JPRS L/10553

28 May 1982

USSR Report

CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

(FOUO 11/82)

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APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000500060066-8

JPRS L/10553

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USSR REPORT

CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

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HARDWARE

UDC 51:681.3.06

UNIFIED SOFTWARE SYSTEM FOR CONTROL OF ION BEAM APPARATUS AND KSR-4100 COMPUTER

Kiev SPETSIAL'NYYE SREDSTVA PROYEKTIROVANIYA I MODELIROVANIYA SISTEM /PROYEKT-YeS/ in Russian 1981 (signed to press 29 Jul 81) pp 35-39

[Article by V. F. Lyabakh from book "PROYEKT-YeS Special Facilities for System Design and Simulation", editor-in-chief Academician V. M. Glushkov, Institute of Cybernetics, UkSSR Academy of Sciences, 550 copies, 107 pages]

[Text] A great deal of time is expended on programming facilities enabling interaction between the designer and computer-aided design [CAD] system. And the complex programs are compiled from modules differing little from each other in functional purpose, but very bulky in size. To enable interaction between a CAD system and a peripheral processor, one has to either supplement the programming language for the CAD software, or construct specialized software for the peripheral processor. Direct application of a specialized processor with a simple input language requires a great deal of effort to prepare the data and compile the control programs. For this purpose, it is expedient to use high-throughput computers that, in addition to reducing programming time, permit reducing the number of errors in programs and performing debugging with powerful and convenient facilities. In terms of both hardware and software, the power of peripheral device facilities is small if they are oriented to a broad class of problems. But if they are narrowly specialized, then it is possible to achieve a high level of the programming language or instrumental facilities in some class of problems, but switching to another class of problems requires a great deal of effort.

Described in this work is an approach to constructing software for the specialized KSR-4100 computer that is a continuation of the effort to develop facilities for interfacing the engineering design stage and the stage of manufacturing electronic circuits [1]. The specialized KSR-4100 computer is used to control an electron-ion beam in laying out the patterns on crystal with the electronic-ionic technology for manufacturing circuits. Circuit descriptions made in the engineering design stage are analyzed and converted into a control program for the KSR-4100 by special system facilities.

The software for this part of the system is compiled by the following facilities:

1. Data representation facilities in the system are facilities for representing data in the external description--pattern descriptions, facilities in internal representation--component objects, and data representation facilities to enable interaction--fields having parts that are constant and varying in the interaction process.

2. Processing facilities enable assignment of the type of pattern, its placement in the working field, shifting of the pattern, creating a copy of the pattern, specification of scales on the horizontal and vertical axes, and compilation of a complex pattern from parts. They use the universal mechanism of processing--translation by products, which are specified by using tables, which permits easy reconfiguration of the tables for different types of patterns. These facilities have now been implemented in the PROYEKT-YeS system and adjusted for illustration of texts. The input program for the specialized KSR-4100 computer must have the following structure: The first part is the pattern program proper, i.e. a series of pairs of coordinates of the diagonal points of the rectangles forming the pattern. Each coordinate is specified by a four digit number with a sign. Plus is the default sign. Cordinates are separated from each other by a special character that is accessible to the user only during system setup. Each rectangle (four coordinates) is separated by another character, also user-accessible only at system setup time. The second part is a file of displacements of this pattern relative to the coordinates specified in the first part, if the pattern is used several times in the drawing. This file starts with the character "A". Following it are the coordinates of the displacements arranged in pairs (on the horizontal and vertical axes). Displacement coordinate format is the same as in the first part of the program. The characters "AE" must be placed before the last apir of displacements. If the drawing consists of several different repeated patterns, the program for this drawing must consist of programs for each pattern written by the method described above. The input program for the KSR-4100 is read from perforated tape in ISO codes. These requirements govern the conditions for the structure of the processing program and setup of product tables.

The product table is a two-dimensional array. Arranged in the first dimension are all the pattern types in the language for description of the patterns encountered in a class of drawing data. In the current version, this includes the letters in the Russian alphabet, some of the Latin alphabet letters, the numbers and the punctuation characters. Arranged in the second dimension of the array are the programs for the corresponding types of patterns in the KSR-4100 input language, i.e. in the internal system language up to recoding into ISO codes. The facilities for entering and editing product tables are offered by the interactive data preparation system (DSPD) which uses a display terminal. The control program scans the input text and fills out a file for the drawings, which also consists of a certain number of two-dimensional arrays. The number of arrays matches the number of different types of patterns (letters). In the first dimension, if a given type of pattern is encountered in the input text, the pattern program is written from the product table, and in the second, the apirs of coordinates for the displacements, defined according to some algorithm by the control program. When the pointer, under the control of which text reading occurs, scans in the input text a pattern of a type that had been read earlier, only the second part--the subfile of displacements--is filled out. When the pointer reads in the input text a special functional character--end of processing, the control program terminates the process of filling out the drawing file and begins recoding the contents of it into the ISO codes. The system offers the user two types of pattern specifications: explicit (two four-digit numbers) and that computed by a special algorithm, if the patterns are specified in the form of a series of periodically placed elements. The drawing scale is specified according to the horizontal and vertical axes when the system is set up and consists in the linear conversion factors for the corresponding axes of the coordinates contained in the product tables. Specification of the input text may be performed by the facilities of the INESS system [2] or directly from the external medium, i.e. in the interactive or direct input mode. And the data may be prepared in advance by using the DSPD interactive data preparation system.

With appropriate adjustment, the software described may be used in all spheres of KSR-4100 application: for control of ion-beam, electronic-lithograph and other apparatus [3].

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8545
CSO: 1863/89

UDC 681.3

PRIMARY SPECIFICATIONS OF SM COMPUTER PERIPHERAL UNITS

Moscow PRIBORY, SREDSTVA AVTOMATIZATSII I SISTEMY UPRAVLENIYA, TS-2: PERIFERIYNYYE USTROYSTVA SM EVM (OBZORNAYA INFORMATSIYA) in Russian No 1, Jan-Feb 80 pp inside front cover, 6, 10, 12, 13, 16, 19, 29-30, 40

[Annotation, selected tables, and table contents from book "Instruments, Automation Equipment, and Control Systems, Technical Series No 2: Peripheral Units of SM Computers (Survey Information), by Yu. D. Alekseyev and A. A. Myachev, Izdatel'stvo "TsNIITEIpriborostroyeniya", 4,435 copies, 40 pages]

[Text] Annotation

This survey reviews the classification, primary principles of organization, and technical specifications of peripheral units of SM computers. The book gives examples of organization and the technical specifications of a number of peripheral units in systems produced abroad.

The book is intended for specialists who are designing systems and units based on SM computer hardware.

Table 2. Primary Characteristics of Magnetic Disk External Units Included in the SM Computer Catalog

Type, Number of Unit, (Manufacturing Country)	Average Access Time, milliseconds	Capacity, megabits	Transmission Speed, megabits/seconds
Fixed-Head Magnetic Disk Stores			
SM 5500, MD-500C (Hungary)	10	0.5 megabytes	1.35
SM 5501, MD-800V (USSR)	10	0.864 megabytes	0.67
Magnetic Disk Stores with Removable Disks			
SM 5400, IZOT-1370 (Bulgaria)	50	50	2.5
SM 5401, MERA-9425 (Poland)	40	50	2.5
SM 5403, KDP-721 (Czechoslovakia)	30	50	2.5

[Table continued, next page]

[Table 2 continued]

Type, Number of Unit, (Manufacturing Country)	Average Access Time, milliseconds	Capacity, megabits,	Transmission Speed, megabits/seconds
	Floppy Disk Stores		
SM 5601, MF-3200 (Hungary)	-	3.2	0.25
SM 5602, RLX-45D (Poland)	-	12.8	0.25
SM 5604, Konsul 7112 (Czechoslovakia)	-	3.2	0.25
SM 5605, two-disk (Czechoslovakia)	500	6.4	0.40
SM 5606, MFU-2 (Hungary)	370	6.4	0.25

Table 4. Specifications of Magnetic Tape External Storage Units Included in the SM Computer Catalog.

Type, Number of Unit, (Manufacturing Country)	Speed of Exchange, kilobytes/second	Capacity, megabits	Recording Density, bits/millimeters
	Storage Units Using 12.7 Millimeter Tape		
SM 5300, IZOT-5004Ye (Bulgaria)	10	100	32
SM-5302, IZOT-5005-0IYe (Bulgaria)	20	200	32
SM-5303, IZOT-5006Ye (Bulgaria)	36	-	32
SM-5304, RT-305-2 (Poland)	40	-	32/64
	Storage Units Using 3.81 Millimeter Cassette Tape		
SM-5202, RK-1 (Poland)	0.5	5.76	32
SM-5203, KPP-800 (Czechoslovakia)	0.125	3.2	32

Table 5. Specifications of Punched Tape Input-Output Units of SM Computers.

	Primary Characteristics		
	Speed, lines/Seconds	Number of Tracks	Possibility of Building in Unit
	Punched Tape Input Units		
SM-6203, MR-301 (Hungary)	500	5.8	yes
SM-6205, ST-2030 (Poland)	300	5.8	no

[Table 5 continued, next page]

[Table 5 continued]

	Primary Characteristics		
	Speed, lines/ Seconds	Number of Tracks	Possibility of Building in Unit
SM-6216, ST-2100/2200 (Poland)	1,000/2,000	5.8	no
SM-6208, Konsul 337.2 (Czechoslovakia)	300	8	yes
SM-6209, FS-1503 (Czechoslovakia)	1,500	8	no
Punched Tape Output Units			
SM-6222, DT-105C (Poland)	50	5.8	yes
SM-6227, MP-51 (Hungary)	50	5.8	yes
SM-6206, Daro-1215 (East Germany)	50	5.8	yes
Combined Input-Output Units			
SM-6200, MPR-51/301 (Hungary)	50/500	5.8	yes
SM-6204, SPTP-3 (Poland)	50/100	5.8	yes

Table 6. Specifications of Punchcard Input Units of SM Computers

	Primary Specifications	
	Speed, Card/ Minute	Magazine Capacity, cards
SM-6101, VT-42111 (Hungary)	600	600-640
SM-6102, Daro-1220 (East Germany)	160	500
SM-6105, RSD-9226 (Romania)	300-800	1,000

Table 7. Specifications of Printers of SM Computers

	Primary Characteristics		
	Printing Speed	Line Length, Characters	Set of Symbols, Characters
Parallel-Type Alphanumeric Printer			
SM-6316, VT-24112 (Hungary)	253 lines/min	80	96, 64
SM-6321, VT-25150 (Hungary)	650 lines/min	132	64, 96
SM-6306, VT-25112 (Hungary)	900 lines/min	132	96
SM-6322, RSD-9233 (Romania)	200 lines/min	132	64, 96
SM-6315 (USSR)	500 lines/min	132	96

[Table continued, next page]

[Table 7 continued]

	Printing Speed	Primary Characteristics: Line Length, Characters	Set of Symbols, Characters
Sequential-Type Mosaic Alphanumeric Printer			
SM-6301, Daro-1156 (East Germany)	100 char/sec	132	96
SM-6302, DZM-180 (Poland)	180 char/sec	132, 138	128
SM-6303, Konsul 211.1 (Czechoslovakia)	150 char/sec	132	96
Sequential Alphanumeric Printer with Keyboard			
SM-6312, IZOT 0232D (Bulgaria)	20 char/sec	132	96
SM-7108, Konsul 211 with Konsul 256 Keyboard (Czechoslovakia)	150 char/sec	132	96
SM-7102, UKVKL (East Germany)	45 char/sec	132	94

Table 8. Specifications of Displays

Type, Number of Units (Manufacturing Country)	Primary Specifications: Number of Symbols on Screen/Number of Addressable Points on Screen	Dimensions of Matrix (Millimeters), Method of Formation	Editing Functions
Alphanumeric Displays			
SM 7202 (Czechoslovakia)	1,920	5 × 7	Full
SM 7203, SID-702 (Cuba)	1,440	5 × 7	Full
SM 7206 VT-47100 (Hungary)	1,280	5 × 7	Full
SM 7207 (Poland)	512	5 × 7	Full
SM 7208 (Poland)	1,280	5 × 7	Full
SM 7209 MERA-7952 (Poland)	1,920	5 × 7	Full
SM 7219 VDT-52105 (Hungary)	1,920	7 × 8	Full
VT-05, DYeS, United States	1,440	5 × 7	Partial
822 Burroughs, United States	1,920	5 × 7	Full

[Table continued, next page]

[Table 8 continued]

Type, Number of Units (Manufacturing Country)	Primary Specifications: Number of Symbols on Screen/Number of Addressable Points on Screen	Dimensions of Matrix (Millimeters), Method of Formation	Editing Functions
	Intellectual Alphanumeric Displays		
SM 7401, VT-47605 (Hungary)	2,000	9 × 7	Full
SM 7402, RVT-4000 (East Germany)	256	5 × 7	Full
	Graphic Displays		
SM 7300, EPG-SM (USSR)	1024 × 1024	Vector	-
SM 7301, VT-47607 (Hungary)	512 × 236	Point	-
GT-40, DYeS, United States	1024 × 768	Point	-
Idigrat Display, United States	1024 × 1024	Hachures	-
VU2000, Sintra, France	2048 × 2048	Hachures	-

Technical Specifications of the Active SM-1800 Industrial Unit for Communication with the Object

Central Processor Module

Word Length, bits 8
Capacity of Internal Memory in Central Processor Module, kilobits 1
Capacity of Read-Only in Central Processor Module, kilobytes 2
Execution Time for Instructions, Microseconds 2-8.5

Analog Input Module

Number of Input Channels 16
Range of Conversion, volts . . . . ±5
Resolution, bit positions 13
Maximum Conversion Time, microseconds 60
Primary Error, % . . . . .not more than ±0.2

Analog Output Module

Number of Output Channels 4
Resolution, bit positions 12
Output Signal by Voltage, volts 10; 24
Output Signal by Current, milliamps 20; 48
Primary Error, % 0.2-0.3

[List continued, next page]

[List continued]

Discrete Input Module

Number of Input Channels	16; 32
Level of Input Signal, volts:	
Logical "Zero"	0±2.4; 0±4.8; 0±9.6
Logical "1"	±9.6...±14.4; ±19.2...±28.8; ±38.4...±57.6
Input Current for Each Channel, milliamps	not more than 20

Discrete Output Module

Number of Output Channels	16
Maximum Switchable Current, amps	0.2
Working Frequency, khz	10
Switchable Voltage, volts	±4.8...±7.2; ±9.6...±14.4; ±38.4...±57.6

Module for Outputting Number-Pulsed Signals

Number of Input Signals	4
Capacity of Each Counter, bits	8
Maximum Counting Frequency, khz	20

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CSO: 1863/116

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000500060066-8

UDC 681.3

NEW CONTROL COMPUTER COMPLEXES

Moscow PRIBORY, SREDSTVA AVTOMATIZATSII I SISTEMY UPRAVLENIYA, TS-2: RAZVITIYE UVK SM-1 I SM-2, IKH PRIMENENIYE I PERSPEKTIVY (EKSPRESS-INFORMATSIYA) in Russian No 5, Sep-Oct 81 pp 1-7

[Chapter from book "Instruments, Automation Equipment, and Control Systems. Technical Series No 2: Development of the SM-1 and SM-2 Control Computer Complexes and Their Applications and Prospects," 4,285 copies, 13 pages]

[Text] Hardware and Software of SM Computers

Development of the hardware and software of the SM-1/SM-2 system was oriented mainly to ASUTP's [automated control systems for industrial processes] with continuous types of production. But this system proved quite satisfactory and found broad application for doing the most diverse jobs. Among these jobs are control of industrial objects with complex data processing algorithms, processing geophysical and oceanographic data, controlling scientific experiments and processing their results, testing complex objects, and so on.

