voprosy eckonomiki 3, 159 (67).

26. Sovetskaya Estoniya, Tallin 296, 1 (67).

27. Vestnik Akademii Nauk, SSSR 9, 126 (66).

28. Vestnik Akademii Nauk, SSSR 1, 107 (68).

29. Plastics 9, 52 (61).

30. Plastics 2, 56 (62).

31. Plastics 4, 53 (62).

32. Plastics 11, 49 (62).

33. Kauchuk i rezina 5, 45 (64).

34. All-Union Chemical Society Journal 9, 2 (64).

35. Production and Treatment of Plastics, Synthetic Tars and Glass Fibers, Information Bulletin 6, 52 (64).

36. All-Union Chemical Society Journal 10, 495 (65).

37. Problems of Economics 10, 153 (65).

38. Problems of Economics 1, 142 (66).

39. Vestnik Akademii Nauk, SSSR 5, 110 (67).

40. An Latssr, Izvestiya, 4, 125 (68).

41. Problems of Economics 2, 154 (69).

42. Chemical Industry 4, 48 (66).

43. Chemistry and Technology of Fuels and Oils 4, 35 (66).

44. Plastics 5, 68 (66).

45. Journal of Inorganic Chemistry 11, 1 (66).

46. Plastics 2, 79 (67).

47. All-Union Chemical Society Journal 12, 328 (67).

48. Chemical and Oil Machine Construction 3, 46 (67).

49. Vestnik Akademii Nauk, SSSR 10, 15-19 (66).

50. Economic-Mathematical Methods, Statistika Publishing House, Moscow, 1968, 5-6.

51. Ek. Gaz. 7, 15 (69).

52. Vestnik Akademii Nauk, SSSR 6, 23-40 (68).

53. Ekonomika i matematicheskiye metodye 5, 783-790 (69).

54. Vestnik Akademii Nauk, SSSR 3, 38 et. seq. (64).

55. Vestnik Akademii Nauk, SSSR 3, 32 et. seq. (66).

56. Vestnik Akademii Nauk, SSSR 5, 13 et. seq. (68).

57. Vestnik Akademii Nauk, SSSR 5, 5 (69).

58. Vestnik Akademii Nauk, SSSR 10, 12-13 (66).

59. Vsesoyuznoye khimicheskoye obshchestvo, Zhurnal 1, 2 (64).

60. Voprosy ekonomiki 10, 153 (65).

61. Vestnik Akademii Nauk, SSSR 5, 32 (66).

62. Khimicheskaya promyshlennost' 4, 48 (66).

63. Vsesoyuznoye khimicheskoye obshchestvo, Zhurnal 2, 122 (67).

64. Plasticheskiye massy 5, 68 (66).

65. Khimicheskaya promyshlennost' 5, 45 (68).

66. Vsesoyuznoye khimicheskoye obshchestvo, Zhurnal 5, 495 (65).

67. Zhurnal neorganicheskoy khimii 1, 229 (66).

68. Khimiya v sel'skom khozyaystve 5, 76 (68).

69. Khimicheskaya promyshlennost' 5, 19 (64).

70. Plasticheskiye massy 2, 56 (64).

71. Khimiya i tekhnologiya topliv i masel 4, 35 (66).

72. Plasticheskiye massy 5, 40 (61).

73. Plasticheskiye massy 4, 53 (62).

74. Plasticheskiye massy 2, 56 (62).

75. Plasticheskiye massy 10, 43 (63).

76. Plasticheskiye massy 1, 53 (63).

77. Plasticheskiye massy 4, 1 (65).

78. Referativnyy zhurnal. Khimiya 9, 2 (64).

79. Sovet ekon. vzaimopomoshchi. sredstva i metody mekhanizatsii podgotovki i poiska nauchno-technicheskoy informatsii, inzhenernogo i upravlencheskogo truda lektsii, prochitannyye na vystavke *in orga-65* v maye-iyune 19, 5(66).

