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USSR

TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY
PHYSICAL SCIENCES AND TECHNOLOGY
(FOUO 11/79)

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Aeronautics	Electrical Engineering	Navigation and Communications
Astronomy	Energy Conversion	Detection and Countermeasures
Astrophysics	Materials	Nuclear Science and Technology
Atmospheric Sciences	Mathematics	Ordnance
Chemistry	Mechanical Engineering	Physics
Computers	Civil Engineering	Propulsion and Fuels
Cybernetics	Industrial Engineering	Space Technology
Earth Sciences	Marine Engineering	
Oceanography	Methods	
	Equipment .	

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TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY
PHYSICAL SCIENCES AND TECHNOLOGY

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CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

DEVELOPING AN AUTOMATED CONTROL SYSTEM FOR MOTOR TRANSPORT

Moscow OTRASLEVAYA AVTOMATIZIROVANNAYA SISTEMA UPRAVLENIYA AVTOMOBIL'NYM TRANSPORTOM (Automated Control System for the Motor Transport Sector of Industry) in Russian 1977 signed to press 22 Jun 77 pp 2-6, 18-21, 37-56

[Annotation, table of contents, introduction and excerpts from book by Yu. A. Kaftanyuk, Izdatel'stvo "Transport", 13,000 copies, 112 pages]

[Text] This study is devoted to the subject of improving control of common carrier transport using a branch automated control system. In it are considered some of the scientific, methodological and organizational principles for developing an ASU for a sector of industry. Considerable attention is focussed here on the tasks and function of data processing enterprises. Important functional subsystems of a branch ASU are examined in detail: "Operational Control", "Future Sector Development", "Technical and Economic Planning" and "Materials and Equipment Supply".

The book is intended for scientific personnel, ASU designers, engineer-economists and technical engineers of the motor transport industry.

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Introduction

Motor Transport is a very important link in the country's unified transportation system. Its importance to the national economy is borne out by the fact that more than 80 percent of the freight conveyed by all forms of transportation is carried by motor transport.

Analysis of the trend toward developing the country's industrial strengths shows that the rate of growth in the volume of shipments by motor transport and its role in the country's national economy are growing steadily.

The principle problems facing the country's transportation system are defined in "Basic Directions for the Development of the USSR National Economy in 1976-1980" with the goal of more complete and timely satisfaction of the needs of the national economy and the population for transportation, acceleration of freight shipments and passenger travel.

It is anticipated that the freight turnover of all forms of transport will be increased by approximately 30 percent and the passenger turnover of common carrier transport by 23 percent.

A great significance is given here to common carrier motor transport. In particular, there is a call for "an increase of approximately 42 percent in the freight turnover of motor transport, preferential development of common carrier motor transport and accomplishment of a 45 percent increase in its freight turnover and a 28 percent growth in the passenger turnover of motor transport".[1]

Further concentration of motor transport facilities into large-scale motor transport enterprises will be further implemented in the Tenth Five-Year Plan. Centralized freight shipment by common carrier transport will be expanded, the operating time of trucks during a 24 hour period will be increased and there will be a further extension of intercity motor transportation.

A significant place will be assigned to common carrier motor transport of the Russian Federation in accomplishing the goals set by the 25th CPSU Congress.

1. "Osnovnye napravleniya razvitiya narodnogo khozyaystva SSSR na 1976-1980 gody" /Basic Directions for Development of the USSR National Economy in 1976-1980/, Moscow, Politizdat, 1976, p 61.

The increase in the volume of shipments in the RSFSR Ministry of Motor Transport system is being achieved by means of growth in the fleet of transport equipment, development and technical reequipping of the enterprise production base and improvement of the forms and methods of management based on the use of computer equipment and ASU's.

Having available centralized materials and financial resources, the sector has the full capability for extensive use of economic and mathematical methods and computers in organizing optimum management and planning of the work of its subsectors including problems of long-term development and the disposition and specialization of the fleet to conform with the requirements of the national economy.

Although the individual measures taken up to now for improving these or other aspects of the operation of the system's control equipment have yielded a certain benefit, they have been unable to solve all of the problems of eliminating the deficiencies in planning and management. The use of economic and material methods and computers for solving local problems of management and planning is not able to produce the same effect as a systems approach to improving sector management.

A systems approach to using economic and material methods and computers predetermines the complete solution of the problems of improving management including the development of a methodology for optimum planning of freight shipment for the national economy and of passenger transportation, the development of motor transport enterprises and their production base, the improvement of the sector's economic mechanism, the production of a more efficient organizational structure for management and the technical equipping and comprehensive preparation of the plant and personnel for work under ASU conditions.

Among the many management problems, the problem of improving the technical and economic information system has a particular urgency. Even now more than 100,000 people are engaged in processing information in the area of sector management. In the process they spend nearly half of the time on the simplest technical operations. The growing complexity and scale of production are causing an uninterrupted growth in the amount of information processed which is necessary for carrying out the process of controlling production while at the same time there is an increase in demands for quality in the information and speed in its transmission through the entire hierarchy of sector management.

For this reason it is pointed out in "Basic Directions for Development of the USSR National Economy in 1976-1980" that there is a need for carrying out further development and increasing the efficiency of ASU's and computer centers and subsequently combining them into a statewide system for collecting and processing accounting, planning and management information.

Stressing the importance of continued improvement of the process of controlling common carrier transport, which includes motor vehicle transport, it discusses "expanding the adoption by transport of equipment for automation, remote control and automated control systems for shipping and industrial processes".

Successful accomplishment of the tasks at hand requires the solution of a number of basic problems: the choice of the most efficient directions for ASU production and development, the establishment of a concentration of computer facilities, the determination of more efficient methods for increasing the effectiveness of computer equipment use and the development of unified principles and a general methodology for planning, the work record of the computer centers and so on.

In this connection, during the development of the ASU for Motor Transport some of the relationships existing between the performance of assumed control tasks and the characteristics of technical and economic information flows were studied.

Analysis of the information and of the equipment and methods for processing it which make up the structure of sector control has made it possible to conclude that the system for motor transport control has substantial defects. With them must be grouped mainly time lag and prolonged periods for information processing, divergence and incomparability of the different forms of information (planning, accounting, statistical and so on), deterioration, mutilation and loss of information in individual control units, overloading of control equipment with different information, parallelism in processing one and the same information in different control units, the lack of a unified form of documentation adapted to automatic data processing conditions, the lack of efficient means of monitoring the validity of information and the impossibility of effective provision by the data of an analysis of industrial and economic work for interested departments and bureaus of the ministry.

Inadequate correlation of current and future shipment plans with supplies and equipment as well as insufficient flexibility of management have not permitted active reorganization and guidance of the work of enterprises and organizations toward accomplishing the goal that has been set with allowance made for changing circumstances. The result has been unproductive idle time, inefficient use of motor transport and an increase in the deterioration of rolling stock.

The indicated deficiencies constitute an objective basis for the efficient use of new planning, organizational and management methods in motor transport based on the extensive use of modern data acquisition, processing, storage and output equipment. For this reason, in accomplishing the tasks of improving the transportation process, improving service of the national economy and the population through freight and passenger transportation and further improving the use of rolling stock for motor transport, one of the leading places is assigned to the automated control system being developed within the framework of the RSFSR Ministry of Motor Transport (ASU--Motor Transport) which encompasses all management levels.

The efficiency of using computers in motor transport lies mainly in the improvement of the shipping process, reduction of unproductive idle time of motor vehicles, improvement in their mileage and increase in labor productivity including that of management.

Accumulated experience in the development and operation of ASU's and computer centers in RSFSR common carrier motor transport shows that solving all of the control problems of motor transport within the scope of the development of a single system is practically impossible due to its extreme complexity. The trend which includes developing ASU's for the individual units of a sector such as the central staff of the ministry, the transportation administrations and the motor vehicle repair plants and associations is the best solution. In addition ASU's are being developed for industrial processes and automated dispatcher control systems for buses and taxis (ASDU-A and ASDU-T). In the future they will be an integral part of the Statewide Automated Ayatem for Data Collection and Processing for Accounting, Planning and Management of the National Economy (OGAS).

As a result of the operation of the branch automated control system, existing forms of motor transport management will be regulated, efficiency in obtaining and processing different data will be ensured, underutilized material and labor resources will be revealed and the rhythm of motor transport operation will be improved.

This study is devoted to consideration of the problems of development and operation of a branch automated control system for common carrier motor transport.

[Excerpts]

For the past 10-15 years a vigorous network of computer centers numbering more than 3000 on January 1, 1975 has already been developed and in operation and continues to grow steadily.

It is anticipated that 200 computer centers for the autonomous republics, krays, oblasts and a number of large cities will be developed within the framework of development of the OGAS technical base and the State Network of Computer Centers (GSVTs) along with approximately 25,000 multiple- and single-user computer centers for enterprises and organizations of the country's national economy.

In the RSFSR Ministry of Transport system more than two dozen multiple-user computing and data processing centers are already in operation with a pool of computers numbering 70 units and 63 computer facilities with a pool of more than 6000 computers. During the Tenth Five-Year Plan it has again been proposed to develop approximately two dozen more multiple-user computing and data processing centers and 15 computer facilities, to put into operation 120 computers and around 10,000 keyboard calculators. The selection of the most advanced technical equipment for data acquisition and processing is anticipated for organizing new and reequipping existing computer facilities.

For the characteristics of the "Data Processing" sector, in addition to the number of workers and the rate of production growth, it would be adviseable to use such a criterion as the increase in production machinery and capital investments which make it possible to evaluate the sector's progress. Thus, according to accounting data the average annual number of workers in data processing enterprises in the country at the beginning of 1976 stood at 0.6 million people (in the RSFSR Ministry of Motor Transport--around 4500 people).

During the Tenth Five-Year Plan the RSFSR Ministry of Motor Transport spent more than 60 million rubles for capital investment on the development and adoption of automated control systems and computers with a period for investment recovery of up to three years. The volume of expenditures on ASU and computer center development in the Tenth Five-Year Plan is projected to increase by almost 1.5 times.

It must be emphasized that the average daily load of the computers in the country in 1975 averaged 11 hours instead of the economically necessary 14-18 hours.[2] The average daily load of computers as a whole in the Ministry of Motor Transport in 1975 amounted to 13.9 hours and in the GVTs to more than 18 hours.

2. Program and Mathematical Software for a Branch Automated Control System

Until recently the term "mathematical support" was used extensively for automated control systems and understood to mean a collection of mathematical and logical methods, problem solving programs and software for operating a hardware system.

In the literal sense the term "mathematical support" does not correspond to its own subject matter. It would be more accurate to use the term "program and mathematical support". In foreign practice extensive use is made of the terms "hardware" and "software". The jargon word "zhelezki" [pieces of iron] which exists in the field of designers and engineers corresponds to the first term. The second term means "soft objects" and there is no Russian equivalent. In general the translation of these terms is as "technical equipment" and "methods and procedures for its use".

At the present moment the concepts of program and mathematical software are being adopted by government standards. The first concept is defined as a set of programs for implementing objectives and tasks on ASU's and operating the ASU's hardware system. The second is defined as a set of mathematical methods, models and algorithms for solving problems and processing data by means of the computer hardware in the ASU.

2. D. G. Zhimerin, "Nauchno-tekhnicheskiy progress i upravleniye" (Scientific and Engineering Progress and Management, EKONOMICHESKAYA GAZETA, 14 Apr 1976.

The importance of mathematical software is borne out by the sharp increase in expenditures for its development in comparison with the outlays for the development of hardware (table 4).[3]

Table 4

Share of Expenditures	Years 1956	1960	1964	1968	1972
On Hardware	70	60	50	50	40
On Software	30	40	50	50	60
Total	100	100	100	100	100

The OASU for Motor Transport uses third-generation computers, unified system electronic computers (YeS EVM's) based technically on integrated circuits. In YeS EVM's there is a large main memory, a very diversified assemblage of peripheral units which accomplish the man-machine interface and more extensive capabilities for use than second-generation computers.

Under OASU operating conditions when a large group of different production and economic tasks of motor transport control are being executed, the role and significance of program and mathematical software are exceptionally great. In figure 7 the combined structure of program and mathematical software of the OASU for Motor Transport is shown.

Included with the general program software is a set of programs, descriptions and instructions intended for automating labor-intensive production stages in program processing and also for organizing and monitoring the computing process on a machine during operation.

Corresponding to the functions and the programs being executed, the entire set of programs which are part of the general program software may be broken down into four groups: system control programs, system processing programs, auxiliary programs and remote control processing programs.

System programs are intended to provide for the efficient functioning and operation of the computer itself. Sets of system programs which allow a sharp increase both in labor productivity and in the productivity of the computer system itself have acquired the designation operating systems.

The parts of system programs which accomplish the coordination and most efficient operation of the computer system units are called control programs. Another part of the operating system incorporates programs to assist the programmer in developing and debugging new programs. They are called processing programs.

3. A. A. Modin, "On the Development of ASU's for Industry and their Economic Basis," in "Metody i praktika opredeleniya effektivnosti kapital'nykh vlozheniy i novoy tekhniki" [Methods and Practice of Determining the Effectiveness of Capital Investments and New Technology], Moscow, Nauka, 1969, p 47.

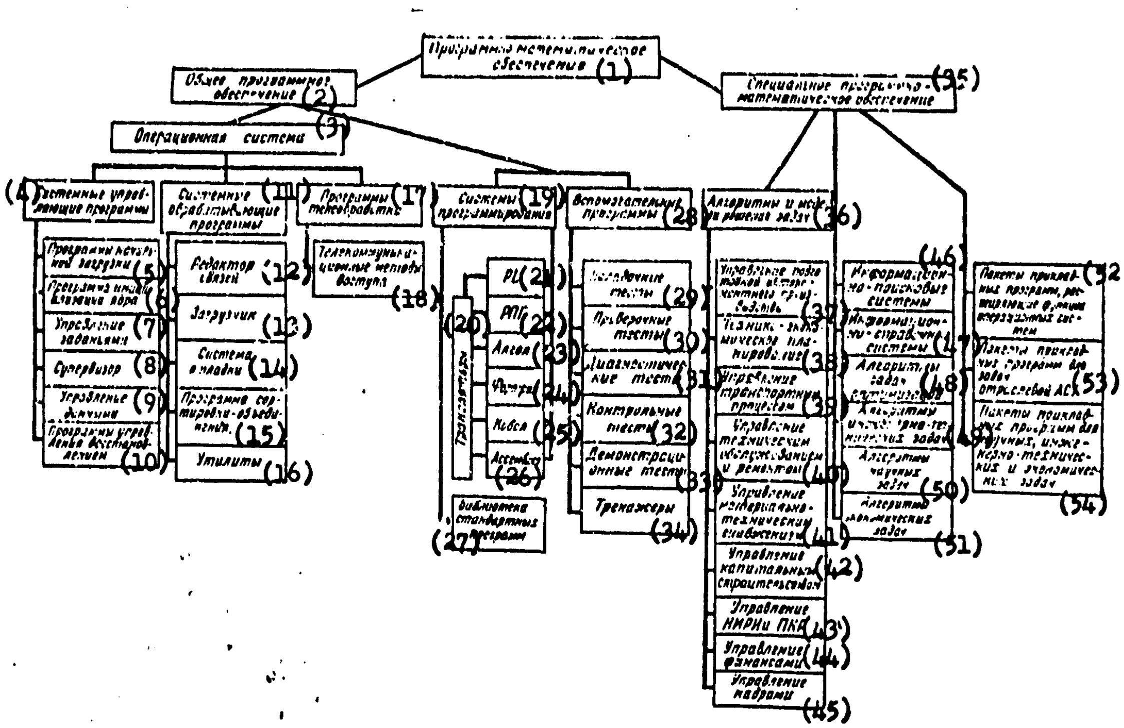

Fig. 7 Program and Mathematical Software System for the OASU for Motor Transport

Key:

1. Program-mathematical software
2. General program software
3. Operating system
4. System control programs
5. Initial loading programs
6. Nucleus initialization program
7. Assignment control
8. Supervisor
9. Data control
10. Restoration control programs
11. System processing programs
12. Communications editor
13. Loader
14. Debugging system
15. Sort/merge program
16. Utilities
17. Remote processing programs
18. Telecommunications access modes
19. Programming systems
20. Translators
21. PL
22. RPG
23. ALGOL
24. FORTRAN
25. COBOL
26. ASSEMBLER
27. Library of standard programs
28. Auxiliary programs
29. Debugging checks
30. Verification checks
31. Diagnostic checks
32. Monitoring checks

Key (cont.)

33. Demonstration tests
34. Simulators
35. Special program-mathematical software
36. Algorithm and problem solving models
37. Control of preparation for the vehicle repair process
38. Technical and economic planning
39. Control of shipping process
40. Control of technical maintenance and repairs
41. Control of materials and equipment supply
42. Control of capital construction
43. Control of scientific reasearch and planning and design work
44. Control of finances
45. Control of personnel
46. Information retrieval systems
47. Information and reference systems
48. Algorithms for optimization problems
49. Algorithms for engineering and technical problems
50. Algorithms for scientific problems
51. Algorithms for economic problems
52. Applied program packages for expanding operating system functions
53. Applied program packages for branch ASU problems
54. Applied program packages for scientific, engineering, technical and economic problems

System programs, by this means, establish the prerequisites for efficient use of the computer system's hardware but are not intended for direct data processing of OASU subsystem problems.

It should be noted that the control programs implement the following functions: planning computing processes, providing a means of external control, organizing dialog with the operator, controlling computing processes, distributing the computer system's resources and controlling the exchange of data between the core and external memories.

The processing programs accomplish translation from high level languages to machine languages, packaging of programs from individual program modules written in various languages, input of external data media and debugging of programs for users.

The auxiliary programs are intended for checking the functioning, debugging and mechanical operation of the computer system units. Checks are intended to reveal the working capacity of individual units and monitoring operations are for comprehensive checking of each system after the annual or semiannual preventive maintenance work has been done.

The need for different users who are OASU for Motor Transport clients to use the computer resources simultaneously has requires making provision for the computer to operate in the time sharing mode. This computer operating mode permits users to have simultaneous access to the computer system directly from their own places of work at a distance from the computer. The data transmission process is carried out by means of telephone, telegraph or special communications channels.

The system operating mode by means of which distant users are linked with the computer by communications channels is called the remote processing mode and is supported by specific programs.

The set of programs which provides for the operation of remote processing systems is called the public telecommunications access mode. The basic applications of the public telecommunications access mode are data acquisition, communications exchanges and data array processing.

Data acquisition and communications exchanges do not require the use of special applied programs and are accomplished by program control of the communications.

During data acquisition remote motor transport enterprises send data to the computer in the form of messages which are accumulated in the computer and then processed. During communications exchanges remote motor transport enterprises relay information to the computer which sends these communications to one or several motor transport enterprises.

Provision is made for processing reference inquiries by means of a communications control program and special programs. The information requested is received by the communications control program and prepared for processing.

The processed information contained in the communications is transferred to a program for communications control for transmission to the appropriate motor transport enterprise.

Programming systems are intended to simplify the work of the programmer and release him from the need to present problems in machine language by the input of a special higher level language. The programming system consists of two component parts: the input language of the programming system and the program which provides the translation from the input language to the machine language.

COBOL, PL, ASSEMBLER and FORTRAN are the primary languages for automating programming during the development of program software for the OASU for Motor Transport.

The program system for technical maintenance is intended for debugging the technical operation of the computer and other hardware in the OASU linked to the computer. The test programs make it possible to detect malfunctions in the computer's hardware, to identify the locations of malfunctions and to make information about the nature of a malfunction available to service personnel. The programs are designed for individual computer units and are based on the assumption that the result of program operation with a faulty unit will differ from the result of output on a unit in good working order. The program operation consists of uninterrupted comparison of the results with those obtained on an operating unit known to be reliable and with discrepancies in the output results in the data print-out which indicate the location of the program in which the discrepancy occurred. The location of a malfunction may be determined by means of this information. If the defect is such that the program as a whole does not operate, the search for malfunctions is carried to the hardware.

The monitoring operations are intended for comprehensive checking of the system's functioning after appropriate preventive maintenance has been done.

The system programs which are part of the general program software are intended to establish conditions for the most efficient operation of the computer system hardware. Implementing direct data processing on actual problems is not one of their functions.

Direct processing of the data problems of OASU subsystems is carried out by means of so-called applied programs directed toward accomplishing tasks of a particular type such as the tasks of the control subsystem for supplies and equipment, the subsystem for planning the shipment of freight and passengers, engineering and technical tasks and so on.

A set of applied programs and methods for solving actual problems and their algorithms constitutes special software for the OASU for common carrier motor transport. The group of programs used for solving a particular category of problems, together with the documentation necessary for its set-up and operation is separated into a package of applied programs. Applied program packages are processed using an OS YeS operating system, are oriented toward solving a comparatively narrow group of problems and have considerable variety. Applied program packages are arbitrarily subdivided into three groups.

Applied program packages which extend the capabilities of the operating system provide for the operation of YeS EVM's of different configurations. Among them are packages which carry out the real-time operation of the system, remote package processing, dialog systems and the operation of conventional multimachine systems. Applied program packages for solving scientific, engineering and other problems provide for different uses of displays, plotters, matrix processing, different types of simulation and so on.

Applied program packages for OASU's should include combined systems for processing the data base, an information retrieval system and the specific sector problems.

The use of microprogram control is a feature of the internal structure of the YeS computer. It is based on the principle that each instruction, the smallest indivisible part of the program to the programmer, is interpreted during technical implementation in the computer by a microprogram which is a sequence of microcommands. The operations executed by microcommands are extremely simple and their number is quite small. As a rule, microoperations are carried out on individual bytes and so, for instance, a microprogram for adding two floating point numbers is interpreted in the form of a series of microoperations on bytes composed of the addends.

Extensive experience in developing and operating ASU's has shown that a computer system may achieve efficiency in obtaining the results of data processing by users and the most complete loading of all hardware only when the available resources are used by several users at the same time, that is with the use of the shared-time operating mode.

Remote package processing is the operating mode for a remote processing system which is most acceptable for the branch ASU for Motor Transport and at the same time is sufficiently simple. With this mode the data coming in from distant users' stations is placed in order and processed by means of programs found in the libraries located in the external storage media. The processing results will be transmitted to the users' station of the addressee.

The request-response mode of computer operation is called for when very simple problems are being solved which require efficiency in obtaining the results of the processing. The information-reference system (SIS) of the ministry staff is an example of the use of a request-response mode in a branch ASU.

In the future there are plans to use the dialog mode of computer operation in the OASU for Motor Transport not only during designing and debugging but also during the solution of very complicated problems of the OASU for Motor Transport subsystem "Operational Control".

With the automation of production process control in motor transport enterprises and motor vehicle repair plants, the important criteria of computer use are the system response time and the number of users, for example in motor transport control systems for bus (ASDU-A) and taxi (ASDU-T) transportation.

The programs used in these ASU's are not very complex. The demands made on the system's response time are exceptionally severe and the number of control objects (buses or cars and taxis) is calculated in the hundreds and thousands. Such systems in which the system's response time is a determining factor are called real-time operating systems.

Efficiency in data processing and the capability of servicing a considerable number of users are achieved due to the relative simplicity and the small number of operating programs.

It should be noted that one of the ways of reducing expenditures on ASU for Motor Transport development which is deserving of serious attention is standardization of program software since expenses for developing programming aids make up a significant share of the overall ASU development costs.

A typical program consists of the program nucleus, the procedures used, the data descriptions, the information tables and the instruction parameters.

The program nucleus is fundamentally a program containing statements for accessing the standard procedures in use. The nucleus is programmed according to the rules for programming standard programs and is included in the library of standard programs from which it is read-out with a supervisory program.

The procedures are part of the library of standard subprograms. Use of and access to subprograms is governed by rules adopted for designing programs in mathematical computer software.

Data descriptions are information about the composition, structure and contents of the arrays being processed. In accordance with the descriptions the program chooses and processes a routine data item in line with its characteristics.

Program operating conditions as applied to actual situations are recorded in the information tables.

Instruction parameters are elements external to the program. They are inserted in it prior to start-up. Using the instruction parameters, the program computes the needed information tables and array descriptions, accesses the arrays and then solves the problem.

3. Data Support of a Branch Automated Control System

Data support of a branch ASU is understood to mean a set of forms for submitting data, document turnover, coding systems, organization methods, storage and monitoring of data arrays which provide an interdependent solution for all sets of problems included in the OASU for Motor Transport.