The development of complexes of the SM-1/SM-2 architectural lines contemplates setting up a program-compatible series of base computer complexes which differ by productivity, logical and structural capabilities, maximum storage volume, and other characteristics.

The junior models of this series are the SM-1M and SM-2M.

While it has a comparatively small number of models, the system must have a broad range of productivity, from 200,000 to 20,000,000 short operations per second. A significant further increase in productivity (to hundreds of millions and billions of operations per second) for more or less narrow classes of problems is accomplished by setting up problem-oriented special processors connected to the base computer complex.

The SM-1M computer complexes are a modernization of the SM-1 complex of SM computers. They can be used in subsystems for input-output control, for autonomous control of aggregates and industrial processes, for engineering calculations, and as built-in control units for complex instruments in scientific experiment systems.

The SM-1M is the first computer in the SM family that outputs to the general-purpose IUS system interface. This insures that the SM-1M is compatible with SM-1/SM-2 complexes in terms of system and user programs and the assortment of units connected to the SM-1 and SM-2.

The design concepts of the SM-1M allow modification of the characteristics of complexes by volume of internal memory (to 64K words) and read-only memory (to 16K words), as well as by number and assortment of connected peripherals.

Some procedures of the operating system (processing interrupts, control of switching a unit into the system) have been transferred to microprograms, which increases the productivity of the complexes in real-time systems. The system timer (unit) has been replaced by a microprogram. It is proposed that the remainder of microprogram storage be used for problem-oriented user procedures.

The SM-2M control computer complexes are modernized SM-2 SM computer complexes.

In the SM-2M the processor and channel for direct access to memory are combined in one module and located in one autonomous block of the complex, which reduces the number of system bundles by almost one-half and also reduces the overall dimensions of the SM-2M control computer complex.

The speed of the channel for direct access to memory is almost doubled in the multiplex regime. Internal and microprogram storage are allocated on integrated microcircuits, which improve the technological suitability for manufacture and reliability of the complexes in operation.

The software of the SM-2M complexes is put on magnetic media: minicassettes and reels of magnetic tape.

The SM-1/SM-1M and SM-2/SM-2M complexes can interact with terminals, with one another, and with YeS [Unified System] computers.

The data transmission hardware of the first and second phase SM computers contains data transmission devices (APD-MA's and APD-MPP's), modems with S2 interface, and also modules specially oriented to use in SM computers; adapters for interlinking with the S2 interface, modules for interlinking with data transmission devices and telegraph communications lines, and high-speed intra-system modules used over short distances.

Our country's telegraph system makes it possible to use telegraph communications channels to transmit data in the SM-1 and SM-2 complexes. For this reason, a software library was developed for work over telegraph lines based on the A722-2 modules for interlinking with telegraph lines and the A722-6 telegraph adapters.

The program modules provide exchange of data between the computer complex and teletypes (T-63, T-59, RTA, and others) on the subscriber telegraph system or in a unipolar or bipolar regime of work on switchable or nonswitchable telegraph lines respectively.

These units are a constituent part of the operating aggregated software system (ASPO) and support the establishment of communications with subscribers to the telegraph system, exchange of autoresponses (whether exchange of data with the given subscriber is permissible in the computing system formulated is tested by the teletype autoresponse), data transmission (input or output of data), switching off telegraph communications, translating the international telegraph code NTK-2 into machine language and vice versa, and system operation during detection of error situations that occur in the telegraph system.

The full set of software and hardware makes it possible to construct territorially decentralized complexes based on the M-7000 ASVT-M and SM-1/SM-2 SM computers.

The PS-2000 problem-oriented computer complex is designed for highly productive processing of large data arrays. It can be used for efficient performance of tasks that permit parallel processing of many data flows according to the same program. The computer complex includes a decision field and control unit. The largest decision field consists of eight processing units, each of which in turn consists of eight processor elements with its own internal memory. Data exchange among processor elements is done by a system of information channels; data exchange with peripheral units is accomplished through a built-in hardware channel for direct access to the memory of the processor elements.

The PSI-2000 complex can be used to solve problems in geophysics, meteorology, and other areas which require processing large data arrays by regular algorithms.

A high-speed special processor built as an external unit interlinked with input-output channels of system ASVT models has been developed for processing seismic exploration data. This processor is intended to perform group operations on arrays. Its high speed results from the use of special computer circuits that interlink in time several arithmetic, logical, and addressing operations.

The special processor consists of a unit for interlinking with the channel, a control unit, and a pipeline-type arithmetic unit. It performs the following operations: convolution of an array with a statement; computing mutual correlations; multiplying two arrays; multiplying an array by a given number; determining a moving average; determining a moving average module; centering an array; and, copying data inside the main (internal) memory.

The technical specifications of the processor are as follows: internal memory capacity — 16 kilobytes; speed in performance of the most complex operations (correlation and convolution) — 4 million paired multiplication-addition operations per second; volume of each of the two input data arrays is limited to 2,048 16-bit words.

The A135-1 microprogrammable controller (MPK) is designed for setting up programmable subcomplexes for input-output, external memory, communication with the object, programmable terminals, and the like within computing systems based on SM computer hardware. The MPK envisions connecting control (internal and read-only) memory with a total capacity of 64 K words to internal interface lines to store microprograms, connecting an internal memory with a volume of up to 64 K words to IUS interface lines, and servicing 256 addresses of input-output units.

The MPK has a multilevel system of interrupts. The word length of micro-instructions and data is 16 bits. The system of microinstructions for the MPK includes operating instructions, the instruction to copy a constant, instructions for conditional and unconditional branches, and input-out instructions. The minimum performance time for microinstructions is 360 nanoseconds.

The arithmetic-logical unit of the MPK processes two operands in each of 32 assigned arithmetic or 16 logical operations and seven shift operations. The contents of one of the 16 registers of the high-speed internal memory is used as the first operand, and the contents of the buffer register serve as the second.

The MPK is controlled autonomously.

The system for preparing microprograms for the A131-5MPK is designed for macro-generation, translation, editing, composing, and debugging microprograms on the SM-1 and SM-2 SM computer complexes. The system makes it possible to work with microprograms written in absolute or shiftable format in the specially developed machine-oriented MIKROKOD language.

The system includes the following programs: translator from MIKROKOD (first version, no-disk variant); translator from MIKROKOD (first version, disk variant); translator from MIKROKOD of the MPK (second version); MPK microprogram assembler; technological program for obtaining truth tables and punched tape for programmable microcircuits; technological program for obtaining tables recorded in the MPK read-only memory.

The A714-5/1 (RIM-1) and A714-5/2 (RIM-2) multiplex interface dividers (branches) broaden the capabilities of SM-1 and SM-2 control computers for input-output by increasing the number of 2K interface outputs used to connect peripherals to the control complex, supporting the work of two control complexes with common peripherals, and moving peripheral units further from the control computer complex.

The RIM-1 with the RIM-2 expansion module permits connecting in as many as 63 peripheral units. The groups of peripheral units arranged on the basis of the RIM-1 and RIM-2 can be moved as much as three kilometers away from the computer complex.

Freeing the central processor of SM-2 computer complexes from the functions of controlling external memory is accomplished by the K312-3 external memory sub-complex. The subcomplex is based on a microprogrammable controller and includes, in addition to the MPK, a read-only memory with capacity of 6K words; internal memory with capacity of 32K words, used to allocate data arrays, buffer control sequences, and load test systems; two A328-6 disk control modules, with up to four YeS 5061 magnetic disk stores connected to each of them; two A318-7 tape control modules with up to eight YeS 5012-03 magnetic tape stores connected to each of them.

The total capacity of external memory with direct access is 232 megabytes, while with sequential access it is up to 320 megabytes. The external memory subcomplex carries on data exchange between the SM-2 and storage on magnetic disks or tapes, marks packages of magnetic disks, and copies data from tape to disks. Two data exchange operations can be performed simultaneously when the external memory subcomplex is in use.

The M-6000, M-7000, SM-1, and SM-2 computer complexes can be used to control a system consisting of a set of standard digital blocks meeting the CAMAC standard. Up to seven CAMAC crates can be connected to the computing complex using the A711-19 device to match with the CAMAC system.

The device is built on three type B boards (for working with 16-bit information words) or four boards (working with 24-bit information words), which are connected to a 2K interface, interlinked by means of a bundle, and connected to the plugs of a type A crate-controller. The last crate cannot be more than 15 meters from the computer complex.

The unit occupies three access codes in the 2K interface, and provides exchange of 16-bit and 24-bit words through the program channel and 16-bit words through the channel for direct access to memory. The M-6000 complex can only work through the program channel.

The M-6000, M-7000, SM-1, and SM-2 computer complexes can be used to set up measuring systems and to automate scientific experiments on the basis of programmable instruments built in conformity with international standard IEEE-488 ("Digital Interface for Programmable Instrumentation") or the standard adopted by the International Electrotechnical Commission ("Standard Interface Systems for Programmable Measuring Apparatus"). The instruments are connected to the computer complex by means of an A711-15 matching device built on two type B boards which are connected to the 2K interface, are bundled together, and are connected to one of the instruments. Fourteen instruments can be connected to the computer complex through the matching unit at one time; the maximum allowable distance from the computer complex is 15 meters.

Information is received and transmitted in eight-bit code (without monitoring) or in seven-bit code (with monitoring). The rate of data exchange is determined by the characteristics of the program channel of the processor being used.

The K-331-3 graphic semitone display is designed for displaying, editing, and processing complex graphic semitone monochromatic and multicolored images. The display is based on a built-in microprogram controller.

The graphic semitone display generates an image in a point matrix formed of 287 television lines with 320 points on each line. Data about the image of each point are stored in the internal memory of the display as words eight bits long (seven bits for the graphic image and one bit for the symbol image).

Among the image processing capabilities provided by the display are: 256 hues of color for color modifications, 64 levels of brightness in a monochromatic image, scaling with coefficients of 1-16 for each coordinate, scanning in the "window" regime, deletion of assigned parts of an image by flashing, erasing assigned parts of an image, work in a regime of true colors or pseudocolors, shifting the image on the screen, constructing graphs of change in the initial function along assigned horizontal or vertical lines, computing and displaying histograms and values of functions at an indicated point, and computing the distance between assigned points.

Printers are widely used to output data from the computer. The new printer included in the SM computer set has several outstanding features: a larger number of printing elements (18 needles) which makes it possible to improve the quality of character formation and print characters with intricate configurations in one pass; greater speed of printing elements (1,000 Hz) and their larger number, which makes it possible to more than quadruple the productivity of data registration; and, the possibility of turning the printing head on its longitudinal axis (information is printed on two mutually perpendicular coordinates). The printer has microprogram control of actuating mechanisms and combines the functions of printer and graph plotter, making it possible to output graphic information on two coordinates. The low level of position discreteness makes possible continuous and point representation of information. It is possible to display the information being registered in two colors.

The various requirements of the systems with respect to the format of blanks and functions performed necessitated development of a number of character-synthesizing printers. Thus, the A521-5 device which automatically segments blanks in the subcomplexes was designed for the ASU-5 mass service system. The A521-6 device is used in subcomplexes built on the basis of micro-programmable controllers. This unit permits output of various types of graphic and alphanumeric information to a blank 420 millimeters wide by program means.

The A521-4 and 531-10 units can print both alphanumeric and graphic information. The blank is 420 millimeters wide. In addition, the A-531-10 has an alphanumeric keyboard block with independent output to an IRPR interface, which broadens the opportunities for operator communication with the machine.

11,176
CSO: 1863/116

UDC 681.3

DISPLAY PROCESSOR FOR EXPERIMENTAL DATA PROCESSING SYSTEMS

Kiev POSTROYENIYE AVTOMATIZIROVANNYKH SISTEM OBRABOTKI EKSPERIMENTAL'NYKH DANNYKH in Russian 1981 (signed to press 3 Jul 81) pp 43-54

[Article by A. K. Belyayev, V. V. Gayduk and N. V. Yarovaya from book "Synthesis of Automated Systems for Processing Experimental Data" edited by G. S. Tesler (editor in chief), Nauchnyy sovet po probleme "Kibernetika", Ordena Lenina institut kibernetika, Akademiya nauk Ukrainskoy SSR, 550 copies]

[Excerpt] Development of automated systems for processing experimental data (ASOED) based on minicomputers requires special resources for representing processes occurring in the system in visual form. Experimental operation of the Pirs system (1) showed that standard television sets can be used as the basis for the visual displays.

This work describes a specialized display processor that allows an operator to interact by way of a television set with a "Etalon" minicomputer system (2). The specialized display processor (DP) has access to a reserved area of the main memory having a volume of 12,000 16-bit words (Figure 1) [figures not reproduced]. All other areas of the main memory and the UPZU [not further identified] are inaccessible to the DP.