80. Planovoye khozyaystvo 6, 24 (66).

81. Referativnyy zhurnal. Khimiya 6, 52 (64).

82. Planovoye khozyaystvo 10, 48 (65).

83. Plasticheskiye massy 10, 48 (65).

84. Khimicheskaya promyshlennost' 9, 32 (64).

85. Khimicheskaya promyshlennost' 8, 37 (65).

86. AN SSSR. Doklady 1, 17 (64).

87. AN SSSR. Izvestiya. Seriya geograficheskaya 2, 167 (67).

88. Kommunist Tadzhikistana Dushanbe 3, 2 (68).

89. Voprosy ekonomiki 5, 143 (65).

90. Planovoye khozyaystvo 11, 55 (64).

91. AN Latssr. Izvestiya 4, 126 (68).

92. AN SSSR. Isvestiya. Seriya geograficheskaya 1, 123 (67).

93. Nto SSSR 2, 19 (66).

94. Vestnik statistiki 6, 74 (64).

95. Voprosy ekonomiki 1, 142 (66).

96. Vechernaya Moskva 300, 4 (68).

97. Knizhnaya letopis'. Dopolnetel'nyy vypusk 6, 155 (66).

98. Vechernaya Moskva 108, 4 (66).

99. Knizhnaya letopis'. Dopolnitel'nyy vypusk 7, 149 (66).

100. AN Kazssr. Izvestiya. Seriya fiziko-matematicheskikh nauk 3, 38 (67).

101. Vechernaya Moskva 103, 4 (66).

102. Vechernaya Moskva 241, 4 (66).

103. Planovoye khozyaystvo 8, 17 (65).

104. Vechernaya Moskva 260, 4 (66).

105. Vechernaya Moskva 66, 4 (68).

106. Vechernaya Moskva 226, 4 (67).

107. Knizhnaya letopis'. Dopolnitel'nyy vypusk 8, 140 (67).

108. Knizhnaya letopis'. Dopolnitel'nyy vypusk 3, 156 (66).

109. Vechernaya Moskva 38, 4 (66).

110. Vechernaya Moskva 38, 4 (66).

111. Vechernaya Moskva 85, 4 (67).

112. Uspekhi matematicheskikh nauk 3, 229 (68).

113. Knizhnaya letopis'. Dopolnitel'nyy vypusk 5, 160 (67).

114. Knizhnaya letopis'. Dopolnitel'nyy vypusk 2, 148 (66).

115. Voprosy ekonomiki 5, 144 (65).

116. Moskovskaya pravda Moscow 141, 4 (68).

117. Vechernaya Moskva 71, 4 (69).

118. Neftepererabotka i neftekhimiya 5, 37 (66).

119. AN SSSR. Doklady 2, 296 (66).

120. Vechernaya Moskva 2, 4 (67).

121. Gazovaya promyshlennost' 8, 53 (66).

122. AN SSSR. Izvestiya. Tekhnicheskaya kibernetika 3, 10 (67).

123. Promyshlennaya energetika 4, 4 (68).

124. Ivuz. Energetika 3, 130 (68).

125. Tekhnika kino i televedeniye 3, 90 (69).

126. Avtomobil'nyy transport 2, 54 (67).

127. Radio, 11, 6 (66).

128. Knizhnaya letopis'. Dopolnitel'nyy vypusk 5, 163 (66).

129. Knizhnaya letopis'. Dopolnitel'nyy vypusk 3, 149 (66).

130. Vechernaya Moskva 44, 4 (66).

131. Vechernaya Moskva 285, 4 (67).

132. Nauka i zhizn' 10, 25 (66).

133. Alma-ata. Kazakhhskiy nauch.-issled. Insti. Energeticki. Probelmy obshchey energetiki i yedinoy energeticheskoy sistemy. No. 3. 1967, 2, 381 (68).

134. Vechernaya Moskva 136, 4 (68).

135. AN SSSR. Doklady 1, 9 (68).

136. Litovskiy Matematicheskiy Sbornik 7, 547 (68).

137. AN SSSR. Doklady 2, 267 (69).

138. AN SSSR. Doklady 6, 1289 (66).

139. AN SSSR. Doklady 5, 993 (65).

140. Vechernaya Moskva 85, 4 (66).

141. Knizhnaya letopis'. Dopolnitel'nyy vypusk 4, 763 (64).

142. AN SSSR. Doklady 4, 763 (64).

143. Knizhnaya letopis'. Dopolnitel'nyy vypusk 12, 141 (67).

144. Vechernaya Moskva 288, 4 (68).

145. AN Kazssr. Vestnik 3, 68 (69).

146. Vechernaya Moskva 22, 4 (68).

147. Vechernaya Moskva 44, 4 (67).

148. Vechernaya Moskva 136, 4 (65).

149. Vechernaya Moskva 108, 4 (68).

150. AN SSSR. Sibirskoye otdeleniye. Izvestiya. Seriya technicheskikh nauk 2, 23 (67).

151. Funktsional'nyy analiz i yego prilozheniya 4, 82 (68).

152. AN SSSR. Doklady 5, 1008 (68).

153. AN SSSR. Doklady 4, 768 (68).

154. Matematicheskiye zametki 6, 685 (68).

155. Matematicheskiye zametki 1, 99 (69).

156. AN SSSR. Doklady 1, 41 (66).

157. Differentsial'nyye uravneniya 4, 688 (67).

158. Funktsional'nyy analiz i yego prilozheniya 4, 70 (68).

159. AN SSSR. Doklady 5, 987 (69).

160. Meditsinskaya radiobiologiya 3, 7 (69).

161. Meditsinskaya radiobiologiya 3, 64 (69).

162. Meditsinskaya radiobiologiya 3, 79 (69).

163. Meditsinskaya radiobiologiya 3, 26 (69).

164. Planovoye Khozyaystvo 9, 93 (64).

165. AN SSSR. Izvestiya. Seriya geograficheskaya 1, 122 (67).

166. AN SSSR. Izvestiya. Seriya geograficheskaya 6, 143 (67).

167. Gazovaya promyshlennost' 9, 46 (67).

168. Ndvsh. Khimiya i khimicheskaya teckhnologiya 9, 93 (67).

169. Vestnik statistiki 9, 80 (67).

170. Vestnik statistiki 7, 84 (68).

171. Avtomatika i telemekhanika 8, 180 (68).

172. AN Kazssr. Vestnik 12, 66 (68).

173. Voprosy ekonomiki 2, 154 (69).

174. Voprosy ekonomiki 4, 144 (66).

175. Zhurnal vysshey nervnoy deyatel'nosti 16, 762 (66).

176. Vestnik statistiki 10, 84 (66).

177. Nauka i suspil'stvo 8, 8 (67).

178. Elektricheskiye stantsii 12, 82 (67).

179. Vestnik vysshey shkoly 10, 57 (68).

180. Vestnik vysshey shkoly 1, 79 (68).

181. AN Estssr. Izvestiya. Khimiya, geologiya 28, 94 (69).

182. AN SSSR. Isvestiya. Seriya geograficheskaya 2, 134 (69).