Development of the OASU data base is a labor-consumptive process and involves solving the following problems: precise definition of the problems solved in the OASU, determining their conformity to the system's function and identifying their data interface, determining the entry sources of the data, the means of its transmission and the rate of presentation to the State Computer Center, organizing data acquisition, systematization, storage and retrieval, developing a coding system and methods of formulating indices based on a unified system for classifying and coding them. developing methods for organizing documents, constructing an efficient system for document turnover, selecting particular types of data media and developing the structure of the data recording medium, organizing unified methods for setting up data arrays, determining their composition, interfaces, storage and retrieval in the basis of computer use and determining means of monitoring the data.

It is customary to subdivide data support into the internal and the external.

In external data support it is necessary to identify items by means of listed references, classifiers and dictionaries of items which allow one item to be distinguished from another. Using appropriate units of measurement descriptions of the properties of an item are produced. Numerical data is represented in conventional form and an acceptable set of words is established for values in text form. Data representation consists of the loading of documents which satisfy the requirements for their computer processing.

In internal data support the conversion of external data representation to machine form (during data input to the computer) and back to external form (during output from the computer) occurs.

Using available data support for the OASU it is expected in the future to develop a data bank which will be a centralized automated system for accumulation, storage, retrieval and transmission of data (planning, normative, accounting and reference) necessary for solving the problems of all the operational subsystems of branch automated control systems.

Data classification and coding is an important part of data support which makes it possible for automated systems to correlate the data of the OASU for Motor Transport both for higher and for lower control units and, in addition, establishes a single form for data translation to the internal machine language.

All of the information in the RSFSR OASU's for Motor Transport is classified according to the following characteristics: relationship to the State Computer Center, stability and use in control processes.

Regarding relationship to the State Computer Center, data is subdivided into input entered from different external sources, intermediate obtained as a result of processing in the computer and used for solving problems of a specific subsystem or several subsystems and output produced by subdivisions of the ministry staff and by republic associations.

As regards stability, the data is divided into constant, relatively constant and variable.

With constant data is grouped data which is not changed over a period of time (indices of specific weight of different types of fuel and materials, factors for converting from one set of units of measurement to another, tables of reciprocals).

With relatively constant data is classified data which is left unchanged for a relatively long but finite period of time after which it is updated.

With variable data is grouped data whose value is brought up to date systematically.

Depending on its use in control processes all data is subdivided into planning, operating, accounting, normative and reference.

With planning data is included the planning data for a specific period on all occupational indices of the ministry derived from the planning and economic management of the ministry and the planning departments of republic associations.

With operating data is grouped data which must be collected and processed with particular speed and which characterizes the working conditions of ministry subsectors over a specific period of time (a day, 5 days, 10 days, a month) and, as a rule, arrives via communications channels.

Accounting information characterizes the actual working conditions of ministry subsectors over a specific per. d of time and is sent by mail in accounting forms established by the U. .R Ministry of Finance, the USSR Central Statistical Administration, USSR Gosplan, USSR Gosbank and others. This information includes data on the execution of the plan of operations in motor transport, capital construction, materials and equipment supply, labor and so on.

Norms developed and approved for occupational indices of a ministry and its subsectors are classified with normative data.

Reference data encompasses data having a relatively constant nature: dictionaries, reference books, constants and so on. A dictionary consists of concise lists of separate classifier items and is used for printing the texts on output forms. References and constants are referred to in solving the system's problems.

The development of the OASU for Motor Transport has required arranging the economic data and coding the technical and economic indices used in the OASU for Motor Transport.

The structure of a technical and economic index consists of an index-name and a subscript.

The index-name is a term (word), phrase or number-coded symbol which characterizes the economic contents and meaning of an index and which gives it a qualitative definition.

The subscript is the quantitative value of the index (a number) obtained as a result of compiling the data of real units of weight, measurement and computation. In the processing operation the index-names are the object of logical and the subscripts of computing operations. A set of index-names without subscripts is not an index. Thus, a qualitative and a quantitative value correspond to each technical and economic index. Some of the qualitative values of the index characterize its basic economic significance and others amplify this significance to an extent and are supplementary index-names.

The structure of technical and economic index P may be presented by the formula

$$P \longrightarrow (S, Q, X)$$

where S is the main index-names of the index;
Q is the supplementary index-names of the index and
X is the quantitative value of the index (the subscript).

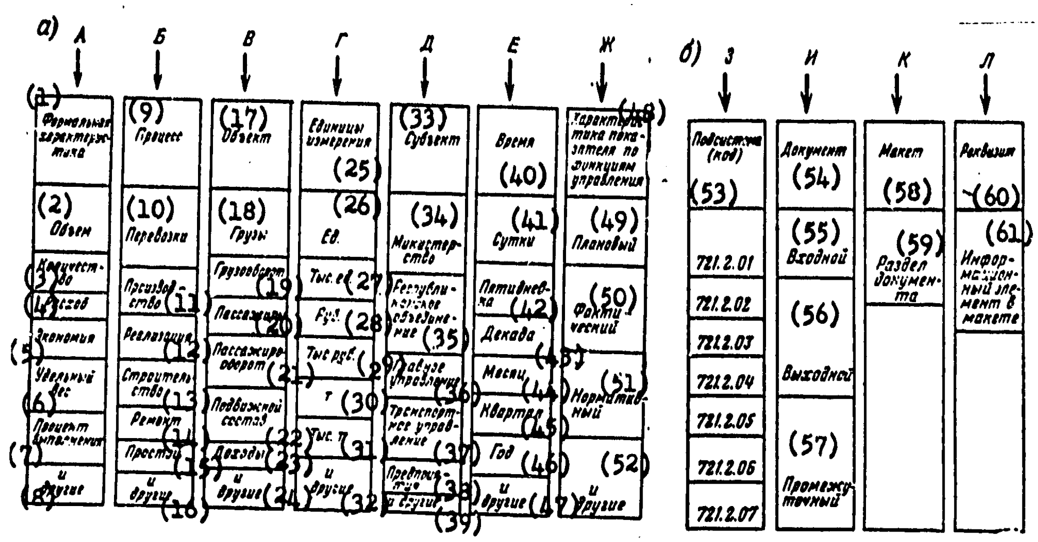

Fig. 8 Principles for Classification and Coding of Technical and Economic Indices of the OASU for Motor Transport

a) according to economic characteristics
b) according to data processing characteristics

Key:

1. Formal characteristics
2. Volume
3. Number
4. Cost
5. Savings
6. Relative importance
7. Percent of implementation
8. Others
9. Process
10. Shipments
11. Production
12. Implementation
13. Construction
14. Repairs
15. Idle time
16. Others
17. Object
18. Freight
19. Freight turnover
20. Passengers
21. Passenger turnover
22. Rolling stock
23. Profits
24. Others
25. Units of measurement
26. Unit
27. Thousand units
28. Rubles
29. Thousand rubles
30. Tons
31. Thousand tons
32. Others

Key: (cont.)

33. Subject
34. Ministry
35. Republic association
36. Main administration
37. Transportation management
38. Enterprises
39. Others
40. Time
41. Day
42. Five days
43. Ten days
44. Month
45. Quarter
46. Year
47. Others
48. Characteristics of the index
49. Planning
50. Factual
51. Production norm
52. Others
53. Subsystem (code)
54. Document
55. Input
56. Output
57. Intermediate
58. Layout
59. Section of the document
60. Requisite
61. Information item in layout

At the basis of classification of technical and economic indices lies a multidimensional principle which includes the attribution of two characteristics to each index: the economic and the data processing. The principle of classification is shown in figure 8.

The RSFSR OASU for Motor Transport is considered to be a component part of the Statewide Automated System for Control of the National Economy (OGAS). In this connection the OASU for Motor Transport must be interconnected with the analog systems of USSR Gosplan, RSFSR Gosplan, the USSR Central Statistical Administration, the ASU's of ministries and departments of sectors of industry and also with ASU's for transport and territorial transport control of a sector of industry (ASU-TU).

The data processing interface of the problems of OASU for Motor Transport with the automated systems of various levels of management is accomplished by the development of a unified system of classification and coding of data, the creation of a standardized system of documentation and the efficient distribution of the information flow between the management levels.

The data processing interface of the OASU for Motor Transport with the higher level control system OGAS is accomplished by a unified system of classification and coding through all-union classifiers of technical and economic data and with a lower level system such as ASU-TU through system-wide and special classifiers.

Rational construction and efficiency of OASU operation is determined to a considerable extent by the internal data support, such as the organization and structures of data arrays (files). This is explained by the fact that large volumes of economic data require suitable organization of their data arrays.

Academician V. M. Glushkov considers the basic systems and engineering problem in ASU design to be a problem of optimum construction, efficient processing and comprehensive use of the data arrays in the system, since it is precisely the data arrays stored and processed in the ASU which link all of the system units and the problems being solved in the data processing plan. The organization of data arrays is called on to carry out the exchange of data between the external files and the main memory, to accomplish efficient access to the data and to correct it.

On the organization and structure of the data arrays depend the reliability and efficiency of the results produced by the system and consequently the effectiveness of control as a whole.

All of the data used during problem solving in the OASU is combined into data arrays which are a set of data recorded on specific recording media and organized in a strictly regulated order. As a rule, arrays are similar in their significance and function. Most often the arrays are composed of symbols (word blocks) which are a logically complete group of sequentially arranged numbers or alphanumerical characters which describe a particular item.

The individual numbers or alphanumerical characters entered in the record are the elements of the record. Owing to the limitations of the main memory the data stored in the external memory is drawn from specified portions known as information blocks. On magnetic tape (ML) one block represents one zone and may have different contents. On punchcards it corresponds to a card and on punched tape to one character.

Proceeding from the composition and structure of the data support and its basic requirements it may be claimed that the main problem of OASU data support is the problem of in-line processing of data arrays, that is rapid retrieval and output of the needed data.

The task at hand is implemented most efficiently by developing an automated data bank in the branch ASU (ABD OASU). The automated data bank should be a self-contained subsystem in the processing part of the OASU and should carry out centralized accumulation, storage, updating, retrieval and output of any stored information by automated means.

Professor S. I. Volkov understands a data bank to be an organizational and technical system which allows storing large arrays of data in strictly systematized order and makes possible random access and output of any stored data in the form of individual data items or the combination of a set of data obtained by automated means for output of needed information for actual control purposes to users of very diverse designation.

The need for developing a unified data base which provides for source data actual problems of all the functional subsystems of OASU for Motor Transport, the exceptionally large volume of data subject to storage, updating and processing, the limited capability for storage of large volumes of data in the system's individual control units, the requirement of different control departments for acquiring one and the same data, the necessity of integrating data processing procedures and the capabilities of third generation computers have predetermined the development of an automated data bank in the branch ASU for Motor Transport.

At the basis of further development of the OASU for Motor Transport lie conceptual considerations which establish the principles of extensive integration of individual ASU's developed previously in the sector and which predetermine the construction of the technical base of data processing enterprises on the basis of an automated data bank system.

In this case data processing enterprises will have to be collective-use computer centers using multimachine computer systems. A most important condition for the operation of an automated data bank is the fulfillment of a number of requirements.

The first requirement consists of registering the index once and making repeated use of it for solving the maximum number of different problems.

After an index is entered into the system it can be used in all problems of functional OASU subsystems where it is applicable. Strict regulation of the storage, updating, transmission and use of any index makes it possible to eliminate duplication of information which occurs naturally during local problem solving. In addition, precise fulfillment of this requirement calls for centralizing previously segregated indices in the data bank and satisfying the needs of different control units for the required data.

The second requirement lies in the fact that a minimum of source indices must be stored in the data bank which can be used to obtain by mathematical means any required number of secondary (derived) indices unless the case is such that repeated acquisition of derived indices requires larger expenditures than their storage and retrieval in an automated data bank.

The third requirement is provision of the capability of simultaneous access by several users to the automated data bank.

Data in the ABD's data collection will be kept current by having the newest information available at all times, the degree of newness to be determined by the degree of its usefulness to the user.

In addition, there must be satisfaction of requirements for the capability of using data from various arrays in different combinations, the capability of reorganizing data arrays without changing the maintenance programs and the capability of man-machine interfacing. The complexity of developing an automated data bank is responsible for its configuration which is a series of diverse elements: a set of technical and economic data arrays, of methods and means for organizing these arrays, of methods for accumulating, updating and retrieving the data, of forms and means for its representation and a system of special program software which automates the hardware operation on the data.

For this reason efficient ABD operation in a branch ASU may be achieved when there is the best combination of structural elements and operation execution procedures as applied to the actual requirements of the specific nature of the problems being solved.

Standardization of the documentation which allows expenditures to be reduced to the minimum for composing, collecting, processing and correcting the data contained in these documents is an indispensible condition for normal operation of the OASU data bank.

Automated data banks whose development is projected for the Tenth Five-Year Plan in data processing enterprises of common carrier motor transport must accomplish: rapid retrieval of data during the solution of ASU for Motor Transport problems, minimization of machine time use for correcting and updating data, elimination of data duplication in the arrays which constitute the data base, preservation of the integrity of index values during their use in solving different problems, a high degree of reliability in operation and flexibility.

Thus, the development of an automated data bank for the OASU for Motor Transport is one of the main directions for further development of a second-phase OASU for common carrier motor transport.

4. Hardware for a Branch Automated Control System

An OASU is based on the use of advanced computer equipment which makes it possible to carry out timely and high-performance data collection, processing and output to control departments. The assemblage of units which implement the processes of data collection, transmission, storage and display is the hardware system (KTC).

At present, third generation YeS EVM's (YeS EVM-1033) have come to replace the second generation computers (Ural-14D) used in the OASU.

The defining principle which characterizes YeS EVM's is a microelement component base, integrated circuits which make it possible to achieve higher operational and technical-economic indices in comparison with first generation (tube-type) and second generation (transistorized) computers.

YeS EVM models are program-compatible. This means that a program designed to accomplish an actual task may be run on any model of the system.

On the basis of program compatibility, a unified programming system is being developed which provides for the control of all hardware, for automation of programming and for accumulation of a library of problem-oriented program packages.

Parallel processing is the basic operating mode of YeS EVM's in which several units of a single machine or several interfacing machines as well as a considerable number of territorially remote users and subscribers operate simultaneously with problems related to one degree or another.

Since the Unified System of Electronic Computers [YeS EVM] includes high-performance computers and the adopted logic structure takes into account the requirements for construction of large collective-use computer systems, a YeS EVM satisfies the requirements of the branch ASU for Motor Transport both from the point of view of hardware provision and also from the point of view of efficient service to remote users over a widespread area.

The list of external and peripheral YeS EVM units includes 39 types of external memories, 32 types of I/O units, 12 types of units for direct communication between the operator and computer, 44 types of remote data processing units and 13 types of data preparation units.

Equipment to interface the computer with communications channels is needed to implement the principles incorporated in the OASU for Motor Transport and characteristic of OASU's as a potential system for collective-use of computers. The capability of transmission both from the computer and to the computer on communications channels with several remote users working with the computer simultaneously is the idea of remote processing. Remote processing is a method of data control in which the data processing system, the collection of hardware and software for processing, uses the facilities of communications equipment.

In the future there are plans to use a complete set of data processing equipment oriented toward collective computer use by remote users in the OASU for Motor Transport.

In view of the considerable territorial isolation of the control objects which are the sources for originating information in the OASU for Motor Transport and the need for centralized processing of this information in the Main Computer Center for the sake of accomplishing operation control functions by the staff of the RSFSR Ministry of Motor Transport, the subject of data collection and transmission on communications channels with its reliability maintained is assuming a particular significance.

It is planned to equip all multiple-user data processing and computing centers of the ASU for Motor Transport with third generation computers which will be interconnected as well as linked with the Main Computer Center by communications channels.

Such a multimachine system will operate through the use of YeS EVM data transmission equipment (APD).

Initial data processing consists of collecting and transferring data from a source document to a data recording device, that is registering a disordered data array in a suitable recording medium, arranging the received data according to defined symbols and executing logical and mathematical operations on the created data arrays.

In the future there are plans to use the SPD-9000 automated data preparation system which is intended for setting up source data on magnetic tape and has the capability of executing the operations of sorting, merging, editing and checking data for validity.

The SPD-9000 system consists of a minicomputer with memories on magnetic tape and disks, a dispatcher terminal, several operator terminals (up to 32) and several additional units.

The SPD-9000 system is constructed on the basis of a third generation computer, the ASVT M-6000, and includes 8 to 32 keyboard terminals for data input. The system permits a sharp increase in productivity and reliability of data set-up on recording media and eliminates from the production process traditional data preparation units for punchcards and punched tape. Magnetic tape is the principal recording medium.

The operating functions of the SPD-9000 are as follows. Operators enter the data in documents from keyboard terminals into a processor in which it is processed by special programs and then recorded on magnetic disks. Data for solving specific problems which is stored on a disk may be transcribed on magnetic tape by a supervisory instruction for subsequent use in a computer. In addition, the SPD-9000 system may be used for initial processing of source data and control of data set-up operations.

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CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

ASPECTS OF THE DEVELOPMENT OF ASUP'S

Novosibirsk AVTOMATIZIROVANNYYE SISTEMY UPRAVLENIYA I IKH ADAPTATISYA (Automated Control Systems and Adaptations of Them) in Russian 1976 signed to press 23 May 1977 pp 88-105

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[Text] Chapter V. Practical Aspects of the Development of Automated Enterprise Control Systems

Beginning in 1961, the operations with respect to the application of computers in control were basically performed along the line of solving individual problems. A number of programs have been developed which implement the methods of linear programming basically for optimization of the producton planning, hauling, material and technical supply, and so on.

However, the gathering of the initial data was at the same time complicated. They were not highly reliable, the operativeness of obtaining them was very low, there was no centralization in the information systems, which in practice reduced to zero the results of implementing the optimization methods.

Work has been started on solving accounting problems such as accounting for labor and the calculation of wages, the personnel accounting, the accounting for movement of material values in the warehouses. After obtaining the first results on the basis of the developed programs, it became obvious that it became necessary to create a united information base of the enterprises. This base must, on the one hand, completely describe all of the primary production resources in order to take them into account, plan and control them. On the other hand, the problem of the organization of this information base was converted to a special area of research which pursued the goal of creating a united methodology, special software and organizational equipment taking into account the specific characteristics of the various enterprises. In addition, the information base itself must correspond to the requirements of saving memory in the computer, simplicity and speed of access to the information elements, the operativeness of updating the data and high reliability of the information.

These prerequisites also provide the basis for the construction principles of the automated control systems.

§1. Barnaul Automated Control System

Development Steps

The work on creating automated control systems in the Siberian division of the USSR Academy of Sciences in 1964 was concentrated on the development of the methods of controlling an industrial enterprise by computer. According to the proposals of former director of the Barnaul Radio Plant B. V. Doktorov, this plant became the base for introducing an experimental version of the automated control system in 1967. Then, after organization of the computer center at the plant, the plant collective set to work on developing the basic version of the automated enterprise control system which, by suggestion of the scientists at the Siberian division, was called the Barnaul automated control system.

The Barnaul automated control system was built as a result of close creative cooperation of the scientists of the scientific division of the USSR Academy of Sciences and the engineering and technical workers of the Barnaul Radio Plant. In December 1971, it was put into operation. The Siberian division transferred all of the rights to further extension of this system to the other enterprises to the Barnaul Radio Plant. At the present time the Barnaul automated control system is in operation or being introduced at more than 150 enterprises of the country.

In 1973 an association of users of the Barnaul automated control system was created, the basic purpose of which was the plan development of this system by the efforts of the users and the development of the strategy of adaptation of the system to the third-generation computers.

Basic Organization Principles

A number of principles have been advanced which serve as the procedural basis for creating the Barnaul automated control system:

The shop-by-shop structure of the processing of the production and material and technical information;

The creation of unified data files considering the shop structure of the enterprise;

The module principle of organizing the software with coordination to the system;

The possibility of continuous development of the system;

The introduction of rigid monitoring of the operation of the automated control system into the system for which errors or nonoperativeness of the operation of the system create disadvantageous conditions for certain categories of enterprise workers, the principle permits the system to maintain itself on a high operating level without input from the directors.

These principles were implemented in practice in the Barnaul system, and conditions were created for good operation of it at the enterprises of various profiles.

The Barnaul system provides for servicing the enterprises with the information by calculating the resources for the plan, production accounting, with respect to all types of settlements, calculation of wages and materials, and operative-production planning. In addition, on the basis of the PERT methods, the system provides for operation planning when putting new products into production. The control of the material and technical supply was decided on the production level and with respect to the material and technical supply administration at the warehouses. In the Barnaul automated control system the problems of personnel management, labor accounting and calculation of wages with respect to all categories and types of payments are solved as autonomous modules entering into the system.

The information base of the automated control system includes models of linear programming, dynamic programming, operations research to find extrema to solve the problems of operative-production and annual planning.

Brief Description of the Barnaul Automated Control System

The primary documentation of the Barnaul automated control -ystem can be broken down into two groups.

The first includes the documents on the basis of which the permanently stored information files are formulated. These include the process-normative chart which is in the form of a list of all normative indexes for each of the objects of labor, a number of the all-plant documents--the nomenclature and price list for materials, the overlap factors and other general plant reference documents.

The second group includes the current information documents which either come daily or once every calculated period or randomly on occurrence. The basic document carrying the current information is the shift report of the section which is filled out every shift in each section. The current information documents include the "normative variations," "the table of failures per operation," "the variation in personal accounts," the documents to correct the plan and the budget data which are filled out as the information arises.

The set of permanently stored information files (using magnetic tapes), the flows of current information and the software are combined by the operation system into an integrated data processing system which is the information base of the enterprise.

As a result of operation of the Barnaul automated control system, a mapping of the course of production, reserves, the process and organization is created in the computer memory.

For operative production control, the analysis of the course of the production process, accounting, mutual calculations between services, calculations with industrial workers and estimates of the activity of the subdivisions the computer puts out the required documents which go to the various plant services daily, monthly and quarterly. A number of documents can be printed out on request.

Development of the Barnaul Automated Control System

In addition to solving the basic control problems, the Barnaul automated control system has created an information base for the enterprise which make it possible without significant expenditures to include in it the programs that implement the optimization techniques, the methods of statistical analysis, simulation models, and so on.

As some examples let us consider the operations with respect to systems development.

The Barnaul Radio Plant, using methods of linear and dynamic programming, has included a number of standard programs in the systems software, and it has solved the problem of optimizing the annual enterprise plan in the automatic mode. As a result of improving the enterprise plan by the optimization procedures, the following has occurred: from the use of optimization the enterprise has increased the production volume by 6 to 8 percent in 1974 and 1975. At the same plant operations have been completed with respect to inclusion of a set of optimal operative-production planning programs in the data processing system. These operations are being performed jointly with the institute of economics and organization of industrial production of the Siberian Department of the USSR Academy of Sciences under the direction of N. B. Mironosetskiy. The basis for this complex is the differentiated planning system for which its own optimization method with its restrictions and optimization criteria is implemented for various groups of parts.

After the Barnaul Radio Plant, the Altay Tractor Electrical Equipment Plant, which was one of the first to introduce the Barnaul system, performed a set of labor and wage classification operations, it organized incentive and competition programs in order to improve the productivity of labor among the workers.

The set of programs was written for complete labor accounting and all types of wage calculations.

Under these conditions, the operations with respect to the personal plans for the workers for labor incentive and competition acquired defined significance. The AZTE [Altay Tractor Electrical Equipment Plant] (a plant of communist labor) increased its productivity of labor by 17.5 percent throughout the entire enterprise in 1974, and its experience has been taken under review by the state committee on labor and wages and the Secretariat of the All-Union Central Trade Union Council for adoption at the other enterprises of the country. The experience of the Altay Tractor Electrical

Equipment Plant also demonstrated that the automated Barnaul system is capable of being adapted to the mass nature of production.

The Neptun Odessa Plant, which makes use of the peculiarities of the Barnaul automated control system, has performed a number of enterprises with respect to improving the control structure under the conditions of the automated control systems. Thus, for example, the control services, with the exception of line management, have been taken out of the basic production shops.

Some of the enterprises are using the methods of statistical diagnostics and forecasting in the Barnaul automated control system, which permits the creation of integral quality control subsystems.

Under the conditions of the operating automated control system, there is a possibility of organizing the preventive control on a higher level. The computer programs implementing the preventive control making use of the operative data from the enterprise subdivisions, accumulate statistical data that are required when solving technical-economic planning and other problems.