The DP memory contains instructions and a data buffer as well as special synchronization service cells (addresses 4000 and 4001). In distinction from the Pirs system, in which the second processor is a processor-type resource of the system, the DP is an external unit-type resource of the system.

1. Structure of the Display Processor

The DP is a microprogram-controlled unit operating with three types of memories and a television set (Figure 2). The television set is an ordinary industrially-produced color television set that is connected without any alterations to the DP control unit.

The effective memory--that is, the memory reserved for the DP microprograms, has a volume of 1,024 64-bit words with a word access time of 500 nanoseconds. Special instructions can be used to update this memory (only in its entirety), and its contents predetermine the problem orientation of the display processor.

There is one other form of DP memory which is accessible only to the DP. This is the symbol generator, which has a volume of 1,024 bytes with a byte access time of 500 nanoseconds. Small in volume, the effective memory and the symbol generator are internal to the DP, and they are accessible to the first processor only in special modes, in which they are memorized as a whole.

The third type of memory with which the DP works is the main memory or, more accurately, a region of the main memory with a volume of 12,000 16-bit words beginning with the address 4000_{16}. This memory is simultaneously accessible to the first processor and the DP. In this case when addresses larger than 4000_{16} are interrogated, the first processor has the least priority in picking up the main memory cycle.

11004
CSO: 1863/137

UDC 681.327

SYNTHESIS OF HIGH PRODUCTIVITY MINICOMPUTER WITH FAST INTERRUPT RESPONSE

Kiev POSTROYENIYE AVTOMATIZIROVANNYKH SISTEM OBRABOTKI EKSPERIMENTAL'NYKH DANNYKH in Russian 1981 (signed to press 3 Jul 81) pp 54-58

[Article by V. F. Bernikov from book "Synthesis of Automated Systems for Processing Experimental Data" edited by G. S. Tesler (editor in chief), Nauchnyy sovet po probleme "Kibernetika", Ordena Lenina institut kibernetika, Akademiya nauk Ukrainskoy SSR, 550 copies]

[Text] The problem of reconciling a number of contradictory demands imposed on the processor must be solved in systems processing experimental data obtained from natural tests on complex objects. On one hand we have high productivity and quick servicing of high speed peripheral input-output equipment, while on the other hand we have minimum dimensions, weight and consumed power on the condition of sufficiently high work reliability. Moreover the computer must respond quickly to change in external conditions, and it must make the corresponding changes from one program to another quickly.

To satisfy the speed requirements, the minicomputer processor is structured according to the principle of combining instruction processing phases--that is, the conveyor principle. The phases of selecting an instruction from the memory, modifying the address part of the instruction, exchanging an operand with the memory and accumulating an arithmetic-logic operation are carried out in independent blocks of the processor (1). To ensure minimum computer outlays, the work of the blocks is controlled synchronously and with microprograms.

Let us evaluate the different structural variants of the processor. We designate the duration of the i-th phase by t_i and assume that all phases are carried out in succession. The total duration of an operation would be

$$t_{\text{total}} = \sum_{i=1}^{n} t_i,$$

where n is the number of phases in the operation (in this case $n = 4$), and the speed of the processor would be

$$S_{\text{Total}} = \frac{1}{t_{\text{total}}} = \frac{1}{\sum_{i=1}^{n} t_i} \qquad \text{(operations/sec)}.$$

It should be noted that the phases of instruction execution are carried out by different blocks at different speeds.

Let us assume that the main memory of the minicomputer consists of separate instruction memory and data memory blocks. The cycle time t_T of the conveyer is set equal to the longest phase:

$$t_T = \max_{(i)} \{t_i\}.$$

Usually the time required to complete the principal, short arithmetic-logic operations is shorter than the memory interrogation cycle. Let t_T be the duration of a memory cycle.

The speed of the processor would be $S = 1/t_T$, operations/sec.

In our case at $t_T = 500$ nanoseconds, $S = 2 \cdot 10^6$ operations/sec.

The actual speed may deviate from this value in both the greater and the lesser direction. If the duration of an arithmetic-logic operation is greater than one cycle, the real speed is less than that calculated; it becomes larger if a "record in memory" instruction or another not requiring four phases for its execution is being fulfilled. Creation of a processor with two independent blocks--instruction memory and data memory--ensures maximum speed for the processor. But this method requires significant equipment outlays to make the memory blocks independent.

Now let us evaluate the characteristics of the processor when the memory is organized in the traditional form of a single physical and address field. In this case the work of the conveyer is delayed during simultaneous interrogation of the memory in the instruction selection and operand exchange phases. While instructions may be processed in all phases simultaneously within the processor when there are separate lines to the instruction and data memories, when the memory is indivisible instructions can be processed simultaneously in up to two phases. In this case the speed is halved, and an additional load is imposed on the processor's separate blocks. Thus the arithmetic-logic unit executes the code for the instruction operation and modifies the address part of the instruction while the memory interrogation block selects the command from the memory and exchanges operands with it. It should be noted in this case that if the selected instruction does not require operand exchange, the memory interrogation block is now ready to select the next command. This variant of the processor's structure is typified by minimal equipment outlays in comparison with the example examined above, and by sufficiently effective use of the processor's apparatus. Moreover, as was noted at the beginning of this article, processor control follows the microprogram principle, and simultaneous control of the processor's independent blocks requires additional independent groups of word bits in the microinstruction and the associated equipment outlays.

The second variant of the structure results in a rather simple microprogram control unit that ensures simultaneous execution of different phases of two commands.

In this case the speed of the processor would be

$$S = \frac{1}{2 \cdot t_T} = 1 \cdot 10^6 \text{ operations/sec.}$$

Looking at the question of achieving a fast interrupt response in this minicomputer, we should note that this requirement arises when a large number of the object's sensing elements must be interrogated at a high frequency. Moreover depending on the course of the experiment, the processing program must be switched quickly, without loss of information.

The rate of the interrupt response is the sum of the following values:

$$t_{in.r} = t_{in.s} + t_n + t_{com} + t_{ecl} + t_{new},$$

where $t_{in.s}$--time from the start of an interrupt signal from the source to the beginning of determination of the number of the interrupt signal's source; t_n--time for determining the number of the interrupt signal's source; t_{com}--time of completion of the current processor instruction; t_{ecl}--time during which the state of the processor is eclipsed at the moment of interruption; t_{new}--time of establishment of the new state of the processor and the beginning of interrupt signal processing.

Time $t_{in.r}$ is determined from the equipment lag associated with activation of the electronic circuits and the load on the input-output channel. This time may be ignored.

Time t_n is determined by searching for the number of the interrupt signal source; however, the rigid time limits do not permit the processor to perform this function. The number of the unit is determined jointly by the equipment of the input-output channel and the interrupt signal source itself. We will assume that $t_n = 3\text{-}5$ μsec (t_n depends on the rate of information transmission along the lines of the channel in both directions and on the rate of operation of the channel's equipment in accordance with a special algorithm).

Time t_{com} is approximately 1 μsec; this time also includes the time for determining the processor state eclipse and recovery zones depending on the number of the interrupt signal source.

Time t_{ecl} is defined as an average of four memory interrogations (eclipsing of the instruction counter, the state register, the processor accumulator register and the program base register).

Time t_{new} is defined as three interrogations of the memory to establish the new values of the processor's registers.

Thus $t_{in.r}$ is 8-9 msec. The operation of determining the number of the interrupt signal source is completely superimposed over the processor's operation, and when execution of the current command ends, control is transferred to the microprogram responsible for eclipsing the contents of the processor's registers. This makes it possible to accelerate the interrupt response.

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11004
CSO: 1863/137

UDC 681.518.3

AUTOMATIC SYSTEM FOR DETERMINING DYNAMIC CHARACTERISTICS

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 1, Jan 82 p 22

[Article by candidates of technical sciences S. I. Yemets and I. G. Khanin and engineers S. D. Popovichenko and V. A. Rezvitskiy: "Automatic System for Determining the Dynamic Characteristics of Actuating Elements"]

[Text] In many cases rigorous demands are made for the dynamic characteristics of actuating elements, for example the amplitude-phase-frequency characteristic, the constant times of the transitional processes of acceleration and deceleration, and the time of deflection of the outgoing element (shaft, stem) of the actuating element. This in turn makes high demands on the means and methods of functional testing of actuating elements with respect to speed and precision.

Determining dynamic characteristics ordinarily involves oscillograph recording of the output parameter of the actuating element (displacement of the outgoing element), then decoding the oscillograms and calculating the characteristics by known formulas. This method has a low level of precision and is very labor-intensive; it make automation of the testing processing impossible.

An automatic system has been developed to automate the processes of functional testing, improve the precision of measurement of displacements, and determine dynamic characteristics. The information-measurement part of the system, the measurement subsystem, contains a displacement sensor; a BS-155A contactless transformer selsyn with a rotor that is rigidly connected to the outgoing element of the actuating element; a measurement block which forms at its output 16-bit parallel binary codes of measurement of the coordinate of the outgoing element -- the displacements that are sent to the storage unit of the computer.

The system has adopted the quantization technique for displacement in time and shaping and processing arrays of data on displacement. The technique is implemented using the phase-pulse method of measuring displacements, with time T of one measurement of a displacement serving as the step of quantization in time. The system uses an Elektronika-60 microcomputer as control machine. It shapes control actions for the actuating element and processes measurement data.

The following characteristics of the actuating element are determined as the result of processing the data that comes to the computer from the measurement subsystem (this is done using the special software of the system): angle of rotation of the shaft; average speed of movement; phase delay depending on the reverse rate; amplitude of oscillations in the amplitude function of a control action and reverse rate; constant times of the transitional processes of acceleration and deceleration of the actuating element.

Analysis of the work of the measurement subsystem showed that in the dynamic measurement regime distortions occur in the shaping of data arrays as the result of measuring the step of quantization in time, which depends on the rate of displacement of the outgoing element of the actuating element. To evaluate the distortions the concept of the coefficient of distortion K was introduced: $K = S_i/S_{i\phi} = \omega_0/(\omega_0+\omega)$, where S_i is the result of measurement in cycle i (i is the number of the measurement); $S_{i\phi}$ is the actual value of displacement of the outgoing element at time t = iT ($T = 2\pi/\omega_0$ is the period of rotation of the stator field of the selsyn, the period of measurement, and the step of quantization in time); ω_0 and ω are the angular velocities of the stator field of the selsyn and the rotation of the rotor respectively.

In the concrete case $\omega = (-240 \div +240)$ degrees/seconds and $T = 10^{-3}$ with coefficent $K = 0.9993 \div 1.0006$. The dynamic component of relative error in shaping the information array for displacement of the outgoing element of the actuating element is $\delta_\Delta = (1-K)100 = (0.006 \div 0.07)$ percent.

The full text of the article has 10 pages with three illustrations and two bibliographic entries. It is deposited at the Central Scientific Research Institute of Technical-Economic Information in Moscow under No 1612.

11,176
CSO: 1863/117

UDC 621.785.92

HEAT TREATMENT FOR FERRITE CORES SIMPLIFIED

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 1, Jan 82 p 32

[Article by engineer V. S. Romanovich: "Thermal Treatment of Round Ferrite Cores"]

[Text] Magnetic materials for pulse and high-frequency engineering must have high electrical resistance. The higher it is, the lower the power losses to eddy currents will be. Oxide magnetic materials, ferrites, have this property. In turn, they must match the required magnetic and electrical characteristics, geometric form, and dimensions strictly. In their production it is necessary to employ the simplest technological processes, those which insure maximum output of finished articles.

After the forming operation round ferrite cores (ferrites) usually go through high-temperature sintering in order to obtain elements with definite magnetic and electrical parameters. The result is ferrites that consist of individual coalesced crystals (grains) that influence their properties. The larger the grains are, the lower the strength of the ferrites will be. In addition, large grains have microcracks and irregular shape, which impairs their electromagnetic properties. We also know that sintered ferrite articles are subjected to annealing at 650-800 degrees C for 6-100 hours in a gaseous medium containing oxygen at a pressure of $0.5 \cdot 10^5 \div 5 \cdot 10^5$ pascal.

The prolonged cycle and complexity of the process of annealing in production lower the productivity of ferrite articles.

The Mogilev Tekhnopribor Plant has introduced a simplified heat treatment process that raises productivity 10-15 times while preserving the excellent electromagnetic properties of the ferrites.

Their heat treatment consists of processing the sintered ferrite cores in a medium of liquid nitrogen (-206 degrees C) for 0.5-2 hours followed by spontaneous hardening to room temperature in order to remove the internal mechanical stresses that occur with abrupt cooling.

The process is done on equipment manufactured at the plant. Five hundred thousand ferrite cores contained in a special package are submerged for 30 minutes in a Dewar flask type thermostat. If the number of articles processed at once is larger, the soaking time is increased to two hours.

The ferrite cores, cooled to the temperature of liquid nitrogen and soaked in it for 30 minutes, are removed from the thermostat and the process of spontaneous hardening begins (the temperature of the ferrite cores begins to rise to room temperature).

Because of high and low temperature oscillations in the ferrite cores, the ferrite grains which are irregular in shape and have microcracks break down into fine, full-value grains and the mosaic blocks are refined.

Simplification of the heat treatment process and raising productivity while preserving the good electromagnetic properties of the ferrite cores after introduction of cryogenic treatment produced an economic benefit of 127,000 rubles a year.

11,176
CSO: 1863/117

SOFTWARE

UDC 519.853

MATHEMATICAL METHODS OF CYBERNETICS

Kiev MATEMATICHESKIYE METODY KIBERNETIKI in Russian 1981 (signed to press 29 Apr 81) p 78

[Table of contents from book "Mathematical Methods of Cybernetics", editor-in-chief Yu. G. Stoyan, doctor of engineering science, Institute of Cybernetics, UkSSR Academy of Sciences, 500 copies, 82 pages]

[Text] Contents Page

8545
CSO: 1863/89

UDC 681.3.06

THEORY AND PRACTICE OF SYSTEMS PROGRAMMING

Kiev TEORIYA I PRAKTIKA SISTEMNOGO PROGRAMMIROVANIYA in Russian 1981
(signed to press 17 Jun 81) pp 106-107

[Table of contents from book "Theory and Practice of Systems Programming", editor-in-chief Ye. L. Yushchenko, corresponding memeber of the UkSSR Academy of Sciences, Institute of Cybernetics, UkSSR Academy of Sciences, 700 copies, 112 pages]

[Text] Contents

8545
CSO: 1863/89

PROGRAMMING IN UNIFIED-SERIES OPERATING SYSTEM BASED ON ASSEMBLER LANGUAGE

Moscow PROGRAMMIROVANIYE V OS YeS NA BAZE YAZYKA ASSEMBLERA in Russian 1981
(signed to press 3 Sep 81) pp 2, 6, 308-309, 316-319

[Annotation, excerpt from introduction, bibliography and table of contents from book "Programming in the Unified-Series Operating System Based on the ASSEMBLER language", by Zhanna Nikolayevna Zaytseva, Izdatel'stvo "Finansy i statistika", 40,000 copies, 320 pages]

[Text] In addition to a detailed description of the ASSEMBLER language, its close relationship with the operating system and the service which it offers the programmer user for the purpose of the fullest utilization of the resources of a computing facility is revealed. The discussion of the material proceeds from concepts of the structure of simple programs to the development of program complexes. Variants of combining programs are described: during compilation, input of the task, editing of connectives and execution.

For users of YeS [Unified Series] computers and VUZ students in the appropriate fields of specialization.

Because of limited space the following questions are not represented in this book: programming for numbers in a format with a floating point, programming at the physical level, files on punched tape, macroprogramming and programming in the time sharing mode.

This book contains the basic information needed by a programmer in writing and debugging programs and program complexes. It is also useful to programmers writing programs in high-level languages such as PL/1, FORTRAN and COBOL. This book is addressed to students studying third-generation machines and to specialists who are improving their knowledge in the area of attending to and using software for YeS computer models.

The author expresses her gratitude to Doctor of Technical Sciences G.K. Gavrilov and Candidate of Technical Sciences L.D. Raykov for their valuable comments and suggestions in writing the manuscript.

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CONTENTS

8831
CSO: 1863/124

UDC 681.3.06

REGULATION OF WORK ASSOCIATED WITH INTERACTIVE PROBLEMS IN DISPAK OPERATING SYSTEM

Irkutsk MATERIALY PO MATEMATICHESKOMU OBESPECHENIYU EVM in Russian 1980 pp 78-81

[Article by V. N. Balakirev, O. M. Balashov, V. P. Petlinskiy and V. F. Tyurin from book "Materials on Computer Software", edited by I. A. Sher, candidate of technical sciences, Sibirskiy energeticheskiy institut SO AN SSSR (SEI)]

[Text] An increase in the proportion of problems oriented toward work in interactive mode, or in ones close to it, can be observed today. Thus for example, the following dialogue systems can function, and are broadly employed, in the OS DISPAK/VESM-6 computer system: For program editing and debugging (DIMON, KRAB, KOP, SERVIS, REKS, PUL'T, SLUGA etc.); for service operations (DIOP, DZhIN, ZAP, PK, SERB, KAMNI etc.); a number of systems for problem oriented research. Obviously as a branched terminal network develops, this trend will be amplified (1).

Each of the dialogue resources used for communication with the computer user is typified on one hand by consumption of a certain amount of the resources of the computer system to support its normal operation, and on the other hand by a certain area of use. At the same time almost all such problems handled by the OS DISPAK have an equally privileged status and enjoy equal priority in selection for solution. This can be explained by the fact that they are not differentiated by rank in any way at this stage. For comparison purposes we can note that systems controlling admission of problems for solution, based on class ranking in accordance with a number of criteria, have already been developed for batch processing (2,3). The need for such a system regulating the admission of dialogue problems arises especially when there is a scarcity of terminal equipment and of computer resources used in dialogue systems (main memory lists and magnetic drum boosting channels) and when dialogue resources are available to all users. Such ranking must be accounted for during times when the terminal network experiences peak loads (daytime on work days); work on an unrestricted schedule is permissible in those times when overloads are known not to occur in the terminal network (night time and days off).

The principal criteria used to rank dialogue problems are: unit consumption of computer system resources to service one terminal of a certain dialogue system; area of applicability or broadness of use of a concrete dialogue system by a group of users; status of a particular terminal of a total number of terminals; status of a particular user.

When dialogue resources are ranked in relation to the first criterion, multiterminal monitoring systems have an advantage over single-terminal systems. In an OS DISPAK, the first criterion may be based on information provided during composition of the call code for the appropriate dialogue system.

The rank of a problem may be determined in relation to the second criterion from information furnished by a human administrator. Such information may be represented by the code (codes) of one (several) most popular dialogue systems.

Not all terminals have an identical status. We define terminals which may be used in accordance with a rigid schedule type 1 terminals. Type 1 terminals are the "personal property" of a certain set of users, and they can be used to run any dialogue problems within the allocated time. All other terminals are type 2 terminals. They are the "collective property" of the computer center users, and work is permitted with them at any time of the day, though only in multiterminal systems.

Introduction of the fourth criterion is necessary because there is always a group of users for whom access is permitted at any time and from any terminal. This list of users usually includes the system programmers and those performing urgent functions, and it is drawn up by the administrator.

Programs regulating admission of dialogue problems in an OS DISPAK have been written in accordance with the criteria described above. They include two program packages contained within the OS DISPAK and a utility service program used to schedule the work of the terminals.

The first package of the OS DISPAK contains a SKORYY nonresident module, and it goes into operation at the moment a request for a dialogue system is keyed in. The functions of this module include: determination of the correspondence of the type of dialogue system requested to the type of terminal; verification of permission to work at the given time, if this is a type 1 terminal; comparison of the user's code with the list of privileged users, if the first two checks produced a negative result.

In the event that any one of the three checks produces a positive result, the problem request becomes a candidate for solution, and it is admitted to the input queue of the processor planner. Otherwise the appropriate diagnosis is fed to the terminal.

The second package of the OS DISPAK functions periodically at a rate determined by the work of the nonresident module NOMBOB (about once every 2 seconds). The functions of this package include monitoring the order of work on those dialogue problems which are presently undergoing solution in both active and passive states (in the sense of occupying the processor's time). Five minutes before the scheduled time for working one (several) dialogue problem expires, this block transmits, to the required terminal (terminals), a warning to the user that the time allotted by the terminals scheduled for the work is expiring. When the allotted time expires, problem solution is mandatorily halted and the appropriate reason is entered into the statistics.

The following tables and scales, located within one of the zones of a 2053 systemic disc, are used as the input information to support the work of these packages: a section operation scheduling table (up to 100_{10} sections, beginning with number 00_{10} and ending with number 99_{10}); a table scheduling the work of terminals for the day (up to 64 terminals); a table of codes for multiterminal systems; a table of codes for priority users (up to 20); a scale of type 1 terminals (this one scale is enough because all other terminals are automatically treated as type 2 terminals).

The tables and scales are drawn up by the utility service program on the basis of the initial information introduced into the program in symbolic form. This information describes the contents of the tables and scales in accordance with the adopted syntax and semantics. The code for requesting the utility service program may be stored together with the initial symbolic information in the archives of one of the dialogue systems (for example in DIMON), and in accordance with the instructions of this system it may be corrected and transmitted to the program package used to draw up the tables and scales at the beginning of the work day. At the end of the scheduled time, all tables and scales are automatically cleared.

We note in conclusion that the scheme proposed in this article for controlling the running of dialogue problems has a number of advantages over known problem running schedules drawn up by resources of the dialogue systems themselves. Here are the most significant of them:

This system is more convenient and easier to operate because it does not require creation of a schedule for each of the dialogue systems contained within the computer center--that is, multiple redundancy is not required;

the same functions need not be made redundant in several dialogue systems, which reduces the outlays on their development;

the possibility of engaging "one's own" dialogue system without the awareness of the administration is totaly excluded;

there is less "trash" (unneeded information) in the statistics on solved problems, since admission to a dialogue program is analyzed before the program is placed in the input queue.

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APPLICATIONS

UDC 65.011.56+658.514.669

AUTOMATED DISPATCHER SYSTEM AT METALLURGICAL PLANT

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 1, Jan 82 pp 2-4

[Article by candidate of technical sciences A. P. Polishchuk and engineers L. I. Dubson, V. I. Shpektor, A. I. Kuranov and V. S. Zaytsev: "Automated System for Dispatcher Control at a Metallurgical Plant"]

[Text] During the 10th Five-Year Plan the Krivorozhstal' [Krivoy Rog Steel] Plant imeni V. I. Lenin completed development, testing, refinement, and introduction of an automated system for dispatcher control (ASDU) of a metallurgical enterprise with a full production cycle. The system is designed to provide the enterprise management and dispatcher service with operational data on the state of the production units and quantitative and qualitative indicators of the work of the principal plant subdivisions: sintering plant; two blast furnace shops and three steel foundries, three blooming mills, three section rolling shops, and warehouses for cast iron, steel ingots, and finished rolled products. The plant ASDU under consideration is the connecting element between the upper and lower levels of the hierarchy in an integrated system of enterprise control (the subsystem for operational calendar planning on the one hand, and shop industrial organization automated control systems on the other).

Figure 1 below shows the functional structure of the ASDU, which has eight subsystems. The principal functions performed by the ASDU are given in the table (below).

In these subsystems the course of production is accounted for and monitored chiefly on a shift and daily breakdown with information in running totals from the start of the month. Operational data are outputted on request to the screens of video terminals (SID-1,000's) which are installed for the director, chief engineer, chief of the production division, and the plant dispatcher service. These data are also printed out in the form of shift and daily datasheets and dispatcher reports. The ASDU has a special complex of data recording and representation problems to support these functions.

The hardware of the ASDU (see Figure 2 below) includes units to collect data and transmit information, data processing means, and a set of devices for representation and recording results and processing data.

The means of data collection are represented by a set of automatic instruments and signaling devices, consoles for manual data input, and specialized video terminals. Automatic data collection instruments are mounted on the two coke feed conveyors and on the sinter conveyor. They are tensometric conveyor

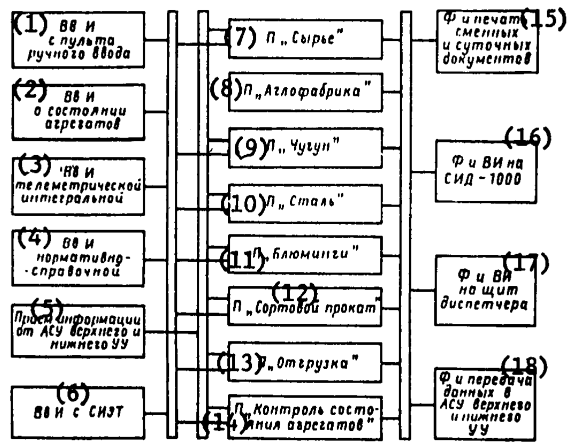

Figure 1. Functional Structure of the ASDU.

Key:
(1) Data Input from Manual Feed Console;
(2) Input of Data on State of Aggregates (Production units);
(3) Input of Integral Telemetric Data;
(4) Inpute of Reference-Norm Data;
(5) Receiving Data from ASU of Upper and Lower Control Units;
(6) Data Input from Station for Representing Symbolic Data on Television Screen;
(7) Raw Material Subsystem;
(8) Sintering Plant Subsystem;
(9) Cast Iron Subsystem;
(10) Steel Subsystem;
(11) Blooming Mills Subsystem;
(12) Section Rolling Subsystem;
(13) Shipping Subsystem;
(14) Subsystem for Monitoring State of Aggregates;
(15) Shaping and Printing Shift and Daily Documents;
(16) Shaping and Outputting Data to SID-1,000;
(17) Shaping and Outputting Data to Dispatcher Console;
(18) Shaping and Transmitting Data to ASU's of Upper and Lower Control Units.

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scales made by the West German Schenk Company. The automatic signaling units are designed to produce signals on the presence or absence of metal in the monitored section or to form signals on the state of particular units.

The following signals are shaped by the use of simple relay circuits: "Operating" and "Down" for sintering machines; "Full Speed," "Slow Speed," and "Tap" for blast furnaces; "Operating," "Down," and "Tapping Steel" for convertors and open hearth furnaces. For the rolling mills the "Operating" and "Down" states are recorded by the time that lapses between the passage of two adjacent rolled lengths through a certain section of the mill. This time is read by photorelay pulses. These same pulses are used to count the number of rolled pieces. The "Repair" state is fed by service personnel of the appropriate units using special switches.

Table.