The programs for operative control of the production process section to obtain production of a given quality have been written. The output production quality is predetermined by certain input parameters. Accordingly, the problem arises of establishing goals, that is, the search for the set of values of the input parameters which under normal process conditions will ensure that a product of the required quality will be obtained. The simulation on a computer using statistical data that are the results of measuring the process parameters under normal operating conditions over a sufficiently long time interval permits us to obtain the required estimates which are close to optimal. Furthermore, the problem of minimizing the deviation of the input parameters from the target values is solved operatively considering the restrictions existing at the given point in time on the raw material resources, the equipment load, and so on. Sometimes the calculated values of the input parameters do not provide for obtaining a product of the required quality, which is established by the computer using the forecasting algorithms. In this case, additional measures are taken or, if possible, certain restrictions on the variables are removed, and the calculation is repeated.

Introduction.

The transition to automated control systems is not the introduction of new equipment. The automated control system touches on the interests of the entire collective of the enterprise, beginning with the plant director and ending with the workers. The entire collective participates directly in the automated control system. The automated control system requires that the collective observe defined instructions, changes in control style, and certain new forms of interrelations.

The introduction of the Barnaul automated control system at the Barnaul Radio Plant and then at other enterprises took place comparatively easily, in spite of the fact that the system was one of the first in the country. The following measures and peculiarities of the system have promoted this.

The plant developers have participated directly in the development, planning, design and introduction of the system. Many of the algorithms and especially the solutions taking into account the psychological factor were proposed by them, and as a result of their proposals, enormous experience in the practical production management has come about.

The Barnaul system was constructed by the principle of the hierarchical structure of the enterprise. The shop-by-shop principle of data storage and processing has made it possible to test the system not directly at the entire enterprise, but only in one shop, after which the system was introduced successively by the planned procedure with respect to all of the shops, and this is how it was brought about in all of the enterprises.

All of the primary information is connected in one way or another with the earnings of the plant workers. Special programs have been written which ensure convenient form and fast output of information on the earnings of the workers which creates an automatic control system that self-supports the conditions on a high operating level and ensures reliability of the primary data.

Inasmuch as the Barnaul automated control system was constructed by the principle of the data processing system and permits output of in practice any information on the course of production, at first provision was made for output documents traditionally required by the administrative personnel. Then the need for these documents was eliminated, and new ones bearing more valuable information appeared. This successive modification of the documents carrying the traditions and using the customary forms of operation aroused no objections on the part of the plant workers, but, on the contrary, attracted them to active creative activities to improve the management methods.

A great deal of significance was attached in the introduction process to the fact that the expenditures of machine time and labor of the personnel on operation and maintenance of the system are low. This problem has been given special attention in the filling out of the primary documents, the information base and optimization of the data processing algorithms.

Effectiveness Estimate

The cost benefit received by the enterprise as a result of introducing the automated control system depends on the gain received by the enterprise from the automated control system and the expenditures on the development and operation of the system. The gain or the effect which is offered by the automated control system is determined by the number of problems encompassed by the automated control system. The more control functions performed by the computer, the higher the level of automation, which means, the lower the labor expenditures with respect to control. Another important factor is reduction of the labor expenditures on the development of the automated control system, its operation and maintenance. These include the expenditures on accquiring and maintaining the technical means.

The cost benefit from the automated control systems at the enterprises is estimated by the corresponding procedures. However, these procedures include only the enterprise indexes which can be quantitatively evaluated (the reduction in losses, increase in output capacity, reduction in number of personnel, and so on). A very important factor in the effectiveness of the automated control system is the qualitative effect of the system on the control functions, for example, the increase in value and operativeness of the information for decision making, the creative activity of the people participating in control and the stability of the administrative functions. The automated control system exerts a great deal of influence on the control quality which, in our opinion, is much more important that some of the quantitative results of automation. Unconditionally, the qualitative effect from automation of control will ultimately be expressed in the quantitative indexes which frequently are very difficult to trace, and for which it is difficult to construct a system of relations. Sometimes it is difficult to show where the effect comes from--from the automated control system, or from certain other measures.

However, in spite of definite imperfection of the existing methods of calculating cost benefits, it is possible to obtain minimum estimates on the basis of them.

At the enterprises that have introduced the Barnaul automated control system, such estimates have been made during acceptance of the system by the state commission for industrial operations.

At the Barnaul Radio Plant, according to the economic service calculations, the direct cost benefit of the Barnaul system after the first year of operation was more than 600,000 rubles per year. The time required for the system to pay for itself was 1.3 years. Approximately the same figure was obtained at the Novosibirsk Elektrosignal Plant. At the Sibsel'mash Siberian Farm Machinery Plant this system was introduced in 25 shops. A benefit averaging 30 to 40,000 rubles each year was obtained at each shop.

Thus, after introducing the system, in every enterprise the direct cost benefit was on the average of 500,000 to 600,000 rubles a year with a time 1.2 years required to recover the investment.

Attention must be given to the fact that the cost benefit data have been calculated only in a startup situation which basically leads to implementation of the information planning goals. However, this type of complex provides an information base also for solving the problems of optimizing the annual and the operative-calendar planning, statistical analysis, and so, which, in turn, give a benefit without significant additional expenditures.

When estimating the cost benefit of the Barnaul automated control system, it is necessary to recalculate the factors as a result of which the enterprise will either receive a direct or indirect effect and also the factors influencing the reduction of expenditures on the automated control system.

The automated control system realizes a quite clear production accounting with respect to each operation part. Under the conditions of the automated control system, these accounting data are easily related to the personal responsibility and earnings of the plant workers. Therefore the production losses dropped sharply immediately after introducing the automated control system. Thus, when introducting the system in the first shop of the Barnaul Radio Plant, the losses dropped from 20 to 0.6 percent.

Timely, available data on the labor normatives, the work assignment, data on the results of the labor of each worker, and daily information on earnings by the workers and also without advance wage calculations have led to significant improvement of the productivity of labor of the workers. This is observed on introducing the Barnaul system at every enterprise and every shop.

It is quite obvious that the clearly functioning information base of the enterprise provides the optimization algorithms with the initial data. Under these conditions the optimization procedures operate not as one time problems, but they are built into the data processing system and can function in the automatic mode. The same information base provides for simulation on different control levels.

In estimating the expenditures on the creation, operation and maintenance of the Barnaul automated control system, let us note the following.

The realization of the principles of assigning information with respect to the deviations, the minimization of redundancy in the primary data, the possibility of creating a branched data storage system in the computer memory, new organization of the primary data gathering--all have resulted in a sharp decrease in expenditures on primary document circulation. The number of volumes of primary documents have been reduced by an order.

At the Barnaul system, the data compression algorithms have been implemented, and the structure and composition of the information files have been selected on the basis of deep preliminary preparation and analysis. This has made it possible sharply to reduce the expenditures of machine time on the operation of the entire system.

The shop-by-shop principle of constructing the Barnaul automated control system has ensured a comparatively simpler structure of the information files and reduced the volumes of data during the operative data processing of each shop.

The above-presented factors which are stimulating improved productivity of labor both in the subdivisions and on the part of each worker, combined with the possibility of calculating the production plan, distribution of the plan with respect to time in parts, are creating conditions for rhythmic operation of the plan as a whole. The improvement of the rhythmicity has been noted by the enterprises that have introduced the Barnaul automated control system.

The system provides all of the data daily on the course of production presented in convenient form for use by the computer. This includes the primary data and the calculated generalized indexes. During operation of this system, the requirements of the administrative personnel for information change: the interest in some of the traditional data drops, and new requests for generalized information on production obtained after computer analysis arise.

Inasmuch as the system provides the computer with all of the primary information on production, in the computer memory there is an information mapping of the course of production, and at the same time conditions are created for good access to the information pertaining to the activities of certain categories of people. This creates conditions for increasing the interest of the plant workers in reliability of the data, operativeness and clarity. This interest does not contradict the general interests of the enterprise. It is possible to talk about an atmosphere of creativity and significant raising of the level of qualifications of all categories of workers.

The operation system of the automated control system compiles the operating programs in such a way that in one examination of the basic information files all the control problems were provided for. This has also reduced the expenditures of machine time on operation and maintenance of the system.

The selection of the technical means and functional problems is tied with the main goal of the enterprise--the basic production control.

Thus, when developing the Barnaul automated control system, the basic factors were taken into account which influenced the general effectiveness of the system independently of whether they can be estimated quantitatively.

§2. Sigma Automated Control System--Further Development of the Barnaul Automated Control System

The Barnaul automated control system was implemented on the M-220 computer. the production of computers of this type has been stopped in the Soviet Union; therefore the question of the development of the automated control system on a third generation computer has come up.

The Sigma automated control system has been developed for industrial enterprises of the machine building and instrument making branches with different nature of production (from mass to individual) with a large nomenclature of parts, in-house manufacturing complexes, materials and procured intermediate products.

The Sigma automated control system is based on the YeS 1020 computer and versions of it. Considering the capabilities of the YeS 1020, the system can service enterprises having up to 30,000 workers, up to 250,000 production units (parts, assemblies, products), up to 50 basic production shops, up to 10 different subdivisions (branches, complexes, production facilities). With the more powerful technical means the Sigma automated control system can be used at larger enterprises. The enterprises having smaller volumes can use the Sigma system in the group mode.

The Sigma automated control system has been developed in several steps. The first step provides for automation of basic production and it is implemented as an automated information control system. In the subsequent steps, work will be in the direction of expanding the automated control system (encompassing the material and technical supply, marketing, auxiliary production, all of the types of bookkeeping activity, personnel accounting, analysis, and so on) and development of the new following functions of it: improvement of the structure of the production facility and the administrative agents; application of optimization methods in the case of long range and operative planning of control; the methods of mathematical statistics for diagnostic and forecasting problems, quality control problems, optimization of the technological process, and so on; the economic methods for improving the organization and efficiency of production, improving the conditions of labor, simulation models for selecting the basic administrative decisions, playing out the production situations, the statement of business games in the dialog mode; the coordination of the operation of the automated production control system with the automated technological process control system, on the one hand, and the automated OKR [experimental design work?] automated control system, on the other hand.

These operations are supported by the information base of the Sigma automated control system developed in the first step.

Structural Principles of the Information Base

The information base of the Sigma automated control system must provide not only for the accounting and information planning problems, but also all of the new problems which will be included in the Sigma automated control system in the subsequent steps of its development.

The composition, structure and organization of the information base exclude to the maximum the duplication of information both by elimination of parallel flows of it and successive repetition of the data; they ensure reliability and operativeness of the information, simplicity of access to the information elements, and informativeness of the data.

The computer includes the primary information, that is, the data on resources and the production process. All of the data processing (accumulation, accounting, summaries, comparisons and other conversions) are performed by the computer. This relieves the enterprise personnel from routine operations which, as a result of monotony in the case of manual processing, have no high reliability, on the other hand, minimization of the redundancy of the data in the computer memory takes place, and various control problems are supported with unique data. The composition of the primary data is determined by the initial information describing the object (the basic production facility, resources, organizational structure).

With the development of the operations with respect to the automated control system, the composition of the problems requiring the primary data changes, which leads to periodic rearrangement of all of the information base. The information description of the object permits provision of data not only to the problems provided for by the plan, but also those which can occur subsequently. This makes the automated control system a constantly developing and improving one.

The primary data include information that is essential to control of the target. The informative data are selected. The composition of the primary data of the Sigma automated control system includes data on resources, the technological process itself, the organization of production and the production process.

The primary information is broken down into stored and dynamic information. The stored data are entered in the long-term memory of the computer for permanent storage. The dynamic data flows carry the changes occurring in the production process, and they are used to provide the control data and to up date the stored information files.

The information base is organized so that the maximum amount of primary data will be stored in the long-term memory, and the dynamic data will reflect only the changes occurring in the production facility. This significant unloads the communications channels, the slowly operating input devices and it reduces the volume of primary data document flow.

The efficient subdivision of the primary information into stored and dynamic data creates conditions for implementation of the principle of assignment of information by deviations.

The documents providing for recording of the primary information are convenient for computer input and examination by the enterprise personnel. Later, the possibility of data input from a language close to natural language will be acquired.

The Sigma automated control system includes rigid monitoring in which the errors in the primary data or the nonoperativeness of the data input and in the operation of the entire system create disadvantageous conditions for certain categories of enterprise workers.

The organization of the data flows, the planning of the primary documents and creation of special programs based on this principle will permit use of the personal interest of various categories of administrative personnel and workers to ensure high data reliability, operativeness of the data, and "viability" of the entire system.

In addition, the system provides for special programs to monitor the input data.

The structure of the information base of the Sigma automated control system corresponds to the hierarchical structure of the enterprise control. The shop by shop principle of storage and data processing at the Barnaul automated control system has completely justified itself. However, in order to expand the possibilities of the Sigma automated control system, in addition to the shop information files and all-plant (nomenclature-price list, and so on) provision has been made to create a special file on the composition of the products reflecting the required intershop relations.

Within the framework of the hierarchical enterprise control structure, the information files are unique for providing for the solution of sets of different problems. The information files are centralized by the corresponding scheme, including the normative and accounting and the planning data. The formation of single files and sets of problems based on these files is realized by the formal procedure with the application of recognition methods.

When formulating the permanently stored information files, use is made of the data compression methods making it possible significantly to reduce the size of the files and the access time to the long-term memory. However, it must be considered that the effectiveness of the various compression methods depends on the structure of the files and their use conditions. It is necessary to perform a preliminary analysis of the expediency of using one compression method or another, and in some cases, to change the file processing conditions or create additional procedures for improving the effectiveness of the compression technique.

When solving certain problems, it can become necessary to create auxiliary, intermediate information files beginning with the basic ones. However, when introducing changes in the data, it is necessary to be oriented toward the basic files. The changes are made at the time of use, that is, in parallel with the functioning of the operating programs.

The structure of the information base, the composition and organization of the software for the automated control system depend essentially on each other. When planning the information, this dependence is taken into account.

Software Characteristics.

The software for the Sigma automated control system uses the general software of the integrated system of computers.

The Cobol, RPG, Assembler and programming means adopted in the integrated system are used as the automated programming means. The operation systems are supplemented by the required programs controlling the packages of operating programs of the automated control system. In organizing the operation of the programs provision is made for one-time and successive use of the stored data files.

When planning the information base and the structure of the automated control system software, the methods of statistical classification were used. Let us give attention to the two main principles in the software of the Sigma automated control system: the strictly modular structure and adaptiveness. These principles provide flexibility in the system and the capability for development.

In the software, just as in the Barnaul automated control system, provision is made for the procedures of maximum possible monitoring of the input data. The operation systems and complexes of operating programs will be developed in order to provide the time sharing and control systems with means of representing the data.

Application of Optimization Techniques

In the Sigma automated control system provision is made for the application of optimization methods first of all in the problems of annual and operative-production planning.

In the problems of annual planning, use is made of the algorithms already available for the selection of the version of the annual enterprise program. These missions have already been approved at the Barnaul Radio Plant within the framework of the Barnaul automated control system.

In the problems of optimizing the operative-production planning it is proposed that the method of differentiated planning and stochastic methods in scheduling problems be used. The nomenclature of the parts planned in production is broken down into groups. For each group of parts, its own method of optimal operative-production planning is used with different restrictions and rigidity of optimization.

Application of Statistical Methods

Hereafter, it is proposed that statistical methods be used to analyze the technical-economic indexes and for operative decision making. First of all, these are the statistical monitoring and analysis of the time series formed by the values of some of the technical-economic indexes. The statistical processing of the observation series will permit objective estimates to be obtained for analyzing the activity of the enterprise.

For the indexes having statistical stability, it is possible to use statistical methods of predicting future values of the time series.

The presence of the developed information base of the automated control system will create favorable conditions, reduce the expenditures on implementing the production quality control subsystem.

The accumulation of statistics in the information files of the automated control system will permit the solution of the problem of selecting the process conditions close to optimal.

Simulation Models

The Sigma automated control system provides for creating simulation models for the functioning of the enterprise and its subdivisions taking into account the economic laws, the technical base, the social aspects of control and also the principles of interaction of the enterprise or association with the economy of the branch of the national economy as a whole.

The simulation models in the Sigma automated control system permit the analysis of the economic index of the enterprise as a function of the organization of production, the technological process, and various administrative solutions. The business games playing out the various situations on the basis of these models permit the selection of the best versions of the structure, the process and the organization of production and prediction of the consequences of the proposed reorganizations.

General Structural Design

The Sigma automated control system is constructed as a united enterprise control system which combines all of the control problems (accounting, planning, analysis, operative control, forecasting, and so on) in a centralized data processing system on the computer.

The structure of the system permits constant development of it. The system can easily include new problems, new improved methods of solving problems. The Sigma automated control system is constructed as a multilevel control system.

Practical Implementation

The operations with respect to creating the Sigma automated control system were started in 1974 after a special resolution of the State Committee of the USSR Council of Ministers on Science and Engineering.

In addition to the computer center of the Siberian Department of the USSR Academy of Sciences, the development project included the Altay Polytechnical Institute imeni I. I. Polzunov, the Barnaul Radio Plant and Machine Building Plant, the Altay Tractor Electrical Equipment Plant, the Institute of Economics and Organization of Industrial Production of the Siberian Department of the USSR Academy of Sciences, the NIIsistem [Systems Scientific Research Institute] of the Ministry of Instrument Making, the Novosibirsk National Economy Institute, the Odessa Neptun Plant.

In 1974 the first volume of the operating plan for the Sigma automated control system was developed which included the structural principles of the system, its composition and structure, the substantiation of the selected structural design, the primary information, all of the calculation algorithms, the instructional material with respect to introduction, operation and maintenance.

This volume contains the necessary materials for preparing the industrial enterprises for the introduction of the Sigma automated control system. It is the production part for writing the operating programs.

The first volume of the operating plan for the Sigma automated control system was transferred to a number of enterprises and branches for preparation for introduction.

The commission on standardization of automated control systems under the state committee of the USSR Council of Ministers on Science and Engineering investigated this operating plan, approved it and recommended it as the standard planning solution.

In 1975 a package of programs was developed for the first phase of the Sigma automated control system made up of four complexes: 1) the control of the information base of the enterprise; 2) the control of basic production; 3) data output on request; 4) the adaptation module. The description of this package is the second volume of the operating plan.

In January 1976, the commission of the Siberian Division of the USSR Academy of Sciences accepted the first phase of the Sigma automated control system for experimental operation at the Barnaul Radio Plant, the Barnaul Machine Building Plant and the Altay Tractor Electrical Equipment Plant.

In July 1976, the state interdepartmental commission accepted the plan for the Sigma automated control system in the second phase. The second phase has the following complexes to supplement the first phase: 1) control of material and technical supply; 2) complete calculation of wages; 3) the personnel complex; 4) preparation for the production of new products; 5) technical preparation of the production facility; 6) optimization of annual planning and 7) procedural materials for introduction.

All of the documentation for the Sigma automated control system has been formulated in a edition of three volumes of the working plan. The coordination plan for further development of the Sigma automated control system exists.

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GEOPHYSICS, ASTRONOMY AND SPACE

FEASIBILITY OF LARGE RADIOTELESCOPES IN SPACE EXAMINED

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[Article by V. I. Buyakas, A. S. Gvamichava, L. A. Gorshkov, G. A. Dalgopolov, Yu. I. Danilov, M. B. Zakson, N. S. Kardashev, V. V. Klimashin, V. I. Komarov, N. P. Mel'nikov, G. S. Narimanov, O. F. Preilutskiy, A. S. Pshennikov, V. G. Rodin, V. A. Rudakov, A. I. Savin, R. Z. Sagdeyev, Yu. P. Semenov, A. G. Sokolov, V. I. Usyukin, K. P. Feoktistov, G. S. Tsarevskiy and I. S. Shklovskiy: "Unlimited Accumulating Spaceborne Radiotelescope"]

[Text] II. Design Features, System Control and Placment in Orbit*

A feasible plan is examined for attaining a spaceborne radiotelescope with a composite spherical reflector which provides a multi-beam operating mode. The accumulating, and in this case efficient at each intermediate stage, mirror is composed of 200-m modules. The modules consist of a three-dimensional strut framework with flat hexogonal mirrors measuring ~4 m installed on it. The precise geometry of the antenna's surface is ensured by autonomouc alignment of the mirrors relative to the framework, as well as by alignment of the connected modules. Presented as being feasible is the creation of spaceborne radiotelescopes with diameters of up to 10 km, operating in the wave band of 1 mm - 1 m. Feasibility evaluations were made concerning delivery and construction of the structure in an assembly orbit. The estimated expenditures on the development and creation of a spaceborne radiotelescope with a diameter greater than 1 km turns out to be less than the creation of antennae systems of the same size on Earth. The state of technology today allows one to proceed to development and creation of a 200-m module.

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* Portion of a report presented to the 28th Congress of the International Astronautical Federation in Prague, Czechoslovakia in September, 1977.

In the previous work [1] the subject concerning the merit of creating a spaceborne radiotelescope consisting of a primary modular accumulating reflector, an autonomous secondary correcting reflector, as well as an autonomous controlling space apparatus was discussed. Thoroughly analyzed were the pertinent astrophysical tasks and investigated were the new methodological capabilities which are opening up in the area of astrophysical observations through the use of one or several large-scale radiotelescopes placed into distant orbits. In this article, problems associated with the realization of creating a design for an unlimited accumulating radiotelescope are examined: the composition of the basic antennae modules and their coupling (section 1), control of the combined construction (section 2), and its placement into orbit (section 3). In addition, in section 3 preliminary estimates of the cost for development and creation of such structures is presented.

1. Construction of the KRT [spaceborne radiotelescope]. The primary element of a KRT is the reflecting antenna. The structure of the reflector must retain its rigidity and stability under the influences of gravity and light pressure. The required pointing accuracy affects the limitation of both the frequency and rigidity characteristics of the reflector. These limitations and the operating conditions of the antenna determine the minimum possible weight of the structure.

We shall examine two feasible construction types: a solid supporting shell and a strut supporting framework to which the reflecting surface is attached [2-5]. Interest is also shown in the construction of a type of solid surface with attached rigid ribs, but at the present time there are no suitable design solutions acceptable for spaceborne antennae.

The calculations performed showed that under the influence of light pressure on the reflector, the maximum value for the total deformation load (normal component) may be determined by the formula:

$$q_{N_{max}} = 0{,}23\beta^2 q_0, \qquad (1)$$

where β is one half the central angle of the segment in the radian, and q_0 is the specific light pressure.

From a condition of the reflector's total stability the $q_{N\ max}$ value should be less than the critical loading on the shell which is equal to [6]

$$P_e = 0{,}15 E_{\pi} \delta_{\pi}^2 / R_a^2, \qquad (2)$$

where E_{π} and δ_{π} are the cited module flexibilities and shell thickness, respectively, and R_a is the reflector's curvature radius.

From the specification (2) the thickness and corresponding minimum mass of the reflector may be determined, which at small angles β amounts to:

$$M = 3{,}9 r_0^3 \rho \sqrt{q_0 / E}, \qquad (3)$$

where ρ is the density of the shell's material, E is the flexibility of the module's material and $r_a = R_a \sin\beta$ is the radius of the reflector's aperture.

For a dual-netted strut shell with a basic element which appears as a tetrahedron the cited characteristics may be recorded in the following manner [7]:

$$\delta_a = \sqrt{3} h_0,\ E_a = \frac{4EF_0}{3\sqrt{3}\,\mathrm{tg}\,\alpha_0 h_0^2},\ \rho_a = \frac{2\sqrt{3}F_0\rho}{\mathrm{tg}\,\alpha_0 h_0^2}, \tag{4}$$

where h_0 is the height of the basic tetrahedron, α_0 is the angle between the tetrahedron's height and its edge, F_0 is the area of the strut cross section and ρ is the density of the material.

In this case the minimum mass of the reflector amounts to:

$$M = 12{,}5 \frac{r_a^4}{h_0} \frac{\rho}{E} q_0 + \pi r_a^2 \rho_r, \tag{5}$$

where ρ_r is the unit area mass of the reflecting surface.

In strut-type construction the minimum mass may be determined also from the condition of stability loss for the separate struts. The maximum stress on a strut in netted construction will equal:

$$N = q_n l R_a / 4\sqrt{3}, \tag{6}$$

where l is the length of the net's strut.

As is known, the value of critical force for a thin-walled tubular strut equals:

$$N_0 = \pi^2 E F_0 d_0^2 / 8 l^2, \tag{7}$$

where d_0 is the diameter of the strut.