Subsystem		Principal Functions	Representation of Results of Subsystem Functioning
1. Sintering plant	1.1.	Operational accounting and monitoring of sinter production for each sinter machine and for the shop as a whole	Print — one shift datasheet; indication on SID-1,000 — two forms; indication on dispatcher console
	1.2.	Operational accounting and monitoring of sinter quality	
	1.3.	Operational accounting of number of railroad cars unloaded by car-tipper and vacuum values in vacuum chambers	
2. Raw materials	2.1.	Operational accounting and monitoring of receipt of basic raw materials and fuel at blast furnace shops Nos 1 and 2	Print — two daily datasheets; indication on SID-1,000 — 24 forms; indication on dispatcher console
	2.2.	Operational accounting and monitoring of raw material and fuel quality	
	2.3.	Operational accounting of expenditures and balances of raw materials and fuel	
3. Cast iron	3.1.	Operational accounting and monitoring of production and distribution of cast iron from blast furnace shops Nos 1 and 2	Print — one shift datasheet; indication on SID-1,000 — 60 forms; indication on dispatcher console.
	3.2.	Analysis of time of tapping and calculation of the rhythm coefficient for the blast furnace	
	3.3.	Operational accounting of availability and distribution of ladles	
4. Steel	4.1.	Operational accounting and monitoring of steel production by open hearth and convertor shops	Print — three shift datasheets; indication on SID-1,000 — 14 forms; indication on dispatcher console.
	4.2.	Operational accounting and montoring of steel quality	

[Table continued, next page]

[Table continued]

Subsystem		Principal Functions	Representation of Results of Subsystem Functioning
	4.3.	Operational accounting and monitoring of performance of orders by steel foundry shops (by shift, day, and month)	
	4.4.	Operational accounting of quantity and quality of cast iron in mixers	
5. Blooming mills	5.1.	Operational accounting of number of ingots received at blooming mills Nos 1-3	Print — three shift datasheets; indication on SID-1,000 — 12 forms; indication on dispatcher console
	5.2.	Calculation and monitoring of metal temperature at moment of arrival and fitting	
	5.3.	Operational accounting and monitoring of blooming mill production with breakdown by section and dimensions (implant, hot rolled products, commercial semifinished articles)	
6. Section rolling	6.1.	Operational accounting and monitoring of production of section rolling shops	Print — one shift datasheet; indication on SID-1,000 — 20 forms; indication on dispatcher console
	6.2.	Operational accounting and monitoring of performance of orders by section rolling shops	
7. Shipping	7.1.	Operational accounting and monitoring shipping of commodity cast iron	Print — one daily datasheet and one shift datasheet
	7.2.	Operational accounting and monitoring of shipment of commodity steel and availability of metal at ingot warehouse	
	7.3	Operational accounting and monitoring shipping of commodity semifinished products by blooming mills and availability of metal in adjunct stages	

[Table continued, next page]

[Table continued]

Subsystem		Principal Functions	Representation of Results of Subsystem Functioning
	7.4.	Operational accounting and monitoring of section rolled products and availability of metal at warehouses of section rolling shops	Print — one daily datasheet and one shift datasheet
8. Monitoring the state of the production units	8.1.	Operational accounting of unit downtime at the plant (as a whole and broken down by causes)	Print — eight datasheets; indication on SID-1,000 — six forms; indication on dispatcher console
	8.2.	Recording the states of the plant's production units	

The manual feed consoles include the TM-301I remote control system and are designed for a set of messages up to 120 digital characters long. Manual control consoles are used in places where raw data originate and are connected by a radial scheme to the monitored points of the remote control system. Manual feed consoles are used to input data on the quantity of raw materials and fuel received and its time of arrival, the weight and distribution of taps of cast iron and steel, hourly and shift production of rolled products with a breakdown by dimensions of shaped pieces, causes of unit downtime, and the like.

At the same time the dispatcher system imposes high requirements for the timeliness and reliability of the data being transmitted, in particular data fed by shop production personnel using remote terminals. Experience with operation of the ASDU has demonstrated that shop operators, weighers, and other production personnel are not always able to prepare and feed the essential data to the computer on time using the manual input consoles. When emergency situations occur during peak loads information is fed 2-3 hours late at best. Furthermore, feeding the computer data on production for a certain period, if it is not conditioned on the technology of the data transmission system existing at the plant, leads, for one, to production personnel performing additional functions, and for two, to lack of monitoring over data being fed (with the exception of very limited possibilities of program monitoring of the completeness of transmission, correctness of format, and locating each parameter within given limits).

For this reason, development of the ASDU is occurring concurrently with introduction, at the Krivorozhstal' Plant imeni V. I. Lenin, of local information systems to transmit production information. They are based on SIET's [stations to display symbolic information on a television screen] and transmit information (and instruction) messages along production lines with simultaneous input of the messages to the computer.

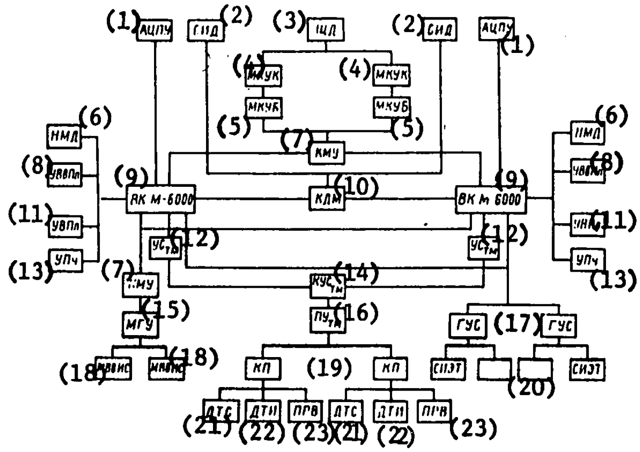

Figure 2. Structural Diagram of the Hardware Complex of the ASDU.

Key:
(1) Alphanumeric Printer;
(2) Data Display Stations;
(3) Dispatcher Console;
(4) Contact Code Control Module;
(5) Contactless Code Control Module;
(6) Magnetic Disk Store;
(7) Control Module Commutator;
(8) Punched Tape Data Input Unit;
(9) M-6000 Computer Complex;
(10) Display Module Commutator;
(11) Punched Tape Output Unit;
(12) Unit for Communication with Remote Control System;
(13) Keyboard Printer;
(14) Commutator of Unit for Communications with Remote Control System;
(15) Group Control Module;
(16) TM-301I Remote Control Point;
(17) Group Communications Unit;
(18) Initiative Signal Input Module;
(19) Monitored Point;
(20) Station for Indication of Symbolic Information on Television Screen;
(21) Remote Signal Sensor;
(22) Sensor of Telemetric (Integrated) Data;
(23) Manual Feed Console.

The use of SIET's makes it possible to set up a message 112 characters long (the capacity of one page of memory), store it in buffer memory, display it on the screen, and transmit it to the pipeline and computer. The total capacity of the SIET memory is up to 10 pages of 112 characters apiece. The contents of each page can be displayed on the screen; the characters are 15 by 24 millimeters in size for a picture tube of 59-61 centimeters on the diagonal, and they can be seen from up to 15 meters. As many as 12 television receivers at distances up to two kilometers can be connected to the pipeline. Data is exchanged with the computer by means of a builtin interlinking device to a telephone line up to 14 kilometers long. The speed of exchange is 600 bauds.

Use of SIET's as remote terminals made it possible to raise the operational qulity of production data input to the computer, significantly reduce the volume of data which operations personnel must transmit exclusively for input to the computer; and, improve the reliability of data being fed by shop production

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000500060066-8

personnel's monitoring it and repeating the input in case of errors. Furthermore, use of SIET's made it possible to increase the volume of information coming to the dispatcher and plant manager because qualitative indicators (chemical analyses of raw materials, fuel, melted pig iron, slag, and steel) of the work of the blast and steel foundry shops were recorded and displayed. In rolling production the SIET permits a more detailed (by grades of steel and dimensions of sections) record of performance of orders.

The data display equipment of the ASDU comprises the dispatcher's panel and console and five SID-1,000 data display stations. The dispatcher panel is designed for indicating the current state of production by lights and giving warning signals. Information on the states of the principal industrial processes (work, downtime, and repair), on output actually produced since the beginning of the shift or day, and deviations from assignments are outputted to the panel; it also indicates the beginning and end of tapping cast iron and steel. Operational digital information is outputted to the dispatcher panel following a request of the dispatcher console. All information on the course of production and state of the production units can be shown on the panel by the dark or light panel circuit following a dispatcher instruction. When the state of the production unit changes the blinking signal can be "skvitirovan" [possibly "stopped"].

The software of the ASDU includes more than 120 programs for feeding and processing operational information, accounting for and analyzing production, shaping arrays of plans and schedules, and outputting data on production through display and printing units and makes it possible to modify programs efficiently. This is epsecially important in the initial stages of functioning of the system, and also provides a possibility of regenerating stored data after malfunction and permits work in real time where there is a large number of subscribers.

The sets of problems of the ASDU are executed under the control of an RV disk operating system. During generation of the system drivers of system terminals from standard ASVT M-6,000 software, the driver of the nonstandard unit for interlinking the telemechanical system of the computing complex, and the driver of the SIET are used.

All user programs which demand rapid response to changed external conditions are formulated as disk resident programs and have the "swapping" feature. Only a few high-priority problems are executed as internal memory-resident programs.

The system of dispatcher control can work in an automatic regime and a correction regime. In the automatic regime data coming from the telemechanical system from the SIET are subjected to logical monitoring, after which authorization is given to switch in the user problems of accounting and analysis that shape the working and resulting data arrays. Production schedules are put into the computing complex at the beginning of the day; planning information is fed at the start of the month. The results of performance of problems can be displayed on the SID-1,000 screen and on the dispatcher panel on request. Upon completion of a certain period (shift or day) the corresponding dispatcher reports are formulated and printed.

The correction regime is used to restore the work capability of the system after malfunctions in the computer complex; when the system is down data input by punched tape is envisioned.

The ASDU being described is based on application of a system of file control. This made it possible to construct the above-named sets of problems on the modular principle and, therefore, to write and debug the programs for them independently of one another. The structure of the information base and program modules of the system is done in a way that insures the possibility of enlarging the total volume of raw data, including data in the system of data components, without significant expenditures for reprogramming.

Access to the data arrays is accomplished by means of appropriate manuals. The internal memory stores only the information array; the results of processing in the form of a working array and a resulting array are copied on external media (magnetic disks).

The working and resulting arrays give information, respectively, for the current (for example since the start of the day) and preceding time segments. The structures of these arrays are practically identical, which makes it possible for the system, without additional efforts for programming, to store and print out or display data on the current and preceding period (shifts or days) and to make corrections for the preceding period and to the running total in case information is fed late.

Because of the limited memory volume printing does not use buffering, but rather is done with output of data through a common region where data, recoded in symbolic form, are copied to output one line (up to 120 characters). The data are outputted; then the readiness of the alphanumeric printers for further work is analyzed and the next line is outputted after recoding.

The system has established monitoring of completion of jobs by a periodic check on the presence of filled information arrays and putting the corresponding jobs in a queue (information arrays are cleared when the job is completed).

The ASDU we have described is a system of operational accounting for production so it is natural that when information is accumulated from the start of the month certain discrepancies between it and the figures of plant accounting documents will occur. To avoid this the ASDU has organized input of refined information on production and the distribution of the principal types of output based on data from the planning division and production division of the plant. This is as follows: each day before 1500 the plant management service prepares refined information for the plant management concerning the actual course of production from the start of the month until completion of the preceding day. One copy of this document is sent to the ASDU duty officer, who must put this information in the computer before 2300.

Thus, in the ASDU information on production from the start of the month always includes refined figures for the end of the preceding day and operational data for the current day. This makes it possible to formulate information on production from the start of the month with a high degree of authenticity and to simplify synchronization procedures with the process when the system is restarted.

The links between the ASDU and other levels of control are conditioned by the fact that it is part of the integrated plant ASUP [automated system for production control] and exchanges information with the subsystem for operational calendar planning at the highest level and with the shop production-organizational automated control systems at the lowest level.

In the 11th Five-Year Plan the ASDU of the Krivorozhstal' Plant imeni V. I. Lenin is to be connected in to the sector automated control system that is under development. The problems of integration make additional demands for the organization of ASDU software, and as a result the latter has a special set of programs for shaping data files with subsequent transmission to these automated control systems.

Introduction of the system into operation by stages began in 1977 with a gradual enlargement of the functions and refinement of software and hardware. The economic impact of introduction of the system is 770,000 rubles of a year owing to a reduction in production losses and penalties. It is contemplated that the fundamental decisions with respect to functional structure, methods and means of collecting data, processing, recording, and displaying information, software, and monitoring and diagnosis techniques will be used to build systems for operational control of primary production at other ferrous metallurgical plants.

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CSO: 1863/117

UDC 669.184.244.66:[658.012.011.56:658.514]

AUTOMATIC DISPATCHER SYSTEM USED SUCCESSFULLY IN METALLURGY

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 1, Jan 82 pp 4-6

[Article by doctor of technical sciences S. K. Sobolev, candidates of technical sciences R. M. Nikolaychuk, V. S. Bogushevskiy and N. A. Sorokin, and engineers S. V. Pirogov and A. A. Rogoznyy: "Dispatcher Control of a Convertor Shop"]

[Excerpts] Studies of the work of convertor shops show that 5-10 percent of the calendar time is taken up by production unit downtime related to organizational factors. Without operational information on the state of the equipment and availability of charge materials, the production preparation foremen and shift heads essentially do not have time to control production. Moreover, it is impossible for an ASU TP [automated control system for industrial processes] to function successfully without solving dispatcher problems.

The Yenakiyevo Metallurgical Plant has launched an ASU TP for a convertor shop. It performs both production and dispatcher jobs. The system is based on a two-processor M-6,000 control computer complex. It collects information on the work of the main shop sectors and controls them. Information on the work of particular sectors and equipment of the convertor shops is outputted to the control panel of the foreman for production preparation of the convertor shop (see Figure 1 [not reproduced]).

The basic information is formed automatically from local data collection networks with realization of corresponding algorithms on the M-6,000 control computer complex. Information on the working order of the valves, the operation of the mixers, and the presence of the slag hopper and steelmaking ladle under the convertor is fed manually in the form of position signals.

The local circuit for determining the position of the cast iron ladles and their loading uses information on the delivery of the empty ladle to the scales, pouring cast iron into the ladle, transporting it, and pouring the cast iron into the convertor. Information on the weight of cast iron in the mixers comes from the sensor of the angle of inclination of the mixer for pouring iron into the ladle, the sensor that determines the number of ladles poured into the mixer, and the local circuit that monitors mixer ware during the operating process.

Information on the technological operations of the convertor travels from the local circuit, which considers the angle of inclination of the convertor and receipt of signals on engagement of the blast, lowering the lance into the convertor, the introduction of loose material, and the duration of the blasting process. Information on the time that pouring in the pouring area begins and ends, the shop number of the melt being poured, and the type of ingot molds travels from the manual data input console installed in the pouring bay.

The work of the dispatcher is controlled differently depending on the nature of the indicating parameter and the source of origin of the information: from the dry contacts of the circuits for control of industrial equipment, from the M-6,000 control computer complex, and a mixed form. Control from the M-6,000 complex is accomplished by means of a special interface block BIF-T which is connected directly to a 2K interlink. Control is done by messages of four binary-decimal bits apiece.

Industrial use of the dispatcher part of the system made it possible to raise shop productivity by three percent and insure rhythmic production. The economic impact from introduction of the system was about 200,000 rubles a year.

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CSO: 1863/117

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METHOD FOR CALCULATING AMPLITUDE CHARACTERISTICS OF RANDOM PROCESSES

Kiev POSTROYENIYE AVTOMATIZIROVANNYKH SISTEM OBRABOTKI EKSPERIMENTAL'NYKH DANNYKH in Russian 1981 (signed to press 3 Jul 81) pp 21-25

[Article by V. Ya. Gal'chuk, V. I. Ivanas, O. I. Starodubova and Yu. F. Luk'yanov from book "Synthesis of Automated Systems for Processing Experimental Data" edited by G. S. Tesler (editor in chief), Nauchnyy sovet po probleme "Kibernetika", Ordena Lenina institut kibernetika, Akademiya nauk Ukrainskoy SSR, 550 copies]

[Text] In research on random processes, the need arises in a number of cases for evaluating the process under analysis on the basis of its amplitude characteristics. For example if we are to evaluate stresses arising in the hull of a vessel as it moves over a wavy surface, if we are to evaluate the sea state and so on, we would need to analyze not the entire temporal series but only its amplitudinal values, spread and periodicity.

This article examines one of the methods of calculating the amplitudes and half periods of a random process.

Assume we are dealing with a random process x_i $(i = 0,1...N-1)$, a portion of which is shown in Figure 1. Amplitudes A_1, $A_2...$, A_k must be isolated and their distribution law must be plotted.

The problem is solved in two stages. In the first stage we isolate all extremums a_1, a_2, ..., a_j,...from the total quantity of ordinates (Figure 2). The criterion we employ in this case is the change in sign of successively calculated differences between two neighboring ordinates--that is, (x_i-x_{i-1}), $(x_{i+1}-x_i)$ etc. If such a change in sign occurred, then the value of the lower ordinate is taken as the sought extremum and entered into the set of extremums (a_j). Concurrently we enter into the memory the current time (t_j) corresponding to this extremum. (At $x_i-x_{i-1} = 0$ a transition occurs to the next difference.)

The next stage in the calculations entails sorting the obtained set a_j with the purpose of sampling out the global extremum to which correspond A_1, A_2, ..., A_k (Figure 3). Global extremum values are those which are maximum in relation to the modulus within the interval of transition to the zero axis--that is, in the intervals of positive and negative domains.

In this approach, however, global extremums may also include a_6, a_7, a_{22}, a_{23} and so on, which must be excluded from further examination. To avoid the addition of such extremums to the set of global extremums, an additional limitation must be imposed on the selected amplitudes in the form of a stop band for amplitudes ($\pm\Delta A$)--that is, amplitudes falling within the interval [$+\Delta A$,$-\Delta A$] are excluded from the subsequent calculations.

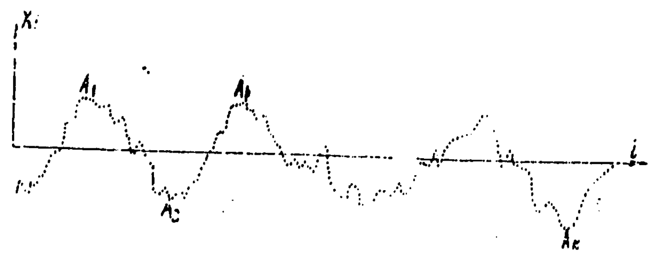

Figure 1

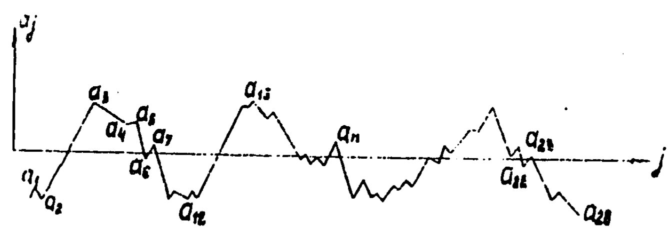

Figure 2

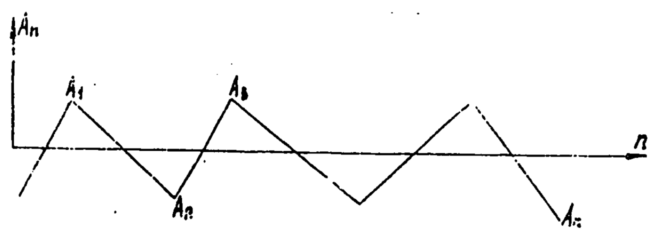

Figure 3

As a result of such calculations we can obtain a set of global amplitudes (A_k) and the set of half periods corresponding to this set (T_k). Then we plot the amplitude and half period distribution laws.

Selecting the theoretical distribution law on the basis of congruence criteria τ^2 or ω^2, we check the correspondence of the experimental distribution law to the

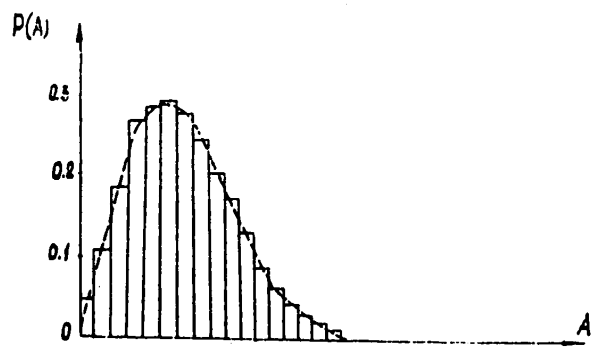

Figure 4

selected theoretical law. We proceed similarly with the set of half periods T_k as well. It should be noted that in certain cases it would be suitable to first smooth the set of ordinates in order to exclude certain frequencies distorting the values of the amplitudes of interest to the researcher. The sliding average method can be recommended as one of the smoothing methods (1).

Let us examine an example. Assume we must evaluate the stress on the hull of a vessel. Let the time of action of the stresses be $T = 12$ minutes (the portion shown in Figure 1). The first stage of the solution gives us set a_j (see Figure 2), and the second stage gives us set A_j (see Figure 3). ΔA is selected by the experimenter. In this case $\Delta A = 0.5\ A_{max}$. The distribution law for the global amplitude is shown in Figure 4. We proceed similarly with the set of half periods T_k.

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CSO: 1863/137

UDC 550.83:53.083.8:681.3

STANDARDIZING EQUIPMENT USED IN GEOPHYSICAL EXPLORATION

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 1, Jan 82 pp 14-17

[Article by candidate of technical sciences L. I. Orlov, chief of the Special Design Bureau of Geophysical Instrument Making: "Problems of Building Standardized Information-Measurement Systems in Geophysical Instrument Making"]

[Text] The current level of technology used in carrying on exploration for petroleum, gas, and other mineral products is determined by the level of development and production of geophysical equipment. The economic and technical indicators of the use of the equipment, which are the basis of the economic indicators of geophysical studies, depend above all on the qualitative parameters (informational value, precision, and the like) and quantitative features (speed of the experiment, rate of data processing, and the like). It is clear that both kinds of characteristics can be improved by refining proven geophysical research techniques and by applying new methods of exploration. The development of geophysical techniques depends on refining the latest scientific and technical advances to improve these techniques. This makes clear how important it is for geophysical work to develop and quickly introduce highly productive modern equipment [1].

The trends in development of geophysical systems permit us to single out the main features that necessitate the application of efficient means of processing measurement data and automating control and monitoring of the measurement process. Among these features are the increase in number of channels, diversity of the sensors that measure the parameters of various physical fields, the impact of external factors, the complexity of the functions of controlling the measurement process and outputting data, and the requirements for diagnostic procedures. In geophysical systems these problems are traditionally solved chiefly by means of analog computers, or in some cases special digital computers (the LTsK-10 well-logging unit, the Progress seismic unit, and others). Various types of software (logic blocks, program blocks, and the like) based on rigid logic are applied to solve the problems of controlling the measurement process.

This method of construction necessitates individualization of the algorithm of the control process, prevents expansion of the system and enlarging its functional capabilities, makes development more complex and expensive, and complicates the process of updating equipment and introducing new developments into production. The great diversity of sensors with different output characteristics and the variety of geophysical techniques make it necessary to have many individual elements, for each case, in measurement and convertor units. This results in greater complexity of geophysical information and measurement systems, overly narrow specialization, and orientation to solving concrete problems. As a result, a large number of narrowly specialized systems have appeared in recent years.

The situation that has come about poses the challenge of standardizing geophysical equipment for different research techniques. This would reduce the time required for development and incorporation into production and produce a major economic impact in the national economy. The development of standardized equipment would act as the "jumping off place" for increasing the pace of technical re-equipping of geophysical work.

The purpose of the present article is to formulate the fundamental principles of building a standardized geophysical measurement-computing complex. The development of a new basic element in recent years, microprocessor computer equipment, is useful in solving this problem.

The principal techniques of geophysical exploration today are seismic exploration, electrical exploration, and geophysical well studies. The latter include also techniques of studying the geological cross-section during the drilling process (gas logging and monitoring the industrial parameters of drilling) because in many cases analysis of drilling parameters gives a reliable description of the geological structure through which the well passes.

Technical equipment for contemporary seismic exploration includes sources that generate P-waves (longitudinal) and S-waves (transverse) and a seismic recording system. Figure 1 shows the typical structure of the recording system. It reflects the fundamental principles of construction of all seismic stations produced in the USSR, including newly developed ones produced by the Moscow Geofizpribor [Geophysical Instrument] Production Association (the Progress Station). Trends in the development of seismic recording systems are analyzed in detail in work [2].

Equipment for electrical exploration work includes generators of electromagnetic fields (direct or alternating) and various types of apparatus to receive and record emissions after they interact with the geological formation. Plants of the Ministry of Instrument Making, Automation Equipment, and Control Systems and the USSR Ministry of Geology are producing about 20 types of recording equipment for electrical exploration methods. Most electrical exploration systems are analog types with few channels. The TeES-2 shown in the block diagram in Figure 2 is a typical representative of a digital electrical exploration unit. Enterprises of the Ministry of Instrument Making, Automation Equipment, and Control Systems are planning the production of multichannel digital electrical exploration stations (TeES-3). Many institutes of the USSR Academy of Sciences, the USSR Ministry of Higher and Secondary Specialized Education, and the USSR Ministry of Geology are working on building multichannel digital recording systems for electrical exploration.

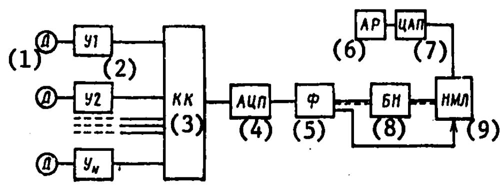

Figure 1. Typical Structure of a Seismic Recording System

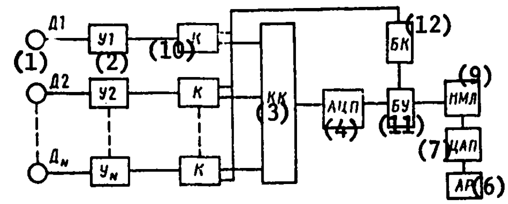

Figure 2. Block Diagram of TsES-2 Digital Seismic [sic] Exploration Apparatus

Key: (1) Sensor [Nos 1, 2, ...N];
(2) Amplifier [Nos 1, 2, ...N];
(3) Channel Switching Unit;
(4) Analog-Digital Convertor;
(5) Format Convertor;
(6) Analog Register;
(7) Digital-Analog Convertor;
(8) Storage Block;
(9) Magnetic Tape Storage;
(10) Compensator(s);
(11) Control Block;
(12) Compensation Block.

Field geophysical equipment consists of various types of well instruments which house sensors to measure physical fields in the wells and logging and gas-logging stations that control the collection and processing of data. Figure 3 below shows a consolidated block diagram of the LTsK-10 digital logging laboratory.

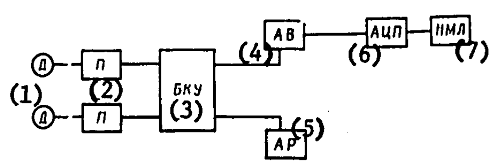

Figure 3. Block Diagram of the LTsK-10 Digital Logging Laboratory.

Key: (1) Sensors;
(2) Panels;
(3) Switching and Control Block;
(4) Analog Computer;
(5) Analog Register;
(6) Analog-Digital Convertor;
(7) Magnetic Tape Store.

Enterprises of the Ministry of Instrument Making, Automation Equipment, and Control Systems, the Ministry of Petroleum Industry, and the Ministry of Geology are producing more than 10 types of logging and gas-logging stations designed for geophysical studies under different conditions. Most of them are analog systems. The stations to monitor industrial parameters during the drilling process based on characteristics are in large part similar to the logging and gas-logging stations mentioned above.

Despite the diversity of equipment in use, with respect to functional structure all these stations are similar to one another, and some differences do not cause fundamental changes in their structure. This gives reason to consider geophysical stations on the level of execution of functions as geophysical information-measurement systems. The heart of any information-measurement system, including the geophysical one, is the measurement-computing complex (MCC). Its structure does not depend on application, operating conditions, or geological technique employed by the particular geophysical information-measurement system.

The functions of any measurement system can be realized by various methods which make up the set of structures. For this reason the central issues of development of geophysical information-measurement systems are selecting and substantiating the structure of the system, defining the function of communication with the object, and analyzing and realizing algorithms for monitoring and controlling the object and algorithms for exchange of information with the operator.

It must be observed that in recent years MCC's have developed along the paths of ever-increasing volume of data processing, more thorough diagnosis of the state of the system, and a more complete volume of information represented for interpretation, in a form that is more convenient for consideration. At the present time the trends in development of the structures of geophysical MCC's have hardly been formulated. But the necessity of working out a uniform conception for the development of MCC's demands that they be defined.

Analysis of the structure of contemporary MCC's used in various fields of science and technology shows that they are practically all constructed on the pipeline principle of data exchange among units included in the complex [3]. Data on signals that are measured and outputted, information on switches, and control and auxiliary signals that define the processes of information exchange are transmitted along the pipelines.

Other equally important characteristics of contemporary MCC's are modular construction and microprogram control of the process of data collection and processing, and of the system and diagnosis. For this structure they are obligated to the developments of microprocessor technology and microcomputers, which make it possible to develop specialized units that realize very diverse control and computing functions, in other words to set up an aggregate system on the principle of pipeline-modular construction with microprogram control.