From the expressions (6) - (7) the minimum cross section of the strut and the mass of the supporting structure may be determined:

$$M = 14\beta r_a^3 \rho q_0 / K_y^2 E, \tag{8}$$

where $K_y = 4d_0/l$ is the relationship of the structure's sizes under folded and opened conditions.

As the calculations show, when directing and stabilizing the reflector the fundamental control cycle T_c of the system will be determined by the least of the following values:

$$T_c = \frac{2}{\pi} T \sqrt{\Delta\theta/3}, \tag{9}$$

$$T_c = \sqrt{r_a \delta_a \rho_a \Delta\theta / q_0\, \mathrm{tg}\frac{\beta}{2}}, \tag{10}$$

where T* is the orbital period of rotation and $\Delta\theta$ is the precision of the reflector's direction.

In high orbits the determination is made by the expression (10).

So that during the creation of the control system there should arise no serious difficulties, the T_1 period for natural skew-symmetric reflector oscillations should be an order of magnitude less than than the T_c period.

The largest period of natural skew-symmetric oscillations for a solid spherical segment is determined by the approximation formula:

$$T_1 = 1,7 \frac{r_a^2}{h_0} \sqrt{\rho/E}, \qquad (11)$$

which was derived through the use of the energy method [6].

From the condition $T_1 \leq 0.1 T_c$ we derive:

$$\frac{r_a}{h_0} = \sqrt[3]{2\Delta\theta E/3\beta q_0}. \qquad (12)$$

Minimum mass of the solid structure will equal:

$$M = \pi r_a^2 \rho \sqrt{3\beta q_0/2\Delta\theta E}. \qquad (13)$$

The period of natural oscillations of a strut-type structure is determined by the expression:

$$T_2 = 0,52 r_a^2 \sqrt{\delta_n \rho_n / D_n}, \qquad (14)$$

when D_π is the resultant cylindrical rigidity of the supporting structure.

Taking into account that T_2 should be $\leq 0.1 T_c$, we obtain the minimum mass:

$$M = \pi r_a^2 \rho_r \frac{3\cdot 10^{-17} r_a^3 \Delta\theta h_0^2 E}{3\cdot 10^{-17} r_a^3 \Delta\theta h_0^2 E - r_a^4 \rho} \qquad (15)$$

or

$$M = 375 q_0 \frac{\beta \rho r_a^3}{\Delta\theta E h_0^2} + \pi r_a^2 \rho_r \qquad (16)$$

for the value T_c from (9) and (10), respectively (r_0 is the radius of the orbit).

Depending on the conditions for orbital insertion, the maximum value of h_0 for a strut-type structure amounts to approximately 10 m. The value of K_y for the collapsible strut-type structure under development at the present time does not exceed 0.02. The dependence of mass for such structures on the diameter is presented in figure 1 for the following values: $E = 1.5 \cdot 10^{11}$

Пa, ρ=1.4·10³ kg/m³, ρ_r=0.1 kg/m², β=15° and $\Delta\theta$=1° [8,9]. From the graphics it is apparent that beginning with r_a=500 m the mass of a solid structure exceeds the mass of a strut-type structure by more than a factor of 10^2.

Strut-type structures which consist of a three-dimensional framework to which the reflective surface is attached are more rational.

Depending on the minimum wave length the reflective surface may be fabricated from a metallic mesh or from panels manufactured with a high degree of accuracy which allows for the control of their position relative to the framework.

The application of collapsible structures allows one to reduce to a minimum the fabrication operations in orbit. However, the manufacture and simultaneous development of a collapsible structure with a diameter of a kilometer in the near time frame is scarcely possible. Based on the prospects for transportation devices the size of an antenna module which can be completely inserted into orbit has been selected as being equal to 200 m.

The modules are inserted into orbit in collapsed form, they automatically unfold and dock to one another. Therefore, it is possible to increase the dimensions of the reflector of an operational antenna. The module's framework consists of a heavy-duty structure and an operating reflector area to which is attached the reflecting surface.

From the relationships presented above it is apparent that the minimum mass and maximum rigidity are achieved at the greatest structure height. Therefore, a heavy-duty framework is fabricated in the form of a collapsible double-latticed shell with the maximum strut length determined by the capabilities of the transport devices. In this case the height of the structure will equal 10 m, which will allow one to increment the antenna's reflector to a diameter of approximately 20 km (see figure 1). In the future, increasing the sizes of antenna mass will begin to grow very rapidly.

The surface of a heavy-duty framework may consist of triangular cells measuring 15 m. Inside each cell is installed a working surface which functions as a single lattice strut-type structure with triangular cells measuring nearly 2 m (figure 2). The struts of the working surface have a diameter one-tenth that of the struts of a heavy-duty framework which is a result of the packaging conditions for the working surface between the connections of the heavy-duty framework.

A heavy-duty framework is made from thin-walled tubing with a cross section of 75 and a thickness of 0.5 mm. The quantity of struts for a heavy-duty framework of a single unit amounts to 1300, and the framework's mass is 4 T.

In the event that precision panels are installed on the working surface and they allow for control relative to the framework, then the mass of the reflecting surface will approximate the mass of the framework.

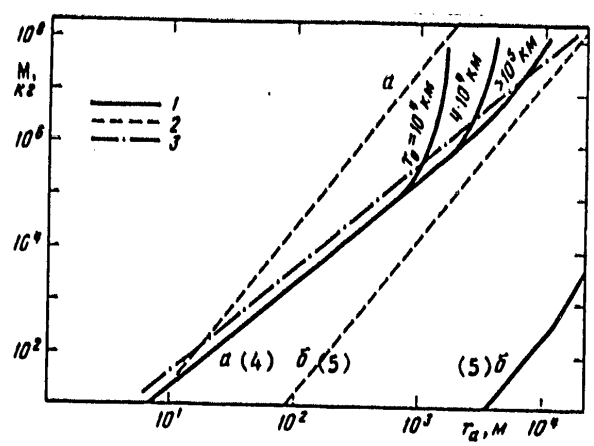


Figure 1. Dependence of KRT Antenna Mass on Diameter

Key:

1. Strut-type construction
2. Solid supporting shell
3. Proposed structure
4. Limitations by frequency characteristics
5. Limitations by stability

Depending on the measurements and operating conditions of the antenna the joining of the modules to one another may be either by rigid or tolerance control of reciprocal position units. The modules of such a structure will be useful for reflector antennae with a diameter of up to 20 km, operating down to the minimum wavelengths.

During antenna operation maximum distortions from the reflecting surface should be no more than 1/10 of the minimum operating frequency. Surface distortions will be composed of technical manufacturing errors in the structure, temperature deformations and deformations arising from gravitational forces and light pressure.

Anticipated technical errors specified through mathematical modeling may be determined from the following expression [10]:

$$\delta_1 = 0{,}02 + 7 \cdot 10^{-4} (2r_a/l)^{1/2}. \quad (17)$$

The first term of this expression is determined by the surface operating errors, and the second by errors in the heavy-duty framework.

Temperature deformations for the structure which has been made from contemporary materials will not exceed the value:

$$\delta_2 = 2 \cdot 10^{-5} r_a. \quad (18)$$

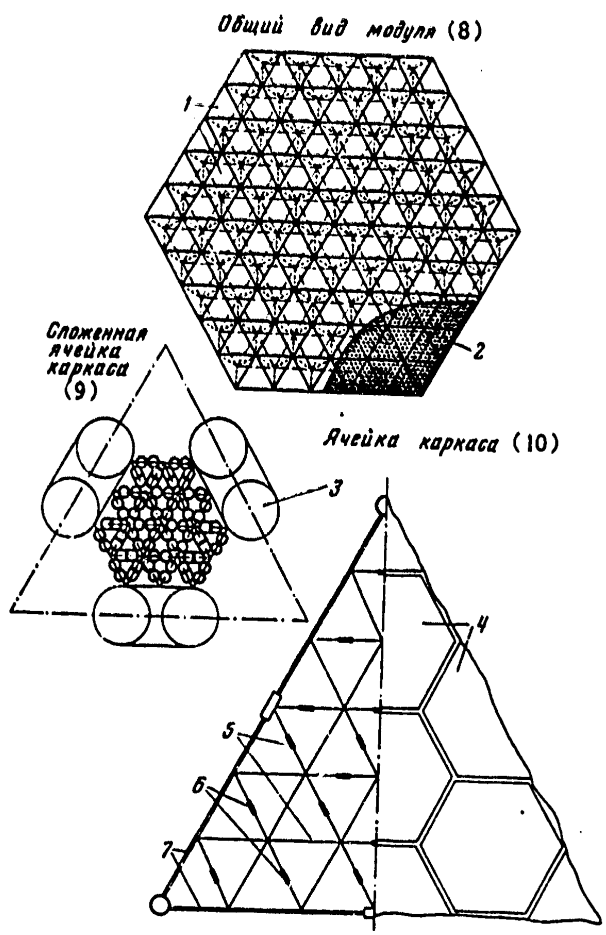


Figure 2. Construction of the Antenna Framework

Key:

1. Heavy-duty framework
2. Working surface
3. Heavy-duty framework connectors
4. Regulating plates for the reflecting surface
5. Struts for the working surface
6. Connectors for the broken struts
7. Heavy-duty framework struts
8. General view of the module
9. Collapsed framework cell
10. Framework cell

Deformations from gravitational forces may be determined from an approximation expression derived, as was the formula (11), through the use of the power method:

$$\delta_3=0{,}8\beta\mu_0\frac{\rho r_0^5}{E r_1^3 h_1^3}(1+K). \qquad (19)$$

Here μ_0 is the gravitational constant, K is the relationship between the weight of the reflecting surface and the weight of the framework.

Deformations from the influence of light pressure may equal:

$$\delta_4 = 1,5 \cdot 10^{-3} \frac{\beta q_0 \, \mathrm{tg}\, \alpha_0 r_a^4}{E F_0 h_0}. \tag{20}$$

These relationships and the total surface surface distortion are presented in figure 3. From the graph it is apparent that within the limits of a single module the error amounts to approximately 8 mm. In a kilometer antenna the error amounts to approximately 25 mm, that is without control of the surface the antenna may operate on a wavelength of approximately 0.5 m. To work on the shorter wavelengths control of the plates relative to the framework is required.

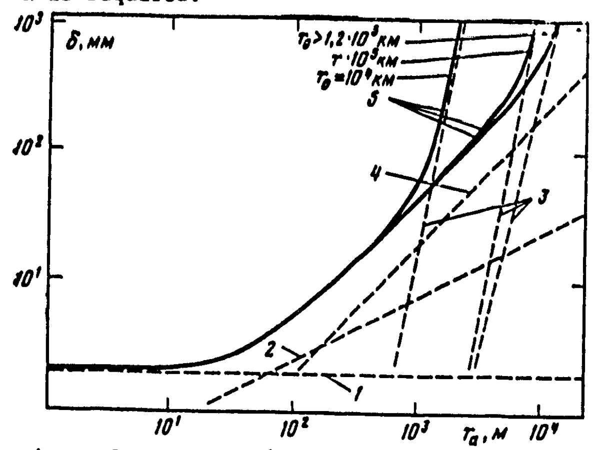


Figure 3. Deformations of the Antenna Surface

Key:

1. Technical errors in manufacture of the reflector surface
2. Technical errors in manufacture of the heavy-duty framework
3. Gravitational deformations
4. Temperature deformations
5. Total deformations

In an antenna with a diameter of 10 km, the surface error will reach 1 m. To compensate for such an error the control range of the plates is insufficient and in this case it is necessary to implement control of the modules' mutual position.

The control system of the modules' mutual position should provide for the exposure of no less than three reference points for each module in the assigned position with an accuracy of ±20 mm. To achieve this objective, within the system there must be no less than 3n -- 3 actuating mechanisms (n is the number of modules). To accomplish control through each mechanism independently the total quantity of kinematic connectors amongst the modules should be equal to 6n - 6. This may be achieved through the installation amongst the modules 3n - 3 of connecting elements which are composed of four cylindrical hinges installed in two mutually perpendicular surfaces, as well as a unit capable of changing the length of the connecting element. Such elements are installed between each pair of modules and at the same time two connectors are installed amongst each of the extreme modules.

When increasing the diameter of the antenna's aperture to a size greater than 20 km, deformations from gravitation forces should increase sharply. Under such antenna dimensions the frequencies of the inherent oscillations will become lower than that permissible.

Increasing the size of the antenna to a value greater than 20 km requires a corresponding increase in the height h_0 of the supporting structure, that is it requires already a three-dimensional increment in the structure.

4. Questions concerning control of the radiotelescope. We shall also examine certain questions connected with control of the KRT. The control system should provide for the cooperative functioning of all parts of the KRT, including orientation of the focus axis for the primary reflector, its fully solid angle turns, attitude stabilization of the receivers and control of the objects within the coordinate system which is tied in with the primary reflector, as well as correcting the KRT orbit.

Within the spherical primary reflector the orientation accuracy of its focal axis should be no worse than 1^0. The gravitational moment acting in the central field is proportional to the difference between the polar and equatorial inertial moments [11]. In the proposal, in which the primary reflector is a uniform spherical shell with a thickness δ_π and a density ρ_π, we arrived at the conclusion that the gravitational moment amounts to:

$$M_g = \frac{3\pi r_a^4 \delta_n \rho_n \mu_0}{8 r_0^3} \frac{\sin 2\vartheta}{\cos^2 \beta/2}, \qquad (21)$$

where ϑ is the angle between the focal axis and the orientation towards the center of the earth.

We derive the moment for the forces of light pressure by integrating the light pressure along the surface of the antenna (see [11]). For a solid diffusely dispersed shell we obtain:

$$M_r = \pi r_a^3 q_0 \operatorname{tg} \frac{\beta}{2} \Phi(\varkappa), \qquad (22)$$

where $\varkappa$ is the angle between the focal axis and the direction of the solar arrays;

$$\Phi(\varkappa) = \frac{1}{4} \sin 2\varkappa \operatorname{sign}(\cos \varkappa) + \frac{1}{3}\left(1 - \frac{2}{3} \sin^2 \beta/2\right) \sin \varkappa.$$

Orientation and stabilization of the kilometer reflector may be accomplished through several reaction control engines with a thrust for each of approximately 1 kg. These are installed along the antenna's periphery. In this case the controling angular acceleration amounts to $10^{-7} \div 10^{-10}$ sec^{-2}, and then within the orientation system there may occur unidirectional oscillation cycles.

Fuel expenditures during these unidirectional cycles are proportional to the perturbing moment [11] and amounts to:

$$G_r = \pi \frac{2r_a^3 q_0 t}{Ig} \operatorname{tg} \frac{\beta}{2} \Phi(\varkappa), \tag{23}$$

where I is the specific impulse of the engine, t is the time of operation and g is the acceleration of the gravitational force.

In using ion engines with a specific impulse on the order of 10^4 sec [12] the daily fuel expenditure for compensation of the moments of solar pressure forces for a kilometer antenna amounts to approximately 0.25 kg (for F/D=1), and for a ten-kilometer antenna -- nearly 125 kg. The electric power capacity for engines with a specific thrust on the order of 600 watts/gram should for a kilometer antenna amount to approximately 15 kw, and for a ten-kilometer antenna -- approximately 1500 kw.

Analogous to the preceding we find that the fuel expenditures for the compensation of the gravitational moment amounts to:

$$G_g = \frac{3\pi r_a^3 \mu_0 \delta_a \rho_a}{8 r_0^3 I} \frac{\sin 2\vartheta}{\cos^2 \beta/2}. \tag{24}$$

For a kilometer antenna with a mass M=200 T, located in stationary orbit, the daily fuel expenditure will equal approximately 6.4 kg, and the electric power capacity of the ion engines is approximately 200 kw. For a ten-kilometer antenna these parameters grow to 6.4 T and 200 mwt, respectively.

Having accepted that turning the antenna follows a normal program (acceleration - inertial motion - braking), we derive the following expression for the value of fuel expenditure which is required to turn the antenna at an angle α^* over a time t [11]:

$$G_n = \frac{tp}{Ig}\left(1 - \sqrt{1 - \pi\alpha^* \delta_a \rho_a r_a^3 / pt^2}\right), \tag{25}$$

where ρ is the thrust of the controlling engine.

To turn a kilometer antenna to $\alpha^* = 180^0$ nearly 2 kg of fuel are required daily. To turn an antenna with a diameter of 10 km over the same angle approximately 1.5 T of fuel are required daily.

We shall evaluate the expenditure of fuel in stabilizing the position of the receiving devices. For example, in placing the KRT in geostationary orbit there arises an acceleration differential between the receiving device and the primary reflector:

$$a = \frac{\mu_0}{r_0^3}(3r_0(lr_0) - lr_0^2), \qquad (26)$$

where l is the vector connecting the centers of mass of the primary reflector in the device being examined.

For a KRT with a focusing distance of 400÷4000 m the acceleration of the receiving device will reach $6 \cdot 10^{-4} \div 6 \cdot 10^{-3}$ cm/sec^2. While using ion engines with a specific impulse of 10^4 sec [12] to compensate for these perturbations daily fuel expenditures will be required in the amount of $6 \cdot 10^{-6} \div 6 \cdot 10^{-5}$ from the object's mass.

The engine system of the receiver device should also provide for the highly accurate tracking of the astronomical sources being studied with variable perturbations in the attitude of the primary reflector. These perturbations (under conditions of unidirectional oscillation cycles with an angular acceleration on the order of $10^{-7} \div 10^{-10}$ sec^{-2} and a stabilization accuracy of the primary reflector on the order of 1^0) require a total velocity increment of 0.06 and 0.6 m/sec per day for one-kilometer and ten-kilometer reflectors, respectively. Fuel expenditures in this case amount to $2 \cdot 10^{-7} \div 2 \cdot 10^{-6}$ from the object's original mass, that is significantly less than providing for motion of the receiving devices along the assigned trajectory.

We shall also examine the possibility of transfering the KRT from a low orbit to an interplanetary orbit which is required following assembly of the KRT to obtain a necessary interferometric base B (see [1]). From the analysis proposed above it follows that a KRT with a diameter of 1 km may be assembled at an altitude no lower than 1000 km, and with a diameter of 10 km -- no lower than geostationary orbit.

Placement into the operational orbit may be provided only by small-thrust engines because of the low level of rigidity of the antenna structure. We shall evaluate the characteristics of the engine system which is required to accelerate the KRT from its initial circular orbit to parabolic velocity. Using the equation for the movement of a body which is moving along a spiral trajectory at a constant thrust [13], one may evaluate the fuel expenditures by the engines and the acceleration time of the telescope to parabolic velocity. The specific impulse of the engine was assumed to equal $I=10^4$ sec, and the boost acceleration for an antenna with a diameter of 1 km is 10^{-4} g (the limitation is the result of the engine's energy requirements), and for a system with a diameter of 10 km -- $3 \cdot 10^{-5}$ g (the limitation is the result of the rigidity retention conditions of the structure). The calculated time values for acceleration and relative fuel expenditure are presented in the table below.

Basic Characteristics of the Engine System

Altitude of initial orbit, thousands of km	Diameter of antenna, km	Acceleration time, days	Relative fuel expenditure, %
1	1	75	7
	10	250	7
36	1	25	2.5
(Geostationary)	10	95	2.5

5. Placement into orbit and the possibilities for realization of the project. The technical-economic evaluations were presented with the objective of determining a rational plan for creating a radiotelescope in orbit and explaining the technical feasibility of the program.

To explain this influence on the primary technical-economic characteristics of the program for the creation of KRT telescope parameters and space rocket devices which are used to place it into orbit it appears advisable to restrict it by an approximate determination of the weight and cost expenditures based on use of specific weight characteristics and costs without a detailed analysis of the different variants. The derived quantitative evaluations should be considered as extremely preliminary and characterizing different variants more in their relationship than by their absolute properties.

As a result of this preliminary examination the following plan for creating a radiotelescope in the orbit of an artificial earth satellite, the follow- plan was selected:

1) Placement of the individual components and elements of the telescope (in a transportable package) into low orbit in "train" with the aid of a special orbital tug;

2) Transport of the "trains" into the operational orbit with the aid of an interorbital tug with a nuclear electric rocket engine;

3) Assembly of the telescope in the operational orbit.

In the telescope's assembly stage the participation of man is envisaged. To accomplish this at the beginning of the assembly a similar plan exists for placing a high orbiting station with a crew of 10 - 15 men into the operational orbit. Another promising variant is the use of specialized automatic robots which may accomplish the assembly and operation of the KRT upon commands from the earth. The station serves also as a basic facility for assembly of the antenna. Delivery and replacement of the crews, as well as providing for their life support requirements is accomplished with the aid of expendable or reusable intra-orbital piloted spacecraft using chemical fuel (depending on the height of the operational orbit).

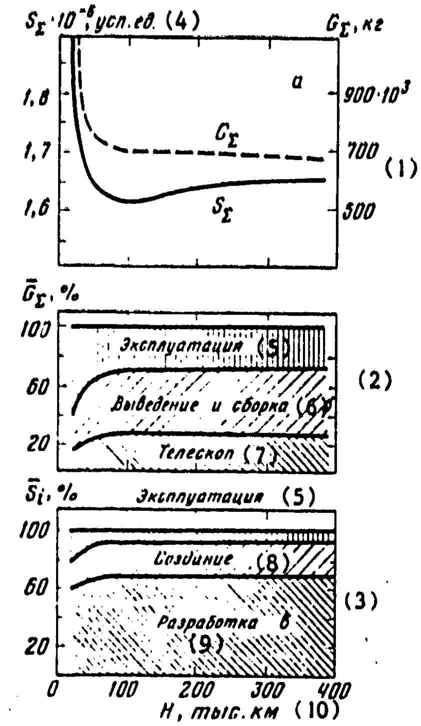
During the operational phase of the telescope periodic delivery of expendable components is proposed (basically fuel for orientation, pointing and maintenance of orbital formation) also with the aid of nuclear powered tugs.

It should be noted that when creating telescopes on relatively low orbits (up to several thousands of kilometers) the use of direct (without tugs) placement of the separate components into the operational orbit or the application of intra-orbital tugs with chemical fuels may turn out to be more rational. From this point of view, the quantitative evaluations presented below for a telescope with an antenna reflector diameter of one kilometer at orbital altitudes of up to several thousands of kilometers may turn out to be somewhat overstated, which, by the way, does not affect the generality of the conclusions which have been made as a result of our evaluations.

During the evaluations for each variant rational parameters for a reusable low-orbiting transporter and intra-orbital tug, a plan for providing cargo-passenger service along the route "earth-high orbital station-earth", the optimum altitude for the circular operating altitude of the telescope were selected -- all dependent on the diameter of the unfolded telescope reflector. The total expenditures S_{Σ} on the creation and operation of the fully assembled telescope, which included the development costs for the telescope and the creation and operation of the space rocket facilities necessary for it, including their flight design development, the manufacturing costs of the telescope, the space rocket facilities and the cost for placement in orbit and assembly, the cost for operation of the KRT, including expenditures for supplying it with expendable components and the functioning of the command and measuring complex over a period of ten years were examined as the criteria. In that case, if it turns out that the parameters of a low-orbiting reusable transporter correspond to the mass of a usable cargo less than 30 T, the expenditures for developing such a transporter were not considered. The following limitations were also accepted: 1) the time for creating the telescope to the beginning of its operation should not exceed five years with a launch rate of low orbiting transporters no oftener than once every three days; 2) the weight of the intra-orbital tug without a usable payload and fuel does not exceed the weight of the usable cargo of a single low orbiting carrier; 3) crew exchange for the high orbiting station is performed every six months.

Taking into account the necessary change in the rigidity (and consequently weight) characteristics of the antenna when changing the altitude of the operating orbit according to the conditions for allowing acceptable deformations of its reflector as a result of the influence of the earth's gravitational field.

The results of the calculations are presented in figures 4 - 7 in the form of graphs.