It is equally important that the use of microcomputers and microprocessors opens broad opportunities for realizing a number of functions: statistical processing, error correction, monitoring work capability, diagnosis, forecasting malfunctions, and others. The realization of these additional functions, which improve metrological characteristics and raise technical-economic indicators, insures a qualitatively higher level of geophysical MCC's.

The technical-economic efficiency of using microprocessors and microcomputers results, in addition to the obvious factors, from the possibility of both enlarging the microcomputer or microprocessor system itself and adding additional peripheral equipment without altering the entire system. Designing for a concrete problem becomes reprogramming without modification or simply a matter of adding certain assemblies or sensors.

The use of microprocessor computer equipment creates conditions for constructing geophysical measurement-information systems on new architectural principles. There are broad opportunities for the development of systems with parallel processing (single-level multiprocessor systems) and multiprocessor systems with multilevel architecture. In such geophysical measurement-information systems the microprocessor (microcomputer) at the lowest level linearizes the output qualities of the sensors, corrects errors, and controls the channels for communication with the microprocessor (or microcomputer) of the higher level. At the highest levels data is processed according to assigned algorithms and the work of processing is controlled.

Thus, the pipeline-modular principle of constructing MCC's using microprocessor or computer equipment is the basis on which it is possible to standardize geophysical equipment and improve metrological support and the quality of processing of geophysical data. All this will make it possible to solve the problem of sharply expanding the volume of production of geophysical equipment in the 11th and 12th five-year plans.

For MCC's based on pipeline-modular structure there must be, in the stage of concrete technical realization: analysis of the logical algorithms of processing data for control, monitoring, and diagnosis; analysis and selection of hardware and means of realizing these algorithms while concurrently optimizing them, and development of hardware for machine realization of algorithms or programs for software realization.

The special characteristics of using a geophysical MCC make additional requirements for such technical specifications as dimensions, weight, power consumption, and resistance to mechanical and climatic effects. This demands, in turn, that in the development of geophysical MCC's concepts be found which differ fundamentally from those for other MCC's. The technology of geophysical work that exists at the present time and, for all appearances, will continue in the near future, ordinarily defines the collection and initial processing of information by simplified parameters. This outlines the range of problems for which geophysical MCC's will be built: collection of information from numerous sensors, preliminary data processing, control of the process of recording information on long-term media, and system monitoring and diagnosis.

The results of analysis of geophysical measurement systems given above made it possible to identify a number of common features that satisfy different conditions of the application of MCC's in seismic recording, electrical exploration, and field geophysical systems. Bearing in mind that microprocessor equipment is the foundation for newly developed MCC's, we must formulate the following specifications, which are most typical for the geophysical MCC being developed:

a. 3-24 measurement channels (except for seismic systems with very large numbers of channels);

b. query time for one channel of 9-10 microseconds (with sequential querying and no more than five parameters measured in one channel);

c. minimum level of the input channel of 0.2-5 microvolts, dynamic range of 80-50 decibels, and frequency range of 0.01 hertz-10 kilohertz;

d. coefficient of phase, amplitude and frequency distortion, which determines the precision characteristics of the system, of 0.01-1 percent;

e. the procedures and algorithms for system diagnosis and monitoring should insure identification of malfunctions to the level of a single card;

f. the work regime in an emergency situation should preserve work capability in the case of malfunctioning of up to 50 percent of the measured channels with a signal on the existence of the malfunction;

g. the procedures for representing measured information visually should use a paper medium (for documents) and a video monitor (to monitor the state of the system and the quality of recording);

h. the long-term medium for subsequent data processing is a magnetic medium with a capacity of 1-2 megabytes;

i. the volume of internal memory is 64 Kbytes, the volume of read-only memory is 16 Kbytes, and the type of read-only memory is an electrically reprogrammable device or a magnetic medium;

j. the depth of data processing is determined by the capabilities of the computer selected and the communications channel, with a data format of 16 bit positions and a speed of 300,000 simple operations a second;

k. the possibility of expanding the system in different variations of use; this parameter is guaranteed by the principle of modular construction itself.

A key decision that determines the level of standardization in building a geophysical MCC is selection of the microcomputer. This is done on the basis of analyzing the generalized processing function, and the functions of control, monitoring, and diagnosis reviewed above. The system of communication between the machine and peripheral equipment or many machines in multiprocessor systems depends on the microcomputer that is used.

The microcomputers being produced at the present time have a limited assortment of units for communication with the object, but there is a capability of connecting various peripheral units to the pipeline of the machine. Because the assortment of such devices in geophysical MCC's is small and operating conditions for them do not permit the use of series-produced instruments with output to machine-independent pipelines (MEK, CAMAC), it would be advisable to use the pipeline of the machine itself. But it is designed to connect up a definite number of peripheral units and increasing this number disturbs the established optimality and leads to unjustified expenditures of hardware and software. In such cases, nonetheless, it is better to add one of the standard machine-independent pipelines to the system. The most reasonable one to use for geophysical MCC's is the MEK pipeline.

The level of standardization in development of MCC's will depend on the level of centralization of processing functions; a high level of centralization makes higher demands for the computing power of the central microcomputer. This means that it is likely there will be some cases where realization of certain processing functions must be accomplished at the lower level of the structure (variation of realization of a multilevel structure).

The latter became possible with the appearance of built-in microprocessor equipment. Of the microcomputers now in production, the Elektronika 60, the Elektronika NTs-03D, and SM 1800 meet these requirements most fully. Series production of the Elektronika NTs-80P1, a single-card microcomputer now under development, is to begin this year. It has greater speed, smaller dimensions, and is compatible with the SM-3 and SM-4 machines. In terms of technical specifications this microcomputer most fully meets the requirements made for the machine in the geophysical MCC: speed of 300,000 operations a second, 16 bit positions, power consumption of 10 watts, and weight of 0.2 kilograms.

We must observe again that the path to standardization of geophysical equipment is blocked by numerous problems linked to the traditionally established departmental approach to development. This does not mean, however, that the particular organizational-technical difficulties cannot be overcome. Without going into questions of organization here, we can give examples of technical solutions to problems of this sort: development of the CAMAC pipeline-modular system (State All-Union Standard 26.201.80), the "Common Line" interface (the DEC Company of the United States), the standard for the digital interface for IEEE-488-78 programmable measuring instruments, and others.

Formulation of software is becoming an important question in the development of geophysical MCC's based on microcomputers and microprocessors. The software is given three basic jobs: processing incoming information, controlling the measurement process, and system monitoring and diagnosis. These jobs involve realization of the functions of data input-output, conversion of data, various types of corrections, producing control signals with a definite sequence, and executing monitoring and diagnostic procedures.

Field geophysical studies contemplate chiefly collection and preliminary processing of data; this means that the peripheral equipment of the MCC usually does not have to have control feedback. In this case processor time will be fully controlled by the operating system, and instructions will be carried out one after another in sequence. The operating system is degenerated into a package of drivers for communications and information exchange by the input-output devices. For this reason it is advisable to use the operating system of the machine selected. In real-time systems (logging stations, stations to monitor geological-industrial parameters, and the like) it will be necessary to formulate more complex control programs.

The language in which the user programs his jobs in a geophysical system can be constructed by three variations: development of one's own language, selection of a standard language, or development of a supplement to a standard language. The first variation offers the possibility of taking account of all special features of the jobs being performed, but the process of developing a library of standard and applied programs is labor-intensive and complex. In the second place program processing is much simpler, even though the language may prove insufficiently effective to solve the specific geophysical problem. In some cases it is advisable to add missing characteristics necessary for the work of geophysical systems to the programming language selected.

If we have application in mind, the main thing in development of software for a standardized geophysical MCC is simplicity of fitting it to specific geophysical systems, the possibility of modification. This is provided by the modular principle of construction of the MCC. The software should be oriented to formulating control (initial load, planning the operation, control of measurements, input-output, and diagnosis) and special-purpose programs which include preliminary processing, computations, correction of drift, analysis of diagnostic results, and the like.

The special-purpose programs must be developed individually for different cases of the application of a geophysical MCC; the control programs are generally similar.

The error of measurement of parameters in a geophysical measurement-information system is determined by the precision characteristics of the sensors themselves, the behavior of the system in a dynamic regime, and the influence of external factors. The parameters of the sensors can be considered given, which is reflected on the magnitude of error of data processing defined in the stage of formulating technical specifications for designing the MCC. This makes it clear how important it is to select the best processing algorithms in the MCC in order to realize the precision characteristics of the system.

For metrological support of the geophysical MCC, after manufacture and periodically during the process of operation the error of measurement of the most important parameters must be monitored. When geophysical MCC's are used under field conditions far from bases built-in metrological support systems must be provided.

In connection with the rise in quality requirements for geophysical measurements and the growing complexity of the equipment, the technical level and precision requirements for monitoring instruments are rising. The great diversity of geophysical equipment and the heightened requirement for monitoring instruments often make it impossible to insure the necessary precision characteristics fully and on time. Standardization of MCC's will permit standardization of monitoring instruments and techniques, which will greatly reduce the time required to manufacture and introduce new geophysical systems.

The formulation of a standardized MCC based on microprocessor computer equipment will offer an opportunity to diagnose the system on a fundamentally new level, realize program procedures for diagnosis, and attain a higher level of diagnosis and forecasting malfunctions both for the MCC and for the geophysical system as a whole. The diagnostic "capabilities" of the system are specially important in geophysical MCC's which are used to monitor geological-industrial parameters during the drilling process. Forecasts of various types of complications and emergency situations will be decided right in the drilling process, for example anomalous layer pressures, or wear on casing columns and twisted lengths of pipe.

The introduction of a standardized microprocessor system will be a decisive contribution to meeting the challenges of accelerated introduction of contemporary scientific-technical advances in geophysical instrument making. The principal factors here that sharply raise all technical-economic indicators are improvement in metrological characteristics, reducing the use of electricity, raising reliability, decreasing dimensions, and reducing time required for development and incorporation in production. Preliminary calculations show that with introduction of standardized geophysical measurement-information systems power consumption is decreased 250-300 percent, labor-intensity is decreased 200 percent, and development time is cut 2-2.5 times.

The development of a standardized geophysical MCC will be a strong basis for implementing new geophysical techniques and will help meet the challenges of the 11th and 12th five-year plans for the development of geophysical instrument making.

FOOTNOTES

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CSO: 1863/117

OPTICAL PROCESSING

UDC 621.382

CONTROLLABLE TRANSPARENCIES AND REVERSIBLE RECORDING OF OPTICAL SIGNALS

Moscow UPRAVLYAYEMYYE TRANSPARANTY I REVERSIVNAYA ZAPIS' OPTICHESKIKH SIGNALOV (TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IM. P. N. LEBEDEVA AKADEMII NAUK SSSR, TOM 126) in Russian Vol 126, 1981 (signed to press 1 Jul 81) pp 2, 157

[Annotation and table of contents from book "Controllable Transparencies and Reversible Recording of Optical Signals", Works of the Order of Lenin Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, editor-in-chief Yu. M. Popov, doctor of physical and mathematical sciences, Izdatel'stvo "Nauka", 1400 copies, 161 pages]

[Text] This collection includes works on current problems of optical information processing performed in the laboratory of Optoelectronics, FIAN [Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences]. Presented are results of research on spatial modulation of light in liquid crystal structures and in electrooptical TsTSL [zirconate-titanate of lead modified by lanthanum] ceramics, as well as on optoelectronic circuits for information processing using controllable transparencies. The current state of research on materials for reversible recording of optical signals has been analyzed and the outlook for using multilayer structures of semiconductors-dielectrics for these purposes is shown. Various circuit solutions are discussed for optical storage units based on the researched materials.

This collection is intended for a broad range of specialists in the field of solid state physics, optoelectronics and computer engineering.

Contents

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CSO: 1863/37

UDC 621.396:535.8

CONTROLLABLE LIQUID CRYSTAL TRANSPARENCIES FOR OPTICAL SIGNAL CONVERTERS AND CODERS

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSITITUTA IM. P. N. LEBEDEVA AKADEMII NAUK SSSR in Russian Vol 126, 1981 (signed to press 1 Jul 81) pp 3-75

[Part 1 by A. A. Vasil'yev*]

[Excerpts] Introduction

The main requirements imposed on cybernetic systems currently being developed are high rates of information processing, large amount of storage, extremely high reliability, minimum consumption of energy and, in addition, small dimensions and low equipment cost. One way of improving these parameters is to use optical methods and devices that permit processing information in the form of large two-dimensional arrays (pictures). In doing so, more extensive functional capabilities are provided by using as the information medium coherent light that, compared to noncoherent light, has higher information capacity in a natural way permits processing of information in the form of complex functions and fields.

The need for coherent optical information processing devices (KOU) long ago became ripe in such fields as analysis (conversion, recognition) of images, for example, in aerial photography, data transmission, medical and biological information processing, photogrammetry, etc.; performing information retrieval operations in catalogs, directories, archives and others; multichannel processing of radio and acoustic signals, especially in systems for radio detection and ranging, navigation, exploration of natural resources, seismic prospecting and others [1].

Modern computers are ill-suited for solving these problems, since they are primarily machines for calculations and control. But KOU's, conversely, are suited primarily for processing information in arrays of 10^3-10^7 bits each.

The major problems in the field of coherent optical methods and devices for information processing are real-time input of information into the KOU and on-line reconfiguration of optical circuits needed in executing complex data processing algorithms. Both these problems can be solved by using electrically and optically

* From the dissertation by A. A. Vasil'yev, "Controllable Transparencies Based on Liquid Crystals and Their Use in Optical Signal Conversion and Coding Circuits," dissertation . . . candidate of physical and mathematical sciences, Moscow, FIAN, 1980.

addressable spatial-time light modulators--controllable transparencies (UT) [2, 3] that are used to generate and convert optical signals and in a KOU can perform the functions of devices for input and display of information [3, 4], amplifiers of brightness and converters of images[3, 4], reconfigurable spatial filters [5-8], coding elements [7, 8] and others.