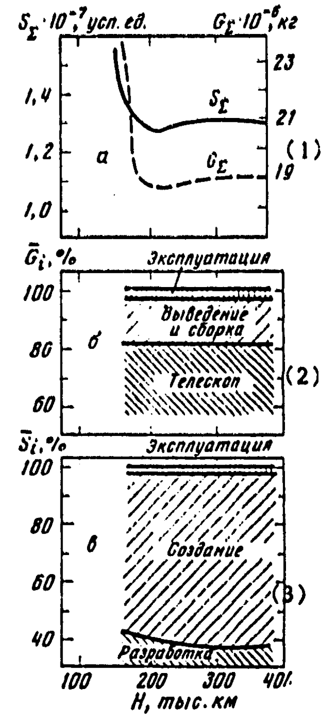


Figure 4. Change in the Weight and Cost Expenditures on the Creation of a Radiotelescope with a Diameter of 1 km Dependent on the Altitude of the Operating Orbit

Key:

1. Distribution of the total KRT weight G_Σ with a 1 km diameter on the telescope proper, and provision for its delivery, assembly and operation
2. Analogous distribution of the total cost S_Σ (3)
4. Representative unit
5. Operation
6. Delivery and Assembly
7. Telescope
8. Creation
9. Development
10. Thousands of kilometers

Figure 5. Variation in Weight and Cost Expenditure on the Creation of a Radiotelescope with an Antenna Diameter of 10 kilometers Depending on the Altitude of the Operational Orbit

[Key continued on following page]

Key:

1. Distribution of the total KRT weight G_Σ with a diameter of 10 km on the telescope proper, provision for its delivery, assembly and operation
2. Analogous distribution of the total cost S_Σ (3)

The figures 4a and 5a illustrate the change in the total weight of G_Σ and the cost S_Σ for a radiotelescope depending on the altitude of its operating orbit H with diameters of the open antenna corresponding to 1 and 10 km.

As a representative unit of cost (figures 4,5 above) the cost for placement into geosynchronous orbit of an antenna weighing 1 kg with an unfolded diameter of 1 km (without considering the costs for development, fabrication and operation) was selected. The repr sentative unit which was selected on the basis of accomodation to the cor rison of the derived results with the results of the other investigations connected with the study of the problem of placing useful payloads of various types into high orbits.

The weight G_Σ which was cited for a low circular orbit H=220 km and directly characterizes the full cargo flow along the route "earth-low orbit" (elements, tugs, transport ships, fuel, etc.) is provided with the aid of a reusable low orbiting transporter.

In figures 4b and 5b for the same antenna diameters the distribution of the total KRT weight G_Σ on the telescope proper (the antenna and supporting elements), provision for its deliver and assembly (mass of the tugs, fuel or fuel components for a high orbital station, transport apparatus, facilities for their orbital insertion, etc.), as well as for the operation (fuel mass, supply facilities, etc.) are illustrated.

The distribution of the total cost S_Σ on the development, creation and operation is shown in figure 4c and 5c.

From figures 4a and 5a it follows that for each telescope size there exists an optimum height for the operating orbit in which the total cost expenditures on its development, creation and operation are minimized. A change in the factors G_Σ and S_Σ which were mentioned above and which were selected for the optimum altitudes relative to the diameter of the unfolded antenna D, are presented in figure 6.

The evaluations presented show that in the development and creation of large spaceborne radiotelescopes with unfolded diameters of from 1 to 10 km the expenditures required are within the range $(1.5 \div 12) \cdot 10^6$ representative units. Accepting the value for the representative unit of 500÷750 dollars (see, for example [14]), and expenditures in absolute units one may evaluate in billions of dollars the corresponding diameters of a deployed antenna.

The expenditures for each ten years of operation for such telescopes may be evaluated as 3÷8% from the costs of their development and creation.

A comparison of expenditures for the development and creation (without taking into account operations) of space and ground telescopes as a result of present day work and data [15] (figure 7) allows one to consider that the creation of spaceborne telescopes with a diameter of the opened antenna at several kilometers will cost less lthan the construction of a system of ground-based radiotelescopes over the same effective area. A similar conclusion was also arrived at in the work [16] where it was noted that in a antenna with a diameter of approximately 5 km the creation of a spaceborne radiotelescope will be cheaper by a factor of two than the construction a ground-based system with the very same equivalent diameter.

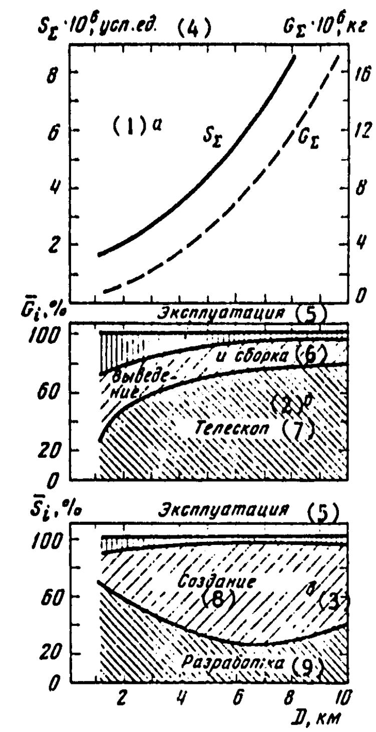


Figure 6. Variation of the Weight and Cost Expenditures in the Creation of a Radiotelescope Relative to the Antenna Diameter for the Optimum Orbital Altitude (in which the expenditures for development, creation and operation are minimized)

Key:

1. Corresponding distribution of total weight
2. Corresponding distribution of total cost (3)
4. Representative unit
5. Operation
6. Delivery and assembly
7. Telescope
8. Creation
9. Development

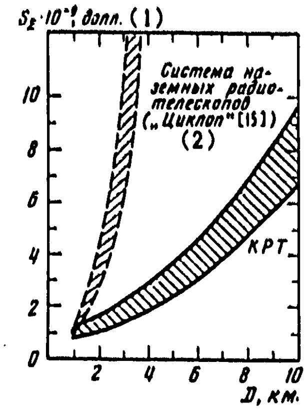


Figure 7. Comparison of the Costs for Creating Spaceborne and Ground-Based Radiotelescopes

Key:

1. Dollars
2. System of ground-based radiotelescopes ("Cyclops" [15])

Conclusion

Cosmic space, with all the difficulties of working in it, presents a number of unique possibilities for astronomical research unattainable under earth conditions. The calculations performed show that spaceborne radiotelescopes permit the investigation of the universe within very broad limits, clear to the curvature radius of space. In so doing, the most important problems such as how did life develop in the universe, and the formation and evolution of a number of celestial objects (stars and planetary systems, galaxies and quasars) may be resolved. Such possibilities are tied in with the fact that under conditions of weightlessness and the distance from earth antenna structures of great size may be created, one may avoid the high level of earth-caused radio interference and the influence of the atmosphere and radiotelescopes may be dispersed at distances on the order of the size of the solar system.

It is important to note that the solution of technical problems in the creation of KRT coincides with the primary direction in the development of space technology at the present stage, substatiating the necessity for using reusable transport craft and the principles for creating very large structures in space. Very similar requirements arise when discussing projects for the creation of large solar electro power stations in space and large research stations. Apropos these projects for the creation of KRT it is necessary to resolve a number of complex technical problems:

-- delivery into space and assembly of large structures, and towing them into near solar orbits;

-- creation of automatic control systems which provide for the control of the KRT reflectors primary surface and the mutual positioning of the receiving devices with accuracies defined by the operation of the KRT in the millimeter radio wavelengths;

-- precise coordinate measurements for the KRT, a precise time coupler for the radio signals and the transmission of wide band signals and their processing.

All of these question are already being resolved at the present time.

The evaluations performed show the principal possibility for the creation in near earth orbits of spaceborne radiotelescope reflectors with a diameter of up to 20 km and erected from automatically deploying antenna modules measuring on the order of 200 m. For the operation of such antennae in the short wave portions of the radio band (to the millimeter wavebands inclusively) the creation of systems for automatic control of the main reflector surface is required. The specific mass of such antennae will amount to 0.2÷0.3 kg/m^2. The total cost for the creation and placement into orbit of a KRT may cost 1÷10 billion dollars for antennae with diameters of 1÷10 km.

The creation and devlopment of modules for an accumulating spaceborne radiotelescope, that is a KRT with a reflector diameter on the order of 200 m one may consider it a task the solution of which it is advisable to enter upon at the present time.

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STRUCTURE OF THE SUBSALT DEPOSITS OF THE CASPIAN SYNECLISE

Moscow NEFTEGAZOVAYA GEOLOGIYA I GEOFIZIKA in Russian No 11, 1978 pp 22-26

[Article by A. V. Yegorkin, H. M. Chernyshev, V. N. Belokopytov, E. G. Danilova and V. F. Kolomiyets, NPO Union of Geophysicists]

[Text] The Caspian syneclise offers significant interest due to the discovery of oil and gas deposits in subsalt deposits on its periphery. However, further expansion of operations is restrained because of the acquisition of conflicting information on the geologic structure of the subsalt complex in its internal areas.

In this paper we interpret new data acquired as a result of deep seismic soundings obtained in regional profiles of Elista-Buzuluk and Saratov-Gur'yev (Fig 1).

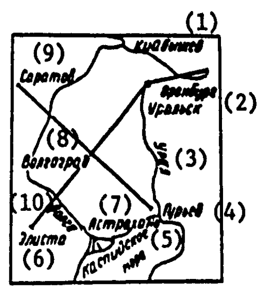


Figure 1. Diagram of the Profile Layout.

Key:

1. Kuabyshev	6. Elista
2. Orenburg Ural'sk	7. Astrakhan'
	8. Volgograd
3. Ural	9. Saratov
4. Gur'yev	10. Volga
5. Caspian Sea	

The spacing between seismic stations in the profiles was 8-10 km, and 150 km between explosion points. The powerful explosions carried out across 500 km provided high-intensity waves of various types.

The predominant frequency on the seismograms was 2-4 Hz. Three components of dislocation were registered: a vertical and two horizontal. The reliability of the construction of seismic boundaries is achieved as a result of interpretation of a wide class of waves: longitudinal and transverse (reflected, refragmented), transmitted and reflected composite waves of type PS. The advantage of this study as opposed to earlier ones lies in the use of polarization analysis of PS waves, which enabled us to obtain a high-grade curve of the ratios of the velocities in the layers separated by the boundaries of the exchange, to follow the surface of the layers with reduced layer velocities.* On the whole, this significantly increases the possibility of geological interpretation of the seismic sections.

Seismological sections were constructed from acquired seismic data and correlation of the available geological materials (Figs 2 and 3). The error in computing the depth of the occurrence of the seismic horizons in these figures is about $\pm$5-7 percent. The regional seismic boundaries are traced: S-surface of salt complex; ΠC-probable base of the salt; Π_1-roof of the carbonate complex in the subsalt layer; Π_2-interface of the carbonate subsalt complex; Π_3-roof of the terrigeneous layer, lying on the basement; B-surface of the crystalline basement.

The observed boundaries Π and Π_4 are autochthonous. They occur near the roof and base of the subsalt part of the section.

The seismic horizon confined to the surface of the salt complex is constructed from the composite and refracted waves. The horizon is indicated in the sections as based on earlier studies [8] because of the complexity of the relief and the insufficiently dense network of observation points.

The horizon LS was separated for the first time solely by composite waves. It lies between the earlier known horizons S and Π_1. The seismic horizons, located on the level of horizon ΠC, during similar studies conducted previously were not recorded.

The waves corresponding to horizon ΠC, reliably separated in an overwhelming majority of seismograms, are characterized, usually, by a uniform anomalous polarization in which they differ from neighboring waves. In large areas of the central depression of the Caspian syneclise the boundary of ΠC is anomalous.

*In the text the boundaries which correspond to surfaces of the layer with a higher layer velocity than the overlying stratum are called normal; with the opposite velocity relationship, they are called anomalous.

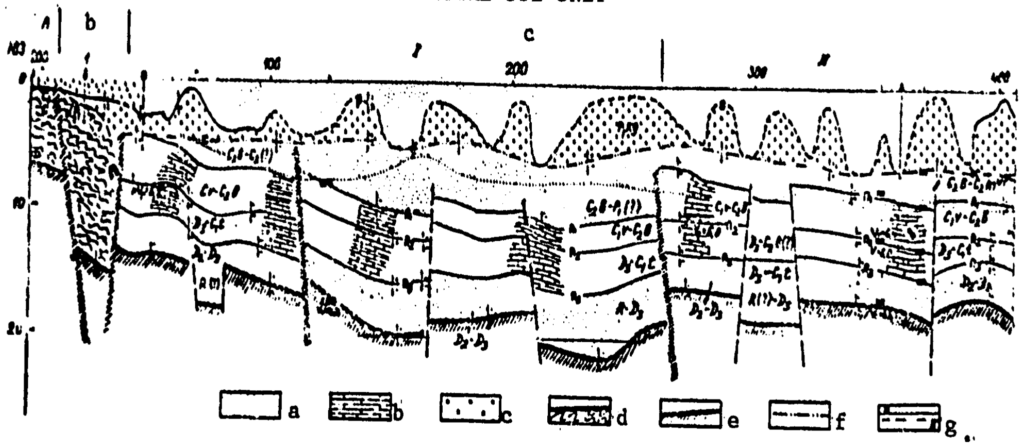


Figure 2. Seismogeological Section along the Elista-Buzuluk profile.

a-terrigeneous deposits; b-carbonate deposits, c-hydrochemical formations. Seismic boundaries: d-surface of the fold-structure stage; e-surface of the crystalline basement; f-base of the salt-bearing stratum; g-in the sedimentary stratum and fold-structure stage: a-certain, b-uncertain; h-relationship of the values of the velocities of the transverse waves higher and lower than the boundary of the composite ("+"-higher, "-" -lower velocity); i-values of boundary and layer velocities from obtained data; j-position of seismic horizon Π_1 [8]; k-position of the boundaries and values of the boundary and layer velocities (km/sec) according to

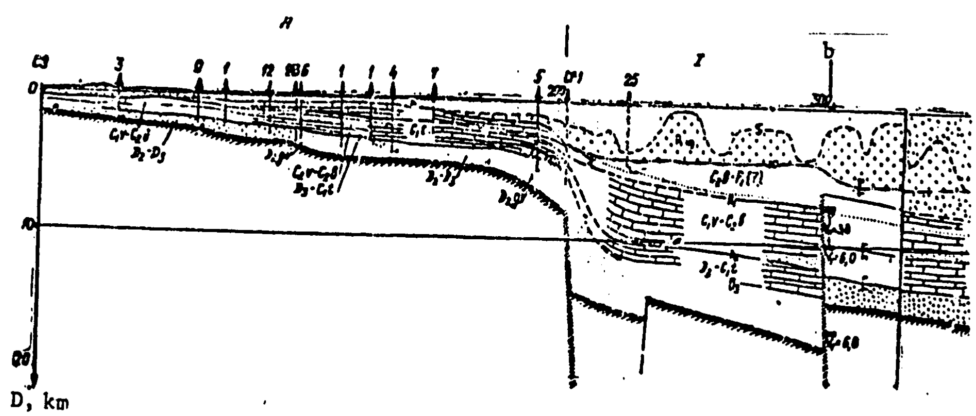
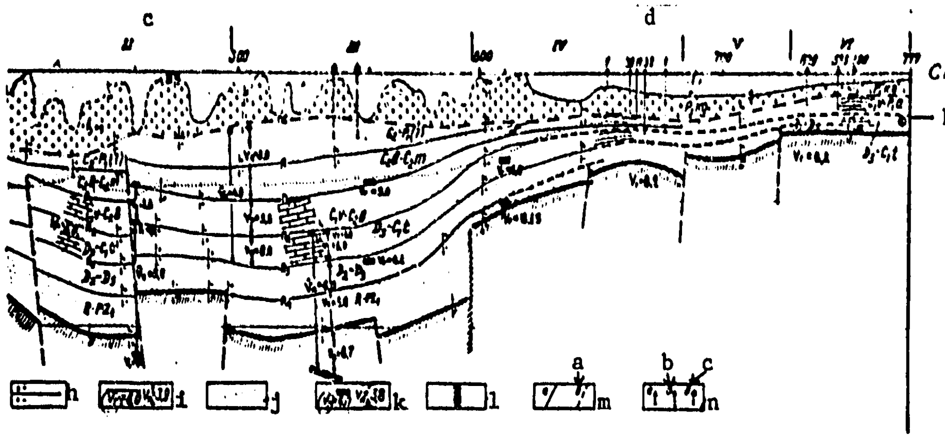
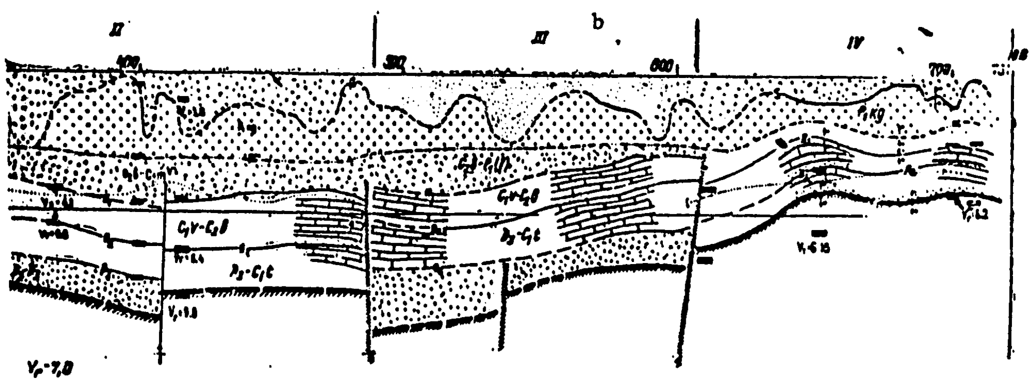


Figure 3. Seismological section along the Saratov-Gur'yev profile.

a-Voronezh anticlise, b-Caspian syneclise: I-Elton-Chelkarskiy trough, II-Aralsor rise, III-Ryn-Peschanka basin; IV-Gur'yev rise; bore hole: a-occurring in the profile (9-Vol'novskiy, 1-Kolokol'tsovskiy, 243-Medveditskiy, 6-Peskovatskiy, 1-Severo-Linevskiy, 1-Topovskiy, 5-Zapadno-



results of deep seismic sounding and seismic refraction studies: l-deep faults; m-other faults: a-separated by seismic data, b-proposed; n-bore holes: a-occurring in the profile (SG-1 Aralsor, 30, 17, 32-Zapadno-Teplovskiy, 535-Sobolevskiy), b-removed from the profile (208.1-Sukhotinskiy, 1-Gremyachinsk, 1-Teplovskiy, 629, 100-Sobolevskiy), c-recommended to drill. A-Karpinsk arch, B-cis Donets trough, C-Caspian syneclise: I-Sarpinskiy trough, II-Aralsor rise; III-El'ton-Chelkarskiy trough, D-Volga-Ural'sk anticlise: IV-Ural'sk stage, V-Buzuluk basin, VI-Solobevskiy shelf.



Rovenskiy); b-removed from the profile (3-Shalinskiy, 12-Novo-Kuvanskiy, 4-Traktovskiy, SG-1-Saratov, 25-Krasnokutskiy). The remaining symbols are the same as in Figure 2.

The regional seismic boundaries Π_1 and Π_3 are also distinguished by composite waves. The first of them is normal and the second is anomalous. Horizons Π_1 and B are exploratory. Their certainty is confirmed by interpretation of waves of the different types.

The seismic survey of horizon ΠC has special significance since it is located higher than horizon Π_1 and, as opposed to Π_1, it usually corresponds to the roof of the layer with lowered velocity.

Study of available materials [8] shows that horizon Π_1 and reflection horizon Π_1, which were separated in our sections, are identical (see Figs 2 and 3). The independence of the hypsometric position of horizons ΠC and Π_1 also established this in which the latter, as traditionally considered, represents the surface of the subsalt bed. Through a comparison of drilling and seismic prospecting data [4.6.7] it was discovered that horizon Π_1 corresponds to surfaces of different ages and different lithologic relations of strata and is found higher or lower than the interface of the salt and subsalt complex, and from this originated the hypothesis that horizon ΠC is confined to this interface.

This is actually borne out by the data of bore-hole 1-Sukhotinskiy in the Karakul'skiy arch, and also by the bore hole located in the Gremyachensk and Zapadno-Teplovskiy areas. At the same time the facial replacement of the subsalt carbonate rocks by terrigeneous one along the line from the borders to the center of the syneclise completely explains the anomalous character of the LS boundaries. Therefore, there is a complete basis for the assumption that under horizon LS in the central part of the syneclise lie terrigeneous sediments. According to our data they possess a layer velocity v_{Π}=3.9 km/sec, while the salt layer has v_r=4.5 km/sec. This does not conflict with the latest conclusions [1], in agreement with which core hole SG-1-Aralsor, drilled in the central depression of the syneclise at a depth of 6630 m, uncovered subsalt terrigeneous deposits.

Approximately at these same depths (6.5-6.6 km) in the sections along the line Elista-Buzuluk, horizon LS was located, taken by us as the roof of the subsalt stratum. The position of horizon LS in this region coincides with the level of occurrence of horizon XX MRNP [expansion unknown] [2].

The correspondence of the chosen horizon LS to the interface of the subsalt and salt strata is indirectly borne out by the resolution of the straightforward problem of gravimetry of deep sections along the Elista-Buzuluk and Saratov-Gur'yev profiles [3]. Judging by these calculations, the depth of occurrence of the base of the salt in the buried section of the syneclise along the profiles cannot exceed 6.7-7 km. This also agrees with recently received data and with other investigators [5].

Thus, a series of independent materials suggests that in the central depression of the syneclise the surface of the subsalt bed is found significantly higher than the assumed earlier level.

The underlying seismic horizon Π_1 in the area of the entire buried part is normal and is registered within the subsalt stratum. We then suggest that the boundaries being investigated occur in higher velocity deposits. According to our data, this stratum has a layer velocity v_{Π}=5.5 km/sec. It is mainly composed, apparently, of carbonate rocks. The stratum of low-velocity sediments, lying between horizons ΠC and Π_1, we determine to be the upper terrigeneous subsalt complex.

The seismic boundary Π_2 has a high boundary velocity (v_r=6-6.2 km/sec) and, similarly to boundary Π_1, is characterized by a normal polarization sign corresponding to ΠC waves. This boundary apparently separates a single high-velocity complex of rocks into two strata, where the upper (v_{Π}=5.5 km/sec) is composed of carbonate and terrigeneous rocks, and the lower (v_{Π}=6 km/sec) is essentially carbonate.

The base of the subsalt carbonate complex is represented by an anomalous boundary Π_3. The underlying seismic boundary (B) characterizes the surface of the basement. The stratum of rock, confined to the interval between boundaries Π_3 and B has a layer velocity v_{Π}=5.6 km/sec. In relation to the enclosing layer, it is a low velocity layer. This layer is most likely represented by terrigeneous deposits of Proterozoic-lower Paleozoic age, and so it separates out as a lower terrigeneous subsalt complex.

The surface of the crystalline basement (boundary B) in the buried part of the syneclise is determined by composite and refracted waves. The depth of its occurrence basically agrees with the depth in other profiles.

Thus, judging by the seismic data, the subsalt part of the section in the central regions of the syneclise is divided into three lithologic-stratigraphic complexes: upper terrigeneous, carbonate and lower terrigeneous.

The sufficiently certain tracing of the seismic boundaries of the border zone of the inner depression of the syneclise shows the continuity of geological growth of this region. Evidently, all the layers of the sediments which accumulated on the periphery of the syneclise, received one or the other distribution in its central part.

The presence of complexes of subsalt rocks of great thickness in more accessible than expected depths increases the prospects of oil and gas explorations in subsalt deposits of the buries part of the Caspian syneclise.

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PHYSICS

STATE OF THE ART OF AND PROSPECTS FOR RESEARCH ON ARTIFICIAL EARTH SATELLITE LASER DETECTION AND RANGING EQUIPMENT*

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 11 pp 2428-2434 manuscript received 6 Feb 78

[Article by K. Gamal, Prague Polytechnical Institute, Prague, CSSR]

[Text] A brief history is given of artificial Earth satellite laser detection and ranging, the specifications for laser rangers are formulated, and a description is given of laser ranging systems in existence at the present time, of the Smithsonian Observatory, NASA and Interkosmos type.

The technique for measuring distances to Earth satellites suggested and implemented by G.G. Plotkin in the first half of the 60's has proven to be very effective for the purposes of geodesy, geophysics and astronomy. The first generation of laser rangers made it possible to gain a measurement accuracy of as much as $\pm$ 1 m. An accuracy of about 10 cm can be obtained when using laser rangers of the second generation, and of less than 3 cm with third-generation. Satellites of the Beacon, Geos and Diadem type have made it possible to get a maximum measurement precision of 10 cm, and of the Starlett and Lageos type, of 3 cm. The main sources of errors can be divided into two groups. In addition to errors associated with the location and design of reflectors in satellites, propagation of the beam in the atmosphere, and the value of the absolute speed of light, there exist laser ranger instrument errors, including errors caused by the finite length of the laser pulse, instability of electronics, time maintenance and the calibration technique. The key requirements for a laser transmitter are short pulse length, high energy (power), and reliability of performance in individual instances. A Q-switched ruby laser met all the requirements for a first-generation transmitter. This utterly simple system generates a pulse 20 ns in length with a mean power of 1 W, but even the use of systems which determine the center of momentum and of systems with memory has not made it possible to use this laser in a second-generation ranger. For the purpose of eliminating errors caused

*The basis of this paper is a report requested for the Third International Conference on Lasers and Their Application, Dresden, 1977.

by the long length of the pulse, it is possible to use methods for forming nanosecond pulses, such as tapping the energy stored in the cavity, or cutting out a pulse from a longer one. If a determination is made of pulse centers in addition, then lasers with a pulse length of a few nanoseconds satisfy second-generation requirements. Third-generation laser transmitters at the present time utilize the principle of mode synchronization and high-speed shutters. The ruby laser is very simple and reliable, but also of interest is the utilization of the second harmonic of a garnet laser and of CO_2 lasers, which are capable of operating under complicated weather conditions. In this paper certain data are presented on the main satellite ranging systems in current use, the Smithsonian, NASA, CNES and Interkosmos.

Introduction

The launching of the first Soviet satellite marked the opening of a new era in science, one of the main trends of which has been space geodesy. At the first stage satellites were photographed against the background of the stars; here the method of cosmic triangulation has made it possible to determine chords a few thousand kilometers long, for the purpose of arriving at the shape and dimensions of Earth with high accuracy. The results of satellite observations have also been used in geophysics, astronomy, etc. Because of atmospheric turbulence and the errors of the instruments used, the accuracy in measuring distances had not exceeded 10 to 100 m. The appearance of lasers made it possible to measure directly the distances to satellites [1], by combining laser and photographic observations or by using laser methods alone. The "Great Arctic-Antarctic Chord" [2] and "Standard Earth III" [3] projects utilized laser measurements with success.

The key requirements for a laser transmitter are a short pulse, high power and low beam divergence, and the ranging set should have a moderate size and high reliability. The pulsed lasers which have appeared [4] satisfy these requirements. For example, a moderate-size (as compared with a microwave transmitter) ruby laser emits a pulse 10 ns long with an energy of 1 J and 3 mrad divergence; with a 1 Hz repetition rate the system provides about 10^5 bursts. For the purpose of amplifying the operating signal, in satellites have been installed corner reflectors [1], which amplify the reflected signal by a factor of 10.

1. Energy Balance of a Laser Ranger

The energy balance of a ranger is determined by the ranger equation. The magnitude of the reflected signal at the point of location of the laser is determined by the expression $E/D_\lambda^2\theta_\lambda^2$, where E is the energy, D_λ is the diameter of the beam, θ_λ is the angular divergence. Key first-generation rangers are described in Yu.L. Kokurin's survey [5]. In fig 1 the ranger equation is presented in graphic form by using the parameters of the Interkosmos ranger [6].

2. Satellites with Corner Reflectors

The optical characteristics of satellites with corner reflectors are given in table 1 [7-10]. The Geos, Beacon, Diadem and Interkosmos-17 are multiple purpose satellites. The large number of different instruments on these satellites has hindered a determination of the center of mass in relation to reflectors with the degree of precision needed for special investigations. For the purpose of obtaining data meeting second-generation requirements, it is necessary to make not less than 10 measurements over a 10 s period. The Starlett and Lageos satellites were protected from such interference as the influence of the atmosphere and the light pressure of the Sun. These are spherical satellites with high specific weight: Starlett--icosahedron; composition: uranium-238, 1.5 percent molybdenum; specific weight 18.7; mass 35.5 kg; number of reflectors 60; launched 6 Feb 75. Lageos--sphere, 60 cm diameter; mass 400 kg; number of reflectors 440; launched 4 May 76.

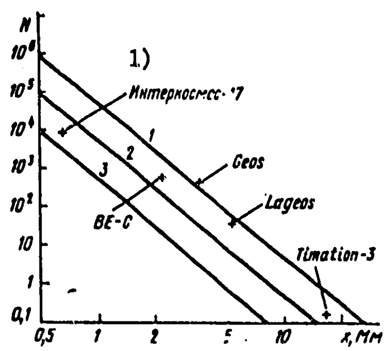

Figure 1. Graphic Representation of Ranger Equation for the Interkosmos Laser Ranger: Energy 1 J; inlet aperture of receiver's telescope 0.07 m^2; beam divergence of laser transmitter 0.6 mrad; nominal atmospheric transmission 60 percent; quantum yield, taking into account all losses of receiver, 1.5 percent [6]; x--distance to satellite; N--number of photoelectrons; ratio of effective area of satellite and angle of divergence of reflectors equal to 10^7 (1), 10^6 (2) and 10^5 (3) m^2/segment

Key:

1. Interkosmos-17

3. Causes of Errors

At the present time instrument errors are determined by the following factors: length of the laser's pulse, the recording unit, and reflectors. The first factor: For the purpose of creating a simple laser transmitter only a multimode laser is used; therefore, it is necessary to operate with a long pulse with an unspecified beam structure [11,12], which increases the error. The second factor: With a not too great number of registered photoelectrons there occurs distortion of the form of transmitted signals and of reception signals

[6,13,14]. The shapes of signals obtained by means of a computer [15] are shown in fig 2. The third factor: Reflection from several reflectors results in signal interference and additional indeterminacy. With a long pulse rise time, for the purpose of reducing the error, instead of a constant discrimination threshold systems have been employed successfully which determine the middle of the leading edge of the pulse or which determine the center of energy of the pulse [13,14,16], but, as is obvious from figs 2 and 3, this is possible only with high signal levels. The first and second factors, as well as the weak anticipated signal from Starlett and Lageos (cf. fig 1), definitely reduce the problem's solution to shortening of the laser pulse. A laser with a pulse length of 4 to 5 ns and a device which determines the center of energy of the pulse can be a compromise solution for second-generation rangers. In fig 4 [9] is illustrated the anticipated improvement in precision when using a laser pulse with a length of 5 ns.

Table 1.

1) Спутник	4) Орбитальное расстояние, Мм	Эффективная площадь (угол расходимости отражателей), 10^6 м²/ср 5)	Относительные отраженные сигналы от спутников, 10^{-18} м⁻²/ср 6)	
			7) Зенит	8) Высота 45°
BE-B	1,13	2,9	2,92	0,918
BE-C	1,00	2,9	4,6	1,47
GEOS I (A)	1,95	13	3,96	0,026
GEOS II (B)	1,53	13	18,2	0,127
GEOS III (C)	0,93		4,01	10
LAGEOS	5,9	6,2	0,0089	0,0047
APOLLO 11, 14	120	40	$0,8\cdot10^{-8}$	$0,8\cdot10^{-8}$
APOLLO 15	360	120	$2,38\cdot10^{-8}$	$2,33\cdot10^{-8}$
STARLETT	0,92	0,55	0,767	0,24
TIMATION III	14,0	2,5	0,00268	0,00183
Геостационар 2)	38.7		$2\cdot10^{-6}$	
Интеркосмос 3)	0,5	0,232	3,72	0,74

Key:
1. Satellite
2. Geostatsionar
3. Interkosmos
4. Orbital range, thousand meters
5. Effective area (angle of divergence of reflectors), 10^6 m²/segment
6. Relative reflected signals from satellites, 10^{-18} m⁻²/segment
7. Zenith
8. Elevation 45°

Let us consider the various causes of errors in detail. Let us assume that the laser has a pulse length of 4 ns, that an appropriate target is used in calibration, a corner reflector, for example, and that 100 measurements are made (which ensures a precision of ± 0.5 cm). Taking into account errors introduced by the atmosphere (± 0.6 cm) and the precision of the calibration instruments (± 1.5 cm), we get a precision of ± 1.7 cm.

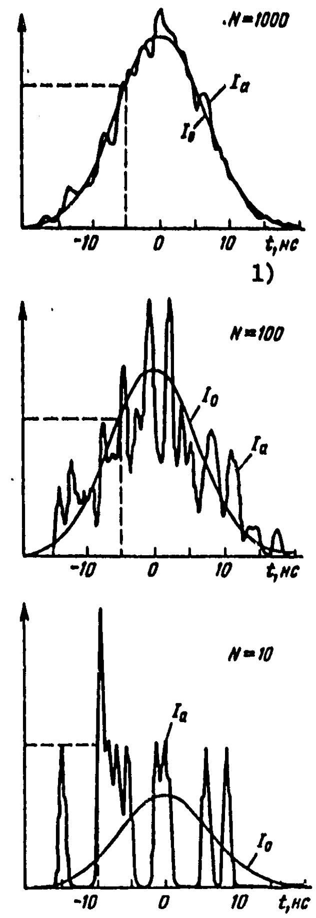

Figure 2. Shape of Reflected Signal Obtained by Means of a Computer (N--total number of registered photoelectrons; I_a--current of photomultiplier, $I_0 = \langle I_a \rangle$ [15]).

Key:

1. t, ns

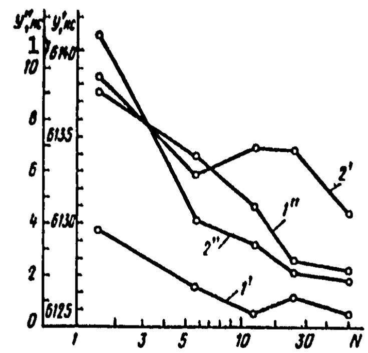

Figure 3. Calibration of Laser Ranger By Means of a Target, in Determining Middle of the Leading Edge of Pulses (1) and in Determining the Center of Energy (2) (Santiago de Cuba, 5 Jun 77; 20 measurements for each point): y' = x/c ; y"--mean error of y' .

Key:

1. y", ns

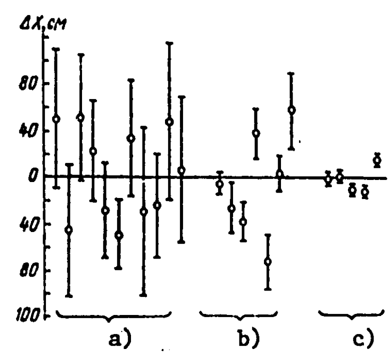

Figure 4. Comparison of Results of Satellite Ranging (Δx--error) for First- (20 ns, a and b) and Second- (5 ns, c) Generation Rangers with a Constant Discrimination Threshold (a) and While Determining the Center of Energy (b and c)

The accuracy of determining the center of energy with a single measurement is 10 cm. If it is assumed that during a period of 10 s the satellite does not experience considerable disturbances, then with 10 measurements during this period the confidence interval equals 3.3 cm. Non-systematic errors introduced by the laser ranger's electronics equal, in NASA's experience, 4 cm (the loran C timing service, for example, enables referencing of ± 5 μs, which results with a satellite speed of 7 km/s in indeterminacy of 3.5 cm). The atmospheric model employed by NASA, based on the temperature, pressure and humidity at the observation point, it is true, gives an error of 0.5 cm [17,18], but we will use 3 cm as a precaution. The indeterminacy introduced by a first-generation satellite equaled 9 cm, and with 10 measurements the reliability equaled 2.9. Taking into account all the errors presented below, we get a maximum total error on the order of 7.7 cm. which meets the requirement for second-generation rangers.

4. Laser with a Short Pulse

For the purpose of Q switching of a laser it is possible to utilize electro-optical shutters, revolving mirrors or coated filters. The length of a laser's pulse is fundamentally limited by the lifetime of photons in the optical cavity [19]. An ordinary pulse under multimode conditions has a length of 15 to 30 ns, which depends on the geometrical parameters of the optical cavity, the Q and the gain. A combination of electro-optical shutters and revolving mirrors with coated filters [20,21] eliminates the appearance of a spurious pulse, makes it possible to increase the gain and, consequently, to shorten the pulse. Even if a semitransparent mirror reflects eight percent, the energy and output are raised to a level which destroys a ruby; therefore, in ruby lasers it is difficult to expect an output higher than 200 MW/cm^2.

At the present time there are two variants for obtaining pulses with a length of a few nanoseconds. Both variants are based on chopping a giant pulse inside the laser cavity by utilizing an electro-optical shutter inside and outside the cavity. It is possible to control electro-optical shutters by means of a spark gap or an electronic high-voltage shaper. With the variant whereby the cavity is "opened," the length of the pulse is equal to the time the radiation passes through the length of the cavity and theoretically it is possible to tap almost all the energy stored in the cavity. A disadvantage is a possible avalanche-type pulse rise, resulting in damage to the ruby. With the second variant the rise time and the maximum length of the pulse depend only on the speed of response of the electro-optical shutter and control circuits and it is fairly simple to obtain a one-nanosecond pulse (according to some data [22], even a pulse with a length of 100 ps). The reliability of this equipment is high, and they have been used, for example in [9,12]. A disadvantage is great losses of energy and the necessity of using boosting amplifiers.

Two variants are employed also for the purpose of obtaining sub-nanosecond pulses. The first variant consists of obtaining them by means of the electro-optical shutters mentioned in the paragraph above. The second variant is a laser with mode synchronization. In both instances it is necessary to use several amplifiers. Mode synchronization can be obtained by the active or passive method for ruby [23-25] and garnet [26]. A garnet laser with active mode synchronization has a pulse length of 100 ps, and of 20 ps with passive. For the time being passive shutters are being used for a garnet laser only under laboratory conditions; passive shutters have been used more extensively for ruby; for example, the Quantel firm [23], using a passive glass shutter, has come up with a ruby laser with an energy of 2 J, a pulse length of 1 ns and a repetition rate of 0.25 Hz. The Silvania firm, employing active switching, has developed a garnet laser with similar parameters: 0.25 J, 0.3 ns and 3 Hz in the green band.

Table 2.

1) Программа	3) Число действующих станций	4) Предполагаемое число станций на 1977-1980 гг.	5) Измеряемые спутники в настоящее время	6) Предлагаемые измерения спутников 1977--1980 гг.	7) Количество станций с двумя радарами	8) Системы наведения
Интеркосмос 2)	4	8	BE—B	Lageos	1	Визуальная 10)
SAO	4	4	Lageos	Lageos	3	Автоматическая 11)
GSFC	3	7	Lageos	Timation	1	«
CNES	1—2	3	Starlett	Starlett	1	«
ONERA	1	1	Starlett	Starlett	1	«
LUNAR	1—2	8	Все отражатели на Луне 9)	Все отражатели на Луне	1	Визуальная и автоматическая 12)

Key:
1. Program
2. Interkosmos
3. Number of active stations
4. Proposed number of stations for 1977-1980
5. Satellites measured at present time
6. Proposed satellite measurements for 1977-1980
7. Number of stations with two rangers
8. Guidance systems
9. All reflectors on Moon
10. Visual
11. Automatic
12. Visual and automatic

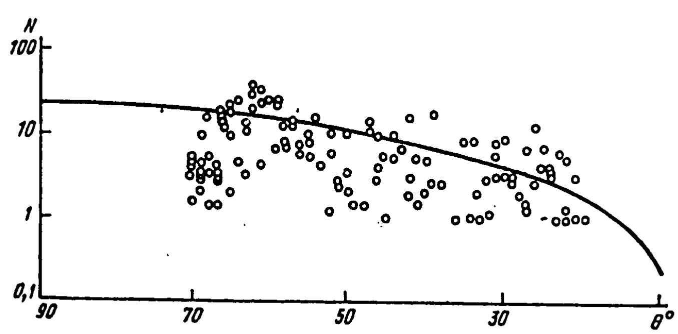

Figure 5. Results of Finding of the Lageos Satellite by the Smithsonian Observatory (Arizona) [30] (θ--altitude of satellite above horizon; curve--calculated signal amplitude)

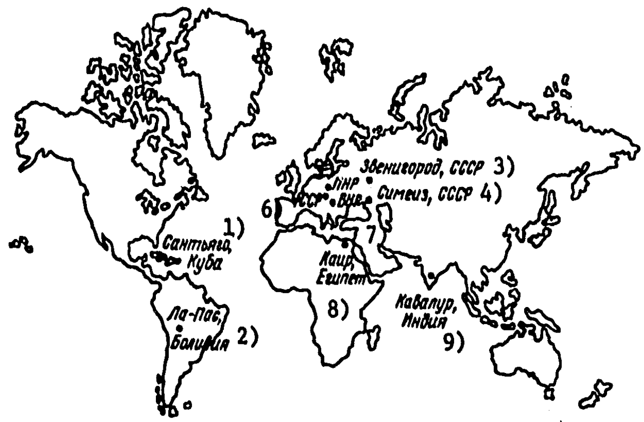

Figure 6. Location of Rangers of Interkosmos Program (July 1977)

Key:

1. Santiago, Cuba
2. La Paz, Bolivia
3. Zvenigorod, USSR
4. Simeiz, USSR
5. Polish People's Republic
6. CSSR
7. Bulgarian People's Republic
8. Cairo, Egypt
9. Kawalur, India

The pulse repetition rate is determined on one hand by the desired accuracy, and on the other by the energy capabilities of the laser transmitter, whereby the requirements for reliability are taken into account. For the purpose of obtaining satisfactory precision it is desirable to make measurements once per second. Furthermore at work is the practical limitation of the impossibility of in general obtaining in experiments [27] a degree of accuracy greater than one tenth of a single measurement. The error in measuring the range of a pulsed optical system depends on $N^{-1/2} \cdot n^{-1/2}$, where N is the total number of photons and n is the number of averaged measurements. For ruby the effective repetition rate equals from 1 [6] to 1/30 Hz [14]. Increasing it involves great difficulties in cooling the ruby. In a garnet laser the repetition rate reaches 3 Hz [28,29].

5. Current Satellite Laser Systems

The number of stations and their chief characteristics are given in table 2, taken from the paper by M.R. Pearlman and G. Geygnebet and the author in [8]. There also mention is made of development prospects on the whole. From the information available to this writer for June 1977 the plans are being successfully fulfilled. In fig 5 is illustrated finding of the Lageos satellite by the Smithsonian Observatory [30] in Arizona (1 J, 4 ns). The location of Interkosmos rangers is shown in fig 6 [31-33].

Conclusion

Discussed above is the feasibility of measuring distances to artificial satellites, whereby the problem is analyzed basically from the viewpoint of the design of a laser transmitter. Analysis has shown that for second-generation laser rangers it is simplest to use nanosecond lasers while making a determination of the center of energy when registering signals. A sub-nanosecond laser is needed for third-generation rangers.

Accuracy (in cm) of Laser Ranging with a Pulse Length of 4 ns

Calibration	1.7
Ranging accuracy ($10/\sqrt{10}$)	3.3
System instability	4.0
Time referencing	3.5
Atmospheric correction	3.0
Correction for reflectors ($9/\sqrt{10}$)	2.9
Total r.m.s. error	7.7

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8831
CSO: 8144/0727

PHYSICS

A STUDY CONCERNING THE USE OF LUMINESCENT SCREENS OF ZnS, CdS-Ag, OR Ni FOR THE RECORDING OF PULSED INFRARED LASER RADIATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 11, Nov 78 pp 2451-2453 manuscript received 6 Feb 78

[Article by Yu. A. Drozhbin, L. M. Zaytsev, L. N. Ivashneva, V. M. Klyuchnikov, V. Ye. Prokopenko and V. S. Trachuk, All-Union Scientific Research Institute of Optico-Physical Measurements, Moscow]

[Text] 1. Introduction

The quenching phosphors ZnS, CdS-Ag and Ni are among the most promising recording media for visualization of the spatial radiation pattern of lasers in the infrared range of the spectrum [1-3].

Inasmuch as phosphors of this kind have no memory, a problem in recording pulsed laser radiation on luminescent screens made with these materials is retrieving the information.

The method of recording infrared radiation on luminescent screens with continuous ultraviolet intensification is employed for visualization of radiation fields of continuous-emission lasers [4]. Recording the radiation of pulsed lasers by this method yields only low-contrast low-resolution quench patterns [5]. The main limitations here are the insufficient intensity of screen glow and the difficulty of synchronizing a photographic or kinematographic attachment with the recorded radiation pulses.

In this study the problems of synchronizing and of ensuring a high intensity of screen glow were solved by exciting the screen with ultraviolet pulses synchronized with the infrared radiation pulses. The photographic attachment operated in the driven mode. Short frame exposures, determined by the duration of glow of the luminescent screen, had made it possible to realize conditions for obtaining infrared quench patterns with a high spatial resolution [6].

In this study were examined the recording characteristics of luminescent screens on ZnS, CdS-Ag, or Ni at wavelengths up to 10.6 μm.

2. Apparatus for Measurement of the Recording Characteristics of Luminescent Screens

A schematic diagram of the experimental apparatus is shown in Figure 1. As the source of near-infrared radiation served a GOS-301 generator (1) on neodymium glass ($\lambda = 1.06$ µm) operating in the free-emission mode. The duration of a recorded microsecond pulse was measured with an SFR-IK high-speed camera (2) which had a mirror sweep and operated in the frame-by-frame mode. The laser radiation was passed through a set of light filters (3) and then aimed through a beam shaping optical system (4) at the window of the SFR camera.

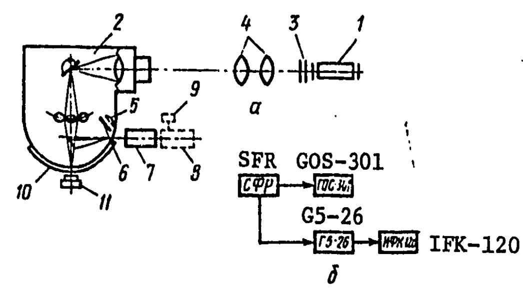

Figure 1. Schematic Diagrams of the Apparatus for Studying the Recording Characteristics of Luminescent Screens (a) and of the Synchronization System (b)

Pulse excitation of the luminescent screen was achieved by means of an IFK-120 flash tube (5), its ultraviolet spectrum having been notched out by UFS-2 and UFS-4 light filters (6). The energy of a recorded pulse was determined with an IMO-2 calorimeter (7). Its shape and duration were determined with an FD 9E-111 photodiode (9) and on an S1-17 oscillograph (8). The duration of an intensifier flash was varied from 40 µs to 2.5 ms, its energy remaining approximately 5 J.

Synchronization of an ultraviolet intensifier flash with a recorded infrared radiation pulse was ensured with the aid of a delay system controlling the G5-26 pulse generator.

A glow pulse from the luminescent screen (10) spread over the focal arc of the SFR-IK camera coincided in time with a quenching pulse, as a result of synchronization, while the visualizable pattern was recorded with a photographic attachment (11) operating in the driven mode.

The delay of ultraviolet intensifier flashes could be regulated from 1 µs to 1 s, making it possible to record various phases of the phosphor quenching process.

The following crystalline phosphors with the peak intensity of glow at about the 0.56 µm wavelength were examined in this study: $ZnS_{0.5}CdS_{0.5}$ $-3\cdot 10^{-4}Ag$; $3\cdot 10^{-6}Ni$. The phosphor was deposited on a thin (6 µm thick) Terylene film which had been precoated with a 5-10 nm thick aluminum layer serving as a nonselective heat absorber. The phosphor film was about 30 µm thick.

3. Analysis of the Characteristics of Luminescent Screens

The study of luminescent screens on a thin Terylene film has revealed that during recording of radiation at the $\lambda = 1.06$ µm wavelength for pattern visualization there occur two quenching modes staggered in time (Figure 2).

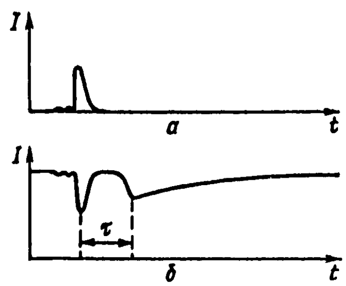

Figure 2. Recorded Trace of Quenching of a Luminescent Screen

The first quenching mode is inertialess (Figure 2b), the quenching pulse here coinciding here in time with the recorded infrared radiation pulse (Figure 2a) and the duration of quenching corresponding to the duration of that pulse. Characteristics of the luminescent screen determined by the first quenching component have been plotted for radiation pulses 40-600 µs long. The sensitivity threshold of the screen was in this case $E_0 = 5$ mJ/cm^2.

The conversion characteristic of such a luminescent screen is shown in Figure 3. The number of screen gradations, determined by the number of noise spikes along the conversion characteristic plotted to a logarithmic scale, is $D^* \sim 20$ over the entire range. The resolving power of this screen was R = 14-15 mm^{-1} and its time constant, determined by the quenching relaxation time, was $t_r \sim 50$ µs.

The second quenching mode is inertial, the quenching pulse here being shifted relative to the infrared radiation pulse by a time τ the length of which depends on thermophysical properties of the screen material. The screen characteristics corresponding to the second quenching component were: $E_0 = 70$ mJ/cm^2, $D^* = 6$-8, R = 12-14 mm^{-1} and $t_r \sim 0.1$ s. The conversion characteristic of this screen is also shown in Figure 3.

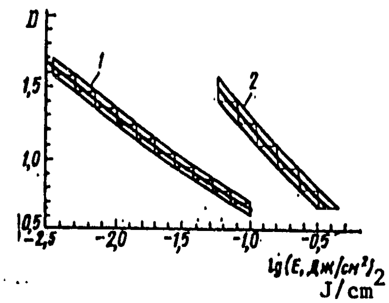

Figure 3. Conversion Characteristic of a Luminescent Screen Corresponding to the Inertialess Quenching Mode (1) and the Thermal Quenching Mode (2): E, J/cm^2

For the purpose of explaining the mechanism of these different quenching modes, additional tests were performed at the $\lambda = 1.06$ μm radiation wavelength. These tests, performed with phosphors on bulky 1 mm thick substrates of acrylic glass, revealed the same first quenching mode but a different second quenching mode with the sensitivity threshold there higher (up to 0.5 J/cm^2) than in the case of screens on thin Terylene substrates.

Recording on screens on thin Terylene substrates without a layer of heat absorber (semitransparent aluminum layer) revealed that the second quenching mode had vanished while the first one had remained without change.

The energy characteristics of screens were measured at the wavelengths $\lambda = 0.69$ μm (OGM-20 laser in the free-emission mode, with a radiation power of approximately 10 kW) and $\lambda = 10.6$ μm (LG-25 laser in the continuous mode, with a radiation power of approximately 10 W). The sensitivity threshold was 0.1 J/cm^2 and 0.3 J/cm^2 respectively.

A comparison between these data indicates that the mechanism of the first quenching mode is not a thermal one and is characterized by selectivity. The mechanism of the second quenching mode is thermal.

With regard to the thermal mechanism of quenching of a luminescent screen, it is interesting how the parameters of the quench pattern change depending on the manner of ultraviolet intensification. When the phosphor is excited continuously, then the sensitivity threshold of the screen is rather high ($E_0 \sim 10$ mJ/cm^2). In the case of pulse excitation, on the other hand, the high intensity of ultraviolet excitation lowers the threshold sensitivity of the screen to $E_0 \sim 100$ mJ/cm^2.

The main advantage of visualization of infrared radiation with the aid of pulsed ultraviolet intensification is that this method ensures a much higher resolution of the recorded quench pattern: $R = 12\text{-}14$ mm^{-1} (compared with 2-3 mm^{-1} in the case of continuous intensification [5]). This means that during visualization infrared radiation on luminescent screens with quenching there occurs, depending on the manner of information retrieval, a redistribution of the recording characteristics of the screen.

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CSO: 8144

PUBLICATIONS

TERMINAL COMPLEXES IN COLLECTIVE-USE COMPUTER SYSTEMS

Moscow TERMINAL'NYYE KOMPLEKSY V VYCHISLITEL'NYKH SISTEMAKH KOLLEKTIVNOGO POL'ZOVANIYA in Russian 1978 signed to press 2 Feb 78 pp 2, 102-103, 108-110

[Annotation, conclusion, list of abbreviations and table of contents from book edited by E. A. Yakubaytis, Izdatel'stvo "Statistika", 18,500 copies, 109 pp]

[Text] Authors listed on reverse of title page: V. V. Pirogov, L. P. Bogomolov, S. F. Gaysterov and I. P. Svirskiy.

The book reflects a modern trend in the development of hardware complexes for automated control systems: hierarchical multimachine collective-use computer systems. The main modes of operation of minicomputer terminal complexes in combination with a central computer in the performance of data processing tasks are discussed.

The book is intended for specialists in the study, planning and use of computer systems, and for students in the corresponding majors.

Conclusion

The terminal complexes whose structures are presented in this book are the main connecting link between powerful modern computer systems and the constantly increasing number of users. The effectiveness of construction of terminal complexes determines the effectiveness of operation of the entire computer system. The constant improvement of computer hardware and the expanding range of components demand a continuous search for ways of improving the efficiency of its use in all areas. In this connection, the design of terminal complexes oriented to the performance of user tasks and capable of distributing the functions to be performed between the computation capacities of the terminal complex itself and of the computer system to which they belong will make it possible to attain important results. This entails particularly the assurance of effective user access to computer system resources and also the attainment of better technical characteristics for the operation of the computer system as a whole.

Minicomputers must be considered a natural way of implementing terminal complexes, since they make possible the most economical matching of user requirements to the capabilities of modern computers. At the same time, in view of developmental trends in the statewide and international computer networks, terminal complexes using macrocomputers will be developed and put into operation in the near future.

The extensive practical use of microcomputers and microprocessors will have considerable importance in the design of terminal complexes. Their emergence has brought about fundamental changes in many aspects of structure in the design of an extremely wide range of computer systems. The authors do not consider it possible at present to forecast an expected terminal complex structure based on microprocessors, much less to give technical parameters and operating characteristics of such terminal complexes. However, realizations of certain logical terminal functions, particularly interface functions, with microprocessors are already known. The practical experience of their use will make it possible in the future to determine the design characteristics of terminal complexes based on microcomputers and microprocessors.

The book devotes considerable attention to the structural characteristics of terminal complexes in hierarchical computer systems, since the Institute of Electronics and Computers has accumulated experience in designing these during the development of the Latvian SSR Academy of Sciences experimental computer system. In this connection, the authors express their gratitude to the staff members of the institute who offered technical material on the experimental computer system of the Latvian SSR Academy of Sciences that was used in this book, and who have offered valuable comments during the manuscript stage.

List of Abbreviations

ARM	Avtomatizirovannoye rabocheye mesto Automated work place
APD	Apparatura peredachi dannykh Data transmission device
AP	Abonentskiye punkty User stations
VZU	Vyzyvnoye ustroystvo Calling unit
VS	Vychislitel'naya sistema Computer system
VS KP	Vychislitel'naya sistema kollektivnogo pol'zovaniya Collective-use computer system
DSM	Dialogovaya sistema modelirovaniya Interactive simulation system

DRM	Dialogovoye rabocheye mesto Interactive work place
ZU	Zapominayushcheye ustroystvo Memory unit
IP	Informatsionnyy protsessor Information processor
KS	Kommutatsionnaya sistema Switching system
MIS-28	Mezhmashinnyy interfeys [simmetrichnyy] [Symmetrical] inter-computer interface
MPD	Mul'tipleksor peredachi dannykh Data transmission multiplexor
NDP	Neposredstvennyy dostup k pamyati Direct access to memory
OP	Osnovnoy protsessor Main processor
PMP	Paket modeliruyushchikh programm Package of simulation programs
PMT	Programmiruyemyye mini-mashinnyye terminaly Programmable minicomputer terminals
PZU	Postoyannoye zapominayushcheye ustroystvo Read-only memory [ROM]
RMK	Raspredelennyye mini- i mikromashinnyye komplexy Distributed mini- and microcomputer complexes
RPS	Raspredelennyye programmnyye sistemy Distributed programming systems
SU	Sistema upravleniya Control system
SP	Svyaznoy protsessor Communications processor
SAP	Sistema avtomatizatsii proyektirovaniye Automated design system
TK	Terminal'nyy kompleks Terminal complex

TIP	Terminal'nyy interfeysnyy protsessor Terminal interface processor
TMK	Terminal'nyy mini-mashinnyy kompleks Terminal minicomputer complex
TMS	Terminal'naya mini-mashinnaya stantsiya Minicomputer terminal station
TP	Terminal'nyy protsessor Terminal processor
USO	Ustroystvo svyazi s ob"yektom Device for interface with a process
UVS	Uzel vychislitel'noy seti Node of a computer network
UPS-TG	Ustroystvo preobravovaniye telegrafnykh signalov Telegraph signal converter
UZO	Ustroystvo zashchity ot oshibok Error protection device
TsP	Tsentral'nyy protsessor Central processor
TsBD	Tsentralizirovannyy bank dannykh Centralized data bank
EVM-R	Rabochaya elektronno-vychislitel'naya mashina Working computer
EVS	Experimental'naya vychislitel'naya sistema Experimental computer system

Contents

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PUBLICATIONS

MODELING WITH ANALOG COMPUTERS

Moscow OSNOVY MODELIROVANIYA NA ANALOGOVYKH VYCHISLITEL'NYKH MASHINAKH (Fundamentals of Modeling on Analog Computers) in Russian 1978 signed to press 6 Apr 78 pp 2-6

[Annotation and table of contents from book by A. S. Urmayev, S. V. Yemel'yanov, editor, second edition, revised and expanded, Izdatel'stvo Nauka, 39,000 copies, 272 pp]

[Text] This textbook presents in a systematic manner the fundamentals of programming analog computers for solving engineering and technical problems. This book presents the principles of operation of the analog computer and its principal operational units; the author presents general methods of programming analog computers and examines methods of solving specific classes of problems. The material contained in this textbook is illustrated with a large number of examples and contains a substantial number of problems for independent solving.

This textbook is intended for students of all specializations at higher technical schools and can be utilized by instructors in engineering and special departments in preparing lectures and practical classes for courses focused on utilization of analog computers. This book can be of use to engineers and technicians who use analog computers in their work.

The first edition of this book was published in 1974.

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PUBLICATIONS

AUTOMATED CONTROL SYSTEMS AND ADAPTATIONS

Novosibirsk AVTOMATIZIROVANNYYE SISTEMY UPRAVLENIYA I IKH ADAPTATSIYA (Automated Control Systems and Adaptations of Them) in Russian 1976 signed to press 23 May 1977 p 2-8, 112

[Annotation, introduction and table of contents from book by I. M. Bobko, edited by G. I. Marchuk, Nauka, 3,600 copies, 112 pages]

[Text] The development of projects for building automated control systems has posed a number of problems of a procedural nature connected with the selection of the structural design of the systems, the organization of the information base and the solution of the problems of reproduction and circulation of the systems.

This paper is devoted to the construction of automated control systems and studies in the field of systems structure, information aspects and other problems determining the efficiency of automated control systems. A special role is played by the problems of creating adaptive automated control systems having a base version which can be adjusted in accordance with the parameters of a specific enterprise.

The book is designed for engineers, mathematicians, economists dealing with the problems of control automation and also students in the higher courses at the institutions of higher learning.

Introduction

The projects for the construction of automated enterprise and branch control systems in the Soviet Union have received special development at the beginning of the 1960's which has been promoted to a significant degree by the special resolutions of the party and government with respect to these problems. At that time scientific collectives were created or began to be shaped capable of formulation and substantiation of the principle directions of the creation of automated control systems permitting a sharp increase in effectiveness of the control processes.

The works by L. V. Kantorovich, G. I. Marchuk, V. M. Glushkov, N. P. Fedorenko, A. G. Aganbegyan and other great scientists set forth the scientific and procedural principles of building automated control systems. It is important to emphasize that in a country with a socialist economy, the methods of improving production efficiency are distinguished to a significant degree from the methods of intensification of production in the capitalist world. In our country, in contrast to the capitalist companies and monopolies, a unified, planned national economy will permit consideration of such areas in the methodology of automation of control as the national automated system, an integrated network of computer centers of the country, the national economic planning system, the methods of providing incentive for productivity of labor under the conditions of the socialist and production relations, and so on.

The collectives of the cybernetics institute of the Ukrainian SSR Academy of Sciences, the Central Mathematical Institute of the USSR Academy of Sciences, the Mathematics Institute, the Computer Center, the Institute of Economics and Organization of Industrial Production of the Siberian Department of the USSR Academy of Sciences, and others have made an enormous contribution to the development of the scientific principles of control, the creation of the methodology of constructing automated control systems and the practical implementation of the scientific results in production.

Various scientific research institutes and design organizations have been created for the development and introduction of the automated control systems. These institutions, in close contact, on the one hand, with the leading academic collectives and, on the other hand, directly with industry, not only have created and introduced a number of effective automated control systems, but also to a significant degree have formulated and developed the scientific areas in the matter of management and control.

The active period of the construction of information automated control systems (the Eighth and Ninth Five-Year Plans) can basically be characterized by the work in the following areas.

1. The creation of a technical base for automation of control. This is not only the development of computers having large memories, high speed and a capacity for performing the operations needed for the automated control systems. This is also the development of the data transmission equipment which must ensure communicableness of the information both inside the enterprise and within the framework of the interaction of the enterprise with the branch and within the region framework. This is also the creation of new peripheral devices ensuring effective interaction of man and computer, production process and computer. This is also the creation of systems which operate in the time sharing mode which not only are to improve the productivity of the calculated resources, but also to improve the productivity of administrative labor and the necessary conveniences in the work of the personnel.

2. The penetration of computer engineering and mathematical methods into the sphere of management and control requires changes in the customary forms

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and methods of operation not only on the part of the administrative personnel, but also on the part of the entire collective of the enterprise or institution. Therefore the study of the social behavior of man under the automated control system conditions, changes in his functions and the general structure of the administrative agencies is one of the important elements in automated control systems which have a significant effect on the operating stability of the system, the reliability of the data in the control documents, and the "viability" of the system as a whole.

3. Computers, computational mathematical and economic cybernetic methods have had a significant influence on the improvement of methods of solving functional problems in the direction of their substantiation, operativeness and quality improvement.

4. Inasmuch as the control problems are basically information processes, the organization of the information management in automated control systems has primary significance. The operation of the enterprise or institution under automated control system conditions requires a specially organized information base. The information system changes its structure, forms of representation and composition. The expenditures of the automated control system on information and computer time, which significantly influences the efficiency of the system, depend on the proper construction of the information base.

5. It is natural that the use of computers in control problems requires a special statement and program execution of the control problems and the problems ensuring efficient functioning of the information base. Accordingly, the demand has arisen for the creation of automated programming systems and special divisions of algorithm theory.

6. The practical implementation of automated control systems differs significantly from the introduction of new equipment at the enterprises (new technological processes, new equipment and new products). The automated control system influences the functions and the operating style of almost the entire collective. Therefore the procedures used in organizing the development and introduction of the automated control systems, the sequence and methods of solving the problems in this process also are becoming a special division of research.

7. The series production of automated control systems or an individual approach to each individual enterprise is a problem of commensurate expenditures on the creation of automated control systems and their efficiency. The development of the standard systems is cheaper, but as a rule, such systems offer little cost benefit at the specific enterprises, they are not adaptable in general, or expenditures commensurate with the development of the standard design are required for the coordination of the standard systems. The path toward the creation of standard design solutions from which it is possible to construct the specific automated control systems also does not solve the problem completely. It is necessary to create adaptation systems by which it is possible automatically to adapt the base

version of the automated control system to the specific conditions and requirements of the enterprise.

8. Finally, the information automated control systems have the purpose not only of operatively, reliably and qualitatively informing the administrative agencies about the course of the production process, deviations from the planned operating conditions, information processing, performance of the necessary calculations and generation of defined planning and administrative decisions, but also ensurance of conversion to optimizing systems, the creation of information conditions for inclusion of the procedures for optimizing the planning decisions on various planning and control levels, the procedures for statistical analysis of the state of the production process and the solution of the forecasting problems in the software for the operating automated control systems. The most important role must be played by the information automated control systems in creating simulation models of the operation of individual production elements on various levels. These models permit various types of reorganization in production to be played and evaluated in order to improve the basis for such reorganizations.

The scientific areas connected with the creation of automated control systems have been formed for the most part in the process of realizing scientific results in specific systems. At the present time a large number of automated control systems have been built in the country which are operating efficiently both at the individual enterprises and in entire branches. Many of them are operating successfully not only where they were first created but also at the other enterprises of the country. These are, for example, the widely known L'vcv, Barnaul, Kuntsevo, and Svetlana systems, the branch control system of the USSR Ministry of Instrument Making and a number of others.

A great contribution to the development and introduction of automated control systems at the enterprises and branches has been made by the great scientists of our country V. M. Glushkov, N. P. Fedorenko, G. I. Marchuk, A. G. Aganbegyan, V. I. Skurikhin, A. A. Stogniy, V. V. Shkurba, A. I. Kitov, A. A. Modin, S. A. Dumler, O. V. Kozlova, N. P. Lapshin, and so on.

The purpose of this book is to generalize the experience in the creation of procedural principles and the practical development and implementation of automated control systems at the industrial enterprises, including the methodology of constructing the information automated control systems and the means of conversion to the optimizing automated control systems.

In the principal sections we shall consider the following problems.

a) The structure and composition of the automated control system. The breakdown of the automated control systems into functional subsystems is appropriate in the development and selection of the methods of solving functional problems. During the process of implementing these problems on the computer, this form of decomposition leads to excess expenditures on the creation of the information base which is charged with provision not only for the individual functional problems (planning, accounting, analysis, and so), but the control system for the project as a whole. Here direct communications and feedback of the control system are well ensured. During the formation of the structure and the composition of the automated control system, it is proposed that formal methods of statistical classification be used. The expediency of this approach is confirmed in practice. A number of basic principles of the construction of automated control systems have been formulated.

b). It is necessary to attach great significance to the investigation of the information base of the automted control systems. The creation of an efficient data gathering system will permit a sharp reduction in expenditures on gathering the initial data of the automated control systems, significant improvement of the reliability of these data and ensurance of operativeness. The structure of the information files and the system for representation of the permanent storage information essentially influenced the economy of machine time. Therefore a special study has been made of the structures of the information files, and the method of information compression in the computer memory has been developed and implemented. The necessity for constructing the economical information bases has influence on the operating conditions of the operation systems. The structure of the information base as a whole must correspond to the multilevel nature of the control systems. The observation of this condition will also lead to economicalness in the information system.

c) With respect to the problems of the hardware for automated control systems, recommendations have been developed for efficient allocation of computer equipment and determination of the correspondence between the requirements of specific automated control systems and the computer configuration.

d) A special role is played by studies in the field of creating adaptive automated control systems. This problem has been investigated from the point of view of automatic regulation theory, and a specific structural design is given for the adaptive software for automated control systems. In the adaptation system three levels are proposed. The first level presupposes the creation of an adaptive data processing system which encompasses the processes of the economic formation of the permanent storage files, the reception and conversion of the current information and the sorting of the initial data for the functional problems. The software on this level is adapted to the information characteristics of the object. The second level adapts standard problems to the specific nature of the object. The third level is designed for implementation of the original specific problems.

e) A study is made of the problems connected with the improvement of the control process. In this section an effort has been made to demonstrate the possibility of the information automated control system to provide for conversion to optimizing systems and systems that can be adjusted to the planned operating conditions. The optimization procedures for prospective and operative planning are capable of being built into the Barnaul type information automated control systems. This is demonstrated in the example of the Barnaul radio plant. The application of the methods of statistical analysis will permit substantiated solution of the problems of diagnosis and forecasting. Under the conditions of automated control systems, the results of the forecasting problems are used in operative production control. The information automated control systems have led to the possibility and necessity for reorganization in the control structure. A study has been made of the problem of using the methods of automatic regulation in the example of labor normatives. The problems of the application of simulation models within the framework of the operating automated control systems have been investigated.

f) The operating experience and the results of creation and functioning of specific systems are generalized.

The entire work is illustrated and substantiated on the Barnaul and Sigma automated control systems that have been built in practice and which were developed by the collectives of the computer center of the Siberian Department of the USSR Academy of Sciences, the IE i OPP Institute of the Siberian Department of the USSR Academy of Sciences, the Barnaul Radio Plant, the Odessa Neptune Plant, the Altay Tractor Electrical Equipment Plant, the API MV i SSO, the NIIsistem Institute of the USSR Ministry of Instrument Making with the participation of numerous enterprises and institutions--users of the Barnaul and Sigma automated control systems.

The authors express their sincere appreciation to the scientific director of the Barnaul and Sigma projects, Academician G. I. Marchuk and also Academician A. G. Aganbeyan for participation in the scientific direction of these operations and attraction of the collectives of the IE i OPP Institute of the Siberian Department of the USSR Academy of Sciences to them.

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PUBLICATIONS

AUTOMATION OF CLASSIFICATION YARD OPERATIONS

Moscow AVTOMATIZATSIYA UPRAVLENIYA SORTIROVOCHNYMI STANTSIYAMI (METODY RESHENIYA ZADACH). TRUDY VSESOYUZNOGO NAUCHNOISSLEDOVATEL'SKOGO INSTITUTA ZHELEZNODOROZHNOGO TRANSPORTA (Automation of Classification Yard Operation (Methods of Task Implementation). Works of the All-Union Scientific-Research Institute of Rail Transport) in Russian No 575, 1977 signed to press 9 Jun 77 pp 2-3, 159-160

[Annotation, foreward, and contents from book edited by Cand. Techn. Sci. V. A. Buyanov, Transport, 1300 copies, 160 pages]

[Text] The work sets forth problems of the technology, data base, and software for the tasks of automating classification yard operations including the processing of initial data, calculations of sorting sheets and schedules, selection of the sequence of train reforming, and calculations of yard operation plans. It examines the task of organizing the functioning of a routine data model of a classification yard. It presents routine data information necessary for ASU operation and the system's normative base. It sets forth problems of program software for reliable ASU functioning.

The book is intended for scientific and engineering-technical personnel involved with problems of the use of computers to automate rail transport work and railroad operations.

46 illustrations, 14 tables, 27 bibliographic references.

Large classification yards constitute one of the crucial links in the organization of the shipping process in rail transport. The concentration of large volumes of car processing in classification yards requires optimalized operation and automation of the processing of various types of information. In recent years, classification yards have made extensive use of modern computer technology and data transmission equipment to handle routine planning tasks. Regularly, four to six times per day, railroad computer centers calculate current plans of train and switching operations for more than 40 classification yards of the network. The Leningrad-Sortirovochnyy-Moskovskiy and Orekhovo-Zuyevo classification yards have adopted complexes of tasks, including a broad array of automation problems.

Between 1971 and 1975, the Laboratory of Automation of Planning and Administration of Yard and Hub OPerations of the Computer Equipment Department of the Ministry of Railways Central Scientific-Research Institute collaborated with computer center personnel of a number of railroads to develop a standard ASTP [automated system of current planning] of the operation of classification yards, using the computers of the railroad computer centers. In collaboration with specialists of the Moscow Railroad the Institute's staff developed an ASU for the Orekhovo-Zuyevo classification yard. On the basis of the experience of developing ASU's for the Orekhovo-Zuyevo and the Leningrad-Sortirovochnyy-Moskovskiy yards, the laboratory and the Project-Design Technology Bureau of the ASUZhT [ASU for Railroad Transport] made basic decisions on standard ASU's for classification yards, based on their-generation computers.

The present work summarizes the experience of research done in the Institute on the development of ASU's for classification yards with regard to methods of organizing the processing of documentary information and handling of technological tasks, including tasks of logical verification and primary technological processing of data from telegraphed schedule sheets, planning of station operations, selection of the sequence of train reception and reforming, optimalization of reforming programs in parallel dispersal, preparation of schedule sheets on departing consists, routine information for station shift commanders, and automation of station accounting.

Remarks and suggestions concerning the book should be sent to: Moscow, 3-ya Mytishchinskaya, 10, Redaktsionno-izdatel'skiy otdel TsNII MPS.

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PUBLICATIONS

FAILURE AND RESTORATION PROCESSES IN DATA TRANSMISSION SYSTEMS

Moscow PROTSESSY OTKAZOV I VOSSTANOVLENIY V SISTEMAKH ID (Failure and Restoration Processes in Data Transmission Systems) in Russian 1977 signed to press 25 Feb 77 pp 2, 113

[Annotation and table of contents from book by V. P. Altarev, G. I. Shakun, and P. I. Trofimov, Izdatel'stvo Svyaz', 4,500 copies, 113 pages]

[Text] This book examines processes of failures and restorations of data transmission systems, models and characteristics of the quality of operation of data transmission systems in an interrelationship with failure and restoration processes. The authors present methods of estimating the probability of connectivity of multiterminal data transmission systems.

This book is intended for scientific personnel working in the area of problems of improving reliability of technical systems and data transmission systems. It can also be of use to persons specializing in applications of theoretical-probability methods.

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CSO: 1870

PUBLICATIONS

HIGH-TEMPERATURE NUCLEAR FUEL

Moscow VYSOKOTEMPERATURNOYE YADERNOYE TOPLIVO in Russian 1978 signed to press 27 Dec 77, pp 1-8, 430-432

[Annotation, table of contents, prefaces and introduction from book by R. B. Kotel'nokov, S. N. Bashlykov, A. I. Kashtanov and T. S. Men'shikov, Atomizdat, 1,600 copies, 432 pp]

[Text] This book provides information on the properties, preparation processes and uses of a promising nuclear fuel, refractory compounds of uranium, plutonium and thorium. Data on radiation stability of these materials and their compatibility with heat carriers and design materials are systematized and critically generalized. Methods of preparing products from them such as sintering, hot pressing, extrusion, gas compression, vibration packing, rotary forging, casting, application of coatings in a pseudoliquefied bed and so on are discussed. The results from a large number of works on refractory materials are examined, making the book useful for workers in other areas of science and technology associated with process development, study of properties and use of special types of high-temperature materials such as oxides, carbides and metal-ceramics.

The book is intended for scientific personnel and engineers involved in the production, applications and investigation of nuclear fuel for fuel elements of nuclear reactors, and may be used by college students in the corresponding specialties.

Figures, 176; tables, 73; bibliography, 617 items.

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Preface to the Second Edition

The USSR has drawn up and is implementing a major program in the development of nuclear power engineering. The use of nuclear power in ships and space apparatus is expanding. Refractory compounds of fissionable elements are being used in most fuel elements now being developed or planned. The development and investigation of these types of fuel is proceeding intensively.

In the period since the publication of the first edition of this book (1969), a large amount of new data on refractory compounds of uranium, plutonium and thorium has been published, and the compounds are being used increasingly expensively as nuclear fuel. This has necessitated a complete reworking of the entire book. General matters involving these compounds are discussed subject by subject in the first part of the book. In the subsequent sections these questions are discussed in more detail for the individual compounds.

Questions of the suitability of nuclear fuel are inseparably connected with the design of fuel elements and the operation conditions of reactors. Problems of the economics and effectiveness of use of specific types of fuel are no less inseparably connected with problems of the entire fuel cycle. The interrelated nature of these problems has been taken into account in the discussion of the various aspects directly involved with fuel, although questions of the design of fuel elements and the fuel cycle as a whole are outside the scope of this book.

In accordance with emerging tendencies and newly published materials, the extent of the individual chapters has changed somewhat: the chapters on thorium and plutonium compounds have been expanded, and those on uranium compounds somewhat shortened. The sections on analysis of radiation stability of the fuels in question (questions of swelling, gas formation, compatibility with cladding, stability of micro fuel elements and the like) have been significantly expanded. General summaries of production processes, safety procedures, effectiveness of use and economics have been introduced.

All the material has been reworked, and this edition should be considered as a natural development of the questions included in the first edition.

The summary part of the book and the chapters on fuel based on coated particles and fuels based on borides, phosphides, sulfides and arsenides were written by P. B. Kotel'nikov, those on thorium oxide by P. B. Kotel'nikov with N. V. Shishkov, those on oxide fuels by A. I. Kashtanov, those on carbide and nitride fuels by S. N. Bashlykov, and those on the interaction of oxide, carbide and nitride fuels with claddings, the effect of radiation on the properties of carbide and nitride fuels and the use of these fuels in nuclear reactors by T. S. Men'shikov. R. B. Kotel'nikov was the chief editor.

The authors are most grateful to the comrades who have reviewed the manuscript and made valuable comments: V. V. Kalashnikov, I. S. Golovnin and F. G. Reshetnikov.

Preface to the First Edition

Intensified operating regimes and especially higher temperatures are the main direction of progress in power production in general and in nuclear power production in particular. As a result, the interest in refractory compounds of the nuclear fuel elements, uranium, plutonium and thorium, is growing steadily.

The importance of developing fuel elements based on refractory compounds of fissionable elements has increased particclarly as a result of the necessity of increasing the efficiency of operation of nuclear power stations and of developing power production and transportation reactors for space facilities. Most important are the oxides, carbides, nitrides and to some degree the sulfides of uranium and plutonium, which are the subject of this book.

Some of these compounds, for example uranium dioxide and plutonium dioxide, are already used expensively in the manufactore of fuel elements for various types of nuclear reactors in many countries. In particular, uranium dioxide is used as fuel in the fuel elements of the Novoronezhskaya Nuclear Power Station's water-cooled water-moderated power reactor and in the reactor of the icebreaker Lenin. However, in spite of the expensive use of oxide fuels and the large number of works which have been published, there is in Russian no adequately complete survey or book on the production and properties of these materials. The authors have attempted to fill this gap with the present book by bringing together in one place data which have been published in various sources.

In recent years, an extensive research effort dealing with high-temperature nuclear fuel based on uranium and thorium carbides has been begun. The Romashka, the world's first nuclear reactor with semiconductor electrical generators, whose fuel elements are made of uranium dicarbide, is successfully operating in the USSR. Dispersion elements using uranium dicarbide in a graphite matrix have been used in some experimental and power reactors in our country and abroad. Uranium and plutonium monocarbides and a promising fuel for economically advantageous fast-neutron power reactors which reproduce nuclear fuel.

The other refractory compounds of uranium, plutonium and thorium have not as yet come into broad use, but they are being intensively studied as extremely promising fuels, and accordingly the authors have considered it expedient to present in systematic form the maximum amount of data on such refractory compounds as the nitrides and sulfides of uranium and plutonium.

The book discussed questions of processes for production of the compounds, their properties and their uses. The authors hope that the book will be useful for a broad range of scientific personnel, engineers and designers engaged in the development of fuel elements.

Introduction

We can for convenience classify materials which are usable as nuclear fuel into the following groups according to temperature stability:

1. low-temperature materials, with a melting point (temperature stability range) of 700-1200° C or below (primarily alloys of metallic uranium and plutonium, but also some easily fusible intermetallic compounds of these elements);

2. intermediate-temperature materials, with a temperature stability range from 1200 to 2000° C (thorium alloys, silicides, and a number of intermetallic and a few oxide compounds of uranium, plutonium and thorium);

3. high-temperature materials, with a temperature stability range above 2000° C (oxides, carbides, nitrides, sulfides and phosphides).

High-temperature fuel materials have a number of valuable properties as a result of which they are used extensively in reactor construction or are attracting considerable attention as promising fuels. In addition to the high fusion temperature, which in some cases is of independent interest, these materials generally have low vapor pressure, high chemical stability, and considerable mechanical strength at high temperatures. The production processes for many high-temperature fuel materials and the manufacture of products from them also have a number of common characteristics. Accordingly it is advantageous to include these materials in a single group and to discuss their production and operating characteristics and properties together.

This book discusses preparation processes and properties of oxides, carbides, nitrides, borides, sulfides, arsenides and phosphides of uranium, plutonium and thorium. Such materials as beryllides, aluminides, silicides and complex oxide compounds are not discussed, since as a result of certain properties they cannot be included in the first group (low fusion temperature, low volume concentration of fissionable atoms and so on); selenides and tellurides are not discussed because the prospects for their use are doubtful and there is extremely limited information about production processes and properties.

The book consists of two parts. The first gives a general survey of the main characteristics of the high-temperature nuclear fuels which are under consideration and compares their most important properties. Questions of production processes and safety procedures which are common to the high-temperature fuels are discussed, along with certain aspects of the effectiveness of their use. In the second part, questions of production processes for the individual compounds are discussed, a critical analysis of data on radiation stability and compatibility is made, and the physical-mechanical and technical properties of the compounds are analyzed in more detail.

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PUBLICATIONS

OPTICAL PROCESSING OF INFORMATION

Leningrad OPTICHESKAYA OBRABOTKA INFORMATSII in Russian 1978 signed to press 4 May 78 pp 3, 165-168

[Foreword, table of contents and list of abstracts from book edited by Professor S. B. Gurevich, Izdatel'stvo "Nauka", 3,450 copies, 168 pp]

[Text] Foreword

The subject matter of the articles in this collection reflects the current stage of development of methods of optical information processing. Together with an effort aimed at the incorporation of these methods into various areas of science and technology, work aimed at improving the availability of equipment and recording materials and improving coherent methods of optical information processing is under way. At the same time, a more profound understanding of the difficulties which must be met in solving a number of tasks by this method has resulted in a tendency to resort actively to noncoherent or mixed (using electronic components) methods of processing. A number of the works presented in this collection reflect this trend, which may possibly continue to develop, uniting coherent and noncoherent methods with optoelectronic methods and thus making possible a better coupling of optical methods with digital electronic ones (hybrid systems).

We may tentatively group the articles in this collection in three categories. The first includes studies on fundamental components for optical information processing. It includes work on the development of an acoustooptic deflector, development of hologram recording material based on electrooptic crystals, and studies of AsSe films. In the second category are articles dealing with the possibilities and applications of methods of coherent optical information processing in astronomy and in the classification of images containing fine-structured objects (three collective works). We may also include in this category two articles dealing with evaluation of the energy and information capabilities of optical information processing systems. The third group comprises work on noncoherent methods for optoelectronic processing of images which make use of original matrix scanistor photodetectors and maskons. It is becoming possible to consider these noncoherent optoelectric methods on the same basis as noncoherent optical and coherent methods.

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Abstracts

Holographic Recording of Images in Birefringent Electrooptic Crystals. S. I. Stepanov, A. A. Kamshilin and M. P. Petrov. pp 4-21.

The most important aspects of fulfillment of the Bragg conditions in the diffraction of light by holograms recorded in birefringent electrooptic crystals are discussed. A general expression for the diffraction efficiency of a holographic grating of the dielectric tensor is given: $\hat{\varepsilon}(\vec{r}) = \hat{\varepsilon}_0 + \delta\hat{\varepsilon}\cos(\vec{K}\cdot\vec{r})$. The possibility of effective electric control of the conditions for Bragg diffraction in holograms recorded in electrooptic crystals is discussed. The results of the recording of polarization characteristics of an image and of effective electric control of image reconstruction conditions, obtained in experiments on holographic recording in the single-axis electrooptic ferroelectric $LiNbO_3$, are presented. Bibliography, 13 items; 8 illustrations.

An Acoustooptic Laser Light Deflector. M. P. Petrov, G. A. Smolenskiy, V. A. Lemanov, A. A. Uvarov, A. N. Anisimov, N. N. Kovalev, Yu. M. Sosov, N. K. Yushin, A. S. Fatov and S. G. Yegorov. pp 21-25.

The design and performance calculations of an acoustooptic deflector using a paratellurite crystal are described. The authors made use of diffraction of light by a slow transverse elastic wave propagating along the [110] direction. The acoustooptic cell was controlled by a analog input voltage or by a code from a digital computer. The experimental characteristics of the deflector are given for light with a wavelength of 0.6328 microns. Bibliography, 3 items; 4 illustrations, 1 table.

Recording of Holograms in AsSe Films with the Light of a Helium-Neon Laser. N. M. Ganzherli and V. I. Kochenov. pp 26-38.

The amplitude and phase characteristics of AsSe films and the recording and reconstruction of holograms in these films with helium-neon laser light were investigated. The effect of interference phenomena in the films on photoinduced changes in transmissivity and optical path difference and on the size of the maximum attainable diffraction efficiency of the holograms and the dependence of diffraction efficiency on the thickness of KhSP films were studied. The exposure characteristics were investigated and a figure for the holographic sensitivity of AsSe films obtained. Certain possibilities for elimination of the effect of interference phenomena are indicated. Bibliography, 15 items; 9 illustrations.

Use of Optical Processing Methods in Radio Astronomy. N. A. Yesepkina, V. Yu. Petrun'kin, I. A. Vodovatov, M. G. Vystoskiy and S. V. Pruss-Zhukovskiy. pp 38-50.

The possibilities of using methods of optical simulation of the characteristics of radiotelescopes and optical processing for spectral analysis of radiotelescope output signals are discussed. Optical simulation of the directional patterns and space-frequency characteristics of radiotelescope antennas is discussed using the RATAN-600 radiotelescope as an example. Results of simulation of directional patterns of the RATAN-600 with allowance for phase errors resulting from movement of the irradiator out of the antenna focus are determined. Methods of simulating the directional patterns of correlating radiotelescopes are discussed. Questions of spectral analysis using the acoustooptic spectrograph are examined. Certain experimental results are presented. Bibliography, 21 items; 8 illustrations.

An Automatic Correlation Unit for Size Analysis of Bacterial Colonies. A. M. Bekker, N. I. Bukhtoyarova, K. A. Veyner, V. P. Gorelik, S. N. Nikolayev and B. G. Turukhano. pp 50-58.

By using the achievements of holographic correlation analysis of images and electronics, the authors have developed a unit for measurement of the sizes of bacterial colonies which appear in the form of circles of different sizes. A procedure for optimizing the recording parameters of the filter is proposed. The signals in the correlation plane are processed with a PTU-102M television unit modernized for the purpose. The automatic control block controls a counter, a digital printer, a series of filters and a tape drive unit which inputs representations of the bacterial colonies. Bibliography, 4 items; 7 illustrations.

Study of the Statistical Characteristics of Fine-Structured Images by the Correlation Method. A. A. Kolesnokov and N. V. Lapteva. pp 59-72.

The possibility of studying a set of elements which form an analyzable image by the correlation method is discussed. The problem which is set is that of determining two statistical characteristics of this set: the integral distribution of individual elements according to size $P(r)$ and the probability density of distribution of the centers of the elements $W(R_0)$. The main theoretical relationships are derived and the results of experimental testing of the method are presented, confirming the correctness of the theoretical assumptions. Bibliogrpahy, 13 items; 5 illustrations.

Analysis of the Microstructure of Tracks by the Image Autocorrelation Function. O. A. Bukin, Yu. A. Vykovskiy, A. I. Larkin, A. A. Markilov and S. N. Starikov. pp 72-82.

An optical method for analysis of the microstructure of tracks in photographs from a bubble chamber is described. The theoretical basis for a method of determining the density of the bubbles and their average size and distribution from the autocorrelation function and its derivative is discussed. The design of experimental units to implement the method using noncoherent illumination are described. The results of determination of the number of elements and their size distribution in model samples and enlarged bubble chamber photographs are given. The effect of photograph parameters on the accuracy of the results is considered. Bibliogrnphy, 12 items; 7 illustrations.

Energy Calculations for Television Systems Using Preliminary Optical Processing of Information. S. B. Gurevich, B. S. Gurevich and B. I. Rapoport. pp 82-91.

The passage of signal and noise through the input stages of a transmitting television system with preliminary optical processing of images is analyzed. The energy relationships in the various stages with the use of a device to convert noncoherent to coherent radiation are considered. Changes in the signal-to-noise ratio from the input to the output of the system are estimated. Bibliogrpahy, 9 items; 4 illustrations.

Information Calculations for Optical Information Processing Units. S. B. Gurevich and V. F. Relin. pp 92-102.

The information capacity of an optical information processing system is discussed, the effect of various causes of information loss in the system is evaluated, and the necessity of optimal matching of the information characteristics of the main elements of the system is indicated. A procedure for calculating the information capacity of the system and its individual elements is presented. Bibliography, 17 items; 4 illustrations, 1 table.

Correlation Processing of Images with a Multiline Scanistor. K. F. Berkovskaya, S. B. Gurevich, B. G. Podlaskin and V. P. Polivko. pp 102-113.

A new use for the common solid-state switched photodetector is proposed: a multiline scanistor for calculation of the proximity of images analyzed in noncoherent light and certain functions serving as standards or prototypes. The operating of preparing transparencies representing the standard function is eliminated, since the representation of the standard is input electrically into the unit as a delay in the switching signals for the various lines. The mask transparencies which can be synthesized directly on the photodetector matrix have the form of silhouette functions, which can also be shifted or rotated around the center electrically. The accuracy of correlation analysis is limited by the real parameters of the multiline scanistor. Bibliography, 11 items; 5 illustrations.

Use of a Multiline Scanistor for Automatic Determination of the Statistical Characteristics of Stationary Random Processes. K. F. Berkovskaya, Ya. P. Bernshteyn, N. V. Kirillova and L. A. Luizova. pp 113-127.

The possibilities of using a switched solid-state photodetector, the multiline scanistor, for analysis of instances of stationary random processes is discussed. It is shown that such functionals as the area bounded by the process and a horizontal line, the length of time the process remains above a given level, and the number of times the process intersects a given level, can be calculated analogically with the scanistor without intermediate storage of the profilograph of the process. It is proposed to use the degree of modulation of the overall video signal of a multiple recording of the random process as an easily measurable new specific functional. A simple relationship between this functional and the sampling estimate of the variance and the average arithmetical deviation of the curve from the stationary level is identified. The results of classification of irregular surfaces using the scanistor are presented. Bibliography, 4 items; 7 illustrations.

A Coordinate Indicator for a Uniformly Luminescent Object. K. F. Berkovskaya and B. G. Podlaskin. pp 127-135.

A new use for some well-known semiconductor instruments, the multiline scanistor and the maskon, an optical image spectrum analyzer, for rapid determination of the coordinates of a singly luminescent object is proposed. The device has promise for use in industrial process automatic control systems using a gallium arsenide LED as a light source. Bibliography, 7 items; 4 illustrations.

The Hadamard Transform as a Method of Signal Analysis in Optical Information Processing Systems. K. F. Berkovskaya, G. K. Grigor'yev, S. B. Gurevich, B. G. Podlaskin and V. P. Polivko. pp 135-147.

The properties of the Hadamard transform in its realization at the output of an optoelectric information processing system are discussed; the noise characteristics of the system, the possibility of implementing the principle of energy storage using the Hadamard analysis, and the nature of operation of photodiode matrices switched according to the two-dimensional Walsh function are analyzed. Bibliography, 23 items; 4 illustrations.

The possibility of Contructing a Hadamard Spectrum Analyzer Using a Maskon-Type Photodetector Unit. K. F. Berkovskaya, G. K. Grigor'yev, N. V. Kirillova, K. L. Muratikov and B. G. Podlaskin. pp 147-164.

The advantages and shortcomings of television transmission of images in the form of their component space-frequency spectra are discussed. The component elements of such a system are described individually. The possibilities for technical realization of such units are discussed. A photodetector matrix combined with a dynamically controllable transparency is analyzed in detail. Bibliography, 35 items; 9 illustrations.

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PUBLICATIONS

SPECTROSCOPY OF GAS DISCHARGE PLASMA

Leningrad SPEKTROSKOPIYA GAZORAZRYADNOY PLAZMY (Spectroscopy of Gas Discharge Plasma) in Russian 1976 signed to press 8 Jul 76 pp 1-2, 161

[Annotation and table of contents from book by G. A. Grigench, editor, Izdatel'stvo LGU, 1,395 copies, 164 pages]

[Text] This book deals with study of the various elementary processes which take place in a low-temperature gas-discharge plasma. The articles discuss the results of investigations of widening of spectral lines by low pressures of the specific and contaminant gases; excitation and ionization during atom-atom and atom-molecule collisions taking place with the participation of excited particles, etc. The book also contains articles on application of the method of delayed coincidences in atomic and molecular spectroscopy and on the processes of formation of an ultrathin structure of spectral lines in gas-discharge light sources.

This book will be useful to persons working in plasma physics and chemistry and its technical applications, physics of electron and atomic collisions, gas lasers, as well as graduate students and upper-division undergraduate students specializing in the above-enumerated areas of knowledge.

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PUBLICATIONS

AUTOMATIC CONTROL OF VIBRATION TESTS

Moscow AVTOMATICHESKOYE UPRAVLENIYE VIBRATSIONNYMI ISPYTANIYAMI in Russian 1978 signed to press 20 Jan 78 pp 110-111

[Annotation and table of contents from book by A. G. Getmanov, P. I. Dekhtyarenko, B. Yu. Mandrovskiy-Sokolov et al., Energiya, 5,500 copies, 112 pp]

[Text] This book is devoted to discussion of a series of questions related to the analysis, synthesis and practical realization of closed automatic control systems for vibration testing with random and determined (mono- and polyharmonic) perturbations. Systems for control of single-component and multicomponent (vector) random vibrations are discussed. Questions of construction of such systems using analog, digital and hybrid equipment are treated. The results of calculations for specific practical systems, their structural arrangement and some results from their practical use are presented.

The book is intended for a broad range of engineers and scientific personnel engaged in the planning of automatic computer and information measuring systems.

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RECOGNITION OF SPEECH SIGNALS BY THEIR STRUCTURAL PROPERTIES

Leningrad RASPOZNAVANIYE RECHEVYKH SIGNALOV PO IKH STRUKTURNYYAM SVOYSTVAM in Russian 1977 signed to press 27 Jan 77 pp 2-4, 62

[Annotation, foreword and táble of contents from book by R. V. Gudonavichyus, P. P. Kemeshis and A. V. Chitavichyus, Izdatel'stvo "Energiya", 8,000 copies, 62 pp]

[Text] This book is the first attempt at a systematic discussion of the theoretical and practical questions of the use of structural properties of speech signals for their recognition. The bases for design of devices to distinguish characteristics in terms of the structural properties of the signals are discussed, and specific circuits and results of experiments on the recognition of oral commands are presented.

The book may be useful to engineering, technical and scientific workers dealing with problems of information processing in automatic control systems, those who are developing apparatus for processing and recognition of signals, and students in advanced studies and graduate students in the above-mentioned specialties.

Foreword

In recent years an extensive literature has been devoted to recognition of sound specimens. This problem is now occupying specialists working in extremely varied disciplines: psychologists, linguists, physiologists, mathematicians, and engineers; the interest in the subject is easy to explain, since this is a problem whose successful solution will make it possible to partially substitute automata for human intellectual activity. The necessity of solving this problem is being particularly acutely felt in a number of areas of engineering cybernetics, and particularly in the development of means for exchange of information between humans and computers.

The ways the problem is articulated in various works on the recognition of speech, the scientific research procedures and the practical conclusions reached by various authors frequently have rather little in common. A unified approach to the solution of the various problems which arise in the distinguishing of characteristics, the creation of algorithms and the synthesis of mechanisms for recognition still does not exist. Moreover, far too little attention is being devoted to the questions of selection of an initial description of speech signals. Many investigators [4, 5, 6] are of the opinion that almost any logically constructed initial description which preserves the data can untimately lead to positive results given the proper organization of higher levels of the recognition system. But this approach is not entirely correct, if only because it may lead to excessively complex operating algorithms for the system as a whole. In contrast, a properly selected initial description would unquestionably lead to great algorithmic and hardware simplification.

The authors believe that the use of a structural model for signals which comprises several generally acceptable contour models [13, 23] may represent a significant step forward in solving the general problem of recognition of speech signals and in the particular matter of selecting an initial description of them. This assumption, based on the fact that in contrast to the contour model, which encompasses both the signal and any of its functional transformations, a structural model makes it possible to develop algorithms the results of whose use are invariant to certain signal properties; these advantages show up particularly clearly when there is a paucity of a priori information on the initial signal.

The structural properties of signals are already being successfully used to solve a series of problems in communications, measuring technology and process diagnostics [13, 23]. The first experiments in recognition of speech signals in terms of structural characteristics gave encouraging results; further work has removed doubts as to the promise of this approach [8, 9].

This book, which reflects the authors' experience in recent years, discusses theoretical questions of the use of structural properties of signals for recognition of speech signals, makes recommendations for the design of recognizers and presents the results of experimental studies.

The first chapter deals with theoretical problems of the construction of a structural model of signals. The second chapter discusses numerical characteristics of the structural model of speech signals, i.e. characteristics to be recognized. The third and fourth chapters deal with questions of distinguishing characteristics by the structural model and their practical utilization for recognition.

The authors are far from believing that it is already possible to give conclusive formulas for the recognition of speech signals; work in this area is only beginning. However, the authors are firmly convinced that the use of structural properties of signals will make it possible to bring work in the recognition of speech signals to a stage at which recognition can be carried out with a high level of reliability using relatively simple equipment.

The authors express their deep gratitude to A. M. Zayezdnyy for valuable advice and assistance given during preparation of the book.

Comments and suggestions may be sent to: 192041, Leningrad, Marsovo Pole, D1, Leningrad Division, Izdatel'stvo "Energiya".

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