As a result of research performed in many laboratories, certain progress has been observed in recent years in the development of controllable transparencies, since a number of the most promising materials has been determined for spatial-time light modulation [3, 4]. Of primary importance among them are nematic liquid crystals (ZhK). They are distinguished by the exceptional diversity of electrooptical effects that permit developing both amplitude and phase controllable transparencies based on them [2, 9]. The major advantages of liquid crystals are high transmittance and sensitivity to control voltages and power, and also the adaptability to manufacture of the instruments based on them.

When this work was begun (1972), the basic properties and electrooptical effects in liquid crystals had been studied [9]. However, there remained to be investigated the link between many major characteristics of spatial light modulation in electrically and optically controllable liquid crystal structures and the parameters of liquid crystals, as well as of other materials of these structures. Also of great interest was the analysis of maximally achievable parameters of liquid crystal structures and the controllable transparencies based on them. Finally, it was necessary to examine the possibilities of new methods and circuits for conversion and coding of optical signals that are opened when spatial modulators are used in them, and in particular, controllable transparencies based on liquid crystal structures.

Chapter 1. Spatial Modulation of Light in Liquid Crystal Structures and Its Use for Conversion and Coding of Optical Signals

The above analysis of physical methods of spatial light modulation in liquid crystal structures and the achievement in the area of creating EUT and OUT [electrically and optically controllable transparencies] based on liquid crystals indicate that they basically meet the requirements imposed on controllable transparencies intended for coding and converting optical signals (images). Their development and application has permitted demonstrating the great promise of optoelectronic circuits and methods of optical information processing. One can note that with that of greatest interest are the phase controllable transparencies that permit realization of numerous algorithms for optical processing with minimal losses of light power [15]. From the viewpoint of the direction of further research, now coming into the foreground are the problems of optimizing the parameters of the liquid crystal controllable transparencies and control of these parameters, as well as the technological implementation of the devices that have been developed.

Let us note that the work performed at the FIAN [Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences] has made a definite contribution to the study of the electrooptics of liquid crystals and to solving the problem of establishing the research and clarifying the functional capabilities of liquid crystal controllable transparencies [2, 5-8, 14, 15, 17, 18, 34, 44, 52-55].

Chapter 2. Research on Phase Spatial Light Modulation in Electrically Controllable Liquid Crystal Structures

Results obtained can be formulated as follows:

1. A technique has been developed to create experimental samples of phase EUT [electrically controllable transparencies] based on the orientation S-effect in NZhK [nematic liquid crystals].

2. Based on analysis of the properties of the orientation S-effect in nematic liquid crystals, the simplest principle has been suggested and realized for parallel switching by voltages of two different frequencies of all elements in a matrix addressable phase EUT [electrically controllable transparency], which realizes binary sign-variable factorable functions (two-dimensional Walsh functions, Gilbert masks, pseudorandom signals and others). The advantage of the principle is the capability of separate adjustment of the initial transmission of the controllable transparency elements and additional phase delay in the elements switched on. This has permitted reducing approximately to five percent the standard deviation of reproduction of the required function of transmission of the controllable transparency.

3. Behavior of nematic liquid crystals in nonhomogeneous electrical fields during quasigraduated variation of the potential at the boundary of the liquid crystal layer has been studied for the first time theoretically and experimentally. The lack of a threshold of the elctrooptical response was discovered experimentally in planarly oriented liquid crystal layers with positive dielectric anisotropy when components of an electrical field are present along the initial direction of orientation of the molecules.

4. An anisotropic nature was established for the spatial transient characteristics of the electrooptical response of the planarly oriented liquid crystal layers, which permits drawing a conclusion on the anisotropy of the resolution of liquid crystal instruments based on the S-effect. The dependency of the width of the transient region (maximum spatial resolution) on liquid crystal parameters was studied. The common character inherent to all field effects in nematic liquid crystals permits hoping the suggested theoretical model and experimental technique will be useful in defining the resolution of liquid crystal instruments with various methods of addressing which make use of field effects.

Chapter 3. Research on Functional Capabilities of Experimental Models of Matrix Electrically Controllable Transparencies

The above results permit drawing the following conclusions:

1. An optoelectronic circuit with a phase matrix controllable transparency that performs the Walsh transform of two-dimensional optical signals was proposed, implemented and researched. Factors for expansion of the simplest images in the Walsh-Fourier series were determined experimentally.

2. Experimental models of phase matrix electrically controllable transparencies were used for the first time in a circuit for the Hilbert transform of two-dimensional optical circuits. Phase object Hilbert transforms were obtained in which phase nonuniformities and boundaries of regions of constant phase were visualized.

3. The calculations made and experimental results obtained demonstrate the effectiveness of using phase controllable transparencies in circuits that realize Walsh and Hilbert transforms. The basic advantage of these transparencies is their capability of reproducing any phase relationships in transforms being made and the capability of expeditious rearrangement of circuits.

Chapter 4. Research on Spatial Light Modulation in Photoconductor-Liquid Crystal Structures

Here are the main results presented in this chapter:

1. For the first time, calculations were made of the photoelectrical parameters of various types of structures based on liquid crystals and photoconductors to optimize their electrooptical characteristics. Conditions were determined under which maximum sensitivity of structures with modulation of transmitted and reflected light is achieved, and in particular, attention was paid to the importance of matching the impedances of the layers of liquid crystal and photoconductor with regard to features of modulation characteristics of liquid crystals.

2. A record value was achieved for sensitivity of a liquid-crystal-photoconductor structure, on the order of 0.1 microJoule/cm^2, which corresponds to the maximum depth of modulation of transmitted light. For structures with modulation of reflected light, sensitivity was obtained according to similar criterion which exceeds the value of 10^{-5} J/cm^2. Threshold sensitivity of structures in both cases was about $5 \cdot 10^{-8}$ J/cm^2.

3. Holographic and projection techniques were suggested for measuring resolution of FP-ZhK [photoconductor - liquid crystal] structures that allow obtaining complete spatial-frequency characteristics of amplitude and phase modulations of light in photoconductor-liquid-crystal structures. There was a good match of results obtained by both techniques. In structures based on the hybrid effect, resolution reaches the value of 46 lines/mm over a half-drop of the frequency-contrast response. In structures with the S-effect, resolution according to the same criterion reaches the value of 115-120 lines/mm.

4. The anisotropic nature of resolution of devices based on orientation effects in liquid crystals, mentioned in chapter 2, and the resolution dependency on the parameters of the liquid crystal materials were confirmed. In structures with a small value of dielectric anisotropy of liquid crystal, resolution of over 200 lines/mm was obtained over a half-drop in the frequency-contrast response.

5. Measured for the first time were the spatial transient characteristics of photosensitive liquid-crystal structures, which were used to calculate the spatial-frequency responses of a structure with the S-effect. It was shown that the scattering function (pulse response) of the structure has a symmetrical shape; consequently, there are no spatial phase-frequency distortions in the images transformed by the structure.

Chapter 5. Optically Controllable Transparencies Based on Photoconductor-Liquid-Crystal Structures in Optical Signal Conversion and Processing Circuits

Despite the broad functional capabilities of optically controllable transparencies [OCT] noted in the review, until now photoconductor-liquid-crystal [PC-LC] structures have been used in optoelectronic circuits mainly just to amplify brightness and transform images by type of radiation (for example, from noncoherent to coherent) [3, 4, 11]. The most significant achievements in this case are the input of images of moving three-dimensional objects into the circuit of a holographic correlator, and an optical device for subtraction of images by using two PC-LC type OCT's [11].

Given in this chapter are the results of experimental research on the functional capabilities of PC-LC type OCT models in circuits for optical processing of signals and images. The main focus is on using these structures as reconfigurable spatial filters, including the holographic type. The problem of analysis of the capabilities of these circuits has also been raised with regard to parameters of the PC-LC structures studied in this work.

5.1. Conversion and Amplification of Brightness of Images

To evaluate the capabilities of performing various conversions of optical signals by using the researched models of PC-LC structures, an experimental model of an optical conversion module was used. A diagram of this module is shown in fig. 39.

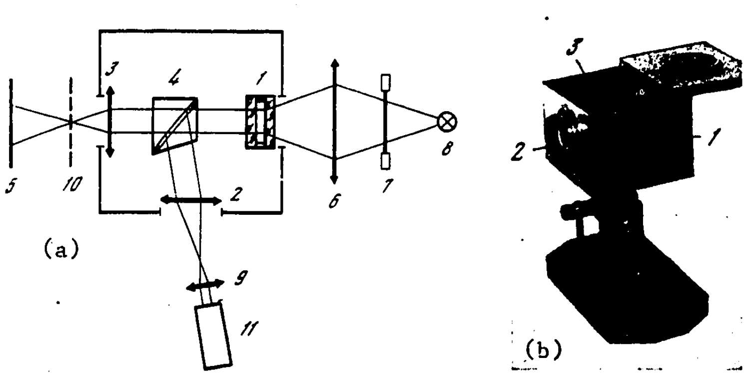
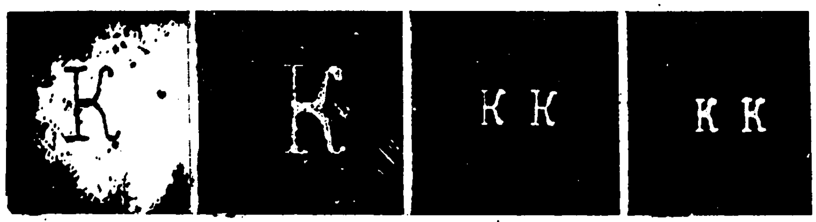


Fig. 39. Diagram (a) and external view (b) of optical module for conversion and amplification of images with the photoconductor - liquid-crystal structure

Key:

1. optically controllable transparency
2 - 6. lenses
4. Glan-Thompson prism
5. output plane
7. input signal
8. noncoherent light source
9. microlens
10. spectral plane
11. laser

When various types of structures and various readout methods are used, this converter can perform the following operations: 1) conversion of noncoherent optical signals (images) into coherent; 2) conversion of images by changing the length of the wave carrying the information of the light beam; 3) amplification of the brightness of images in the blue-green region of the spectrum; 4) conversion of amplitudinal into phasal contrasts; and 5) generation of the spatial spectra of the images being converted.



(a) (b) (c) (d)

Fig. 40. Images of Output Plane of Converter in Different Modes

a. conversion of image by wavelength with inversion
b. without inversion of contrast in structure number two
c. amplification of brightness of image in structure number four with hybrid effect (recording 50 microwatts/cm^2, reading 7 mW/cm^2)
d. recording in noncoherent light of images in structure number four with reading by radiation of an He-Ne laser

The different modes of converter operation are demonstrated as an example in fig. 40. Fig. 40 a and b show conversion of images by wavelength with and without inversion of contrast in structure with the S-effect. Fig. 40 c and d show the result of amplification of the brightness of the images on one wavelength (441.6 nm) and conversion of the images by type of radiation (noncoherent-coherent) in structures with the hybrid effect. The contrast in the converted images in fig. 40 a and b is 15:1, and in fig. 40 c and d, it is over 100:1. Tolerable image brightness amplification is determined by absorption of light in the blocking layer of cadmium telluride and may reach 30 dB (a thousand-fold in intensity) for structure number four.

Structure number two based on the S-effect was used in the circuit for conversion of amplitudinal into phasal contrast and generation of the spatial spectrum. Used as the input signal was a diapositive (fig. 41a) with an image of a chessboard, which matches the modified Walsh function Wal (15,15) (see section 3.1). By means of the structure with the S-effect, this amplitudinal signal is converted into a signal with phase modulation, equal to the corresponding unmodified (true) Walsh function, since the reading light, reflected from the illuminated regions of the optically controllable transparency, acquires an additional phase shift by π. Shown in fig. 41c is the spectrum of derived Walsh function Wal (15, 15), generated by lens 2 in spectral plane 10 of the optical circuit of the device when the information is read by the radiation of an He-Ne laser. Proof of the truth of the Walsh function is the absence of a zero component in the center of the spectral distribution of the intensities. This indicates the mean value of transmittance of the optically controllable transparency is zero in this mode.

Conversion of the amplitudinal spatial into phasal modulation was also performed by using the PC-LC structure number three with the hybrid effect. The source signal in the form of the Wal (7, 7) function, the image of the working plane of the converter and the spectrum of the Wal functions (7, 7) derived as a result of this operation are shown in fig. 41d-f.

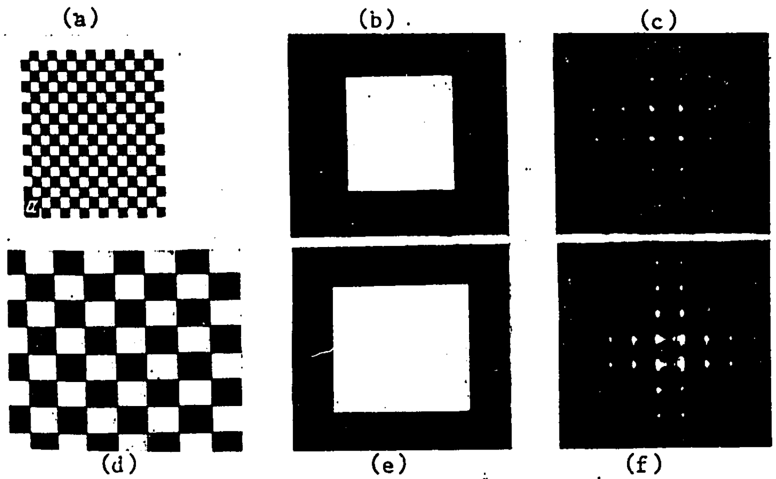


Fig. 41. Conversion of the amplitude into the phase contrast in a structure on the basis of the S-effect

a. image of input signal
b. output plane of converter
c. image of spectrum of converted signal
d-f. same, for a structure on the basis of the hybrid effect

Thus, the operation of PC-LC structures as effective multifunctional image converters has been demonstrated. Experiment results showed that the maximum sensitivity and spatial resolution are achieved in image converters based on PC-LC structures with the S-effect. By slight variation of the supply voltage in these same structures, changing the mode of repetition for inversion of the image contrast is realized most effectively. However, the highest contrast and dynamic range of conversion are achieved in structures based on the hybrid effect in liquid crystals. In connection with this, it is advisable to use structures with the S-effect to intensify images with low initial intensity, as well as in conversions of images and spatial filters with phase modulation of reflected and transmitted light. Structures with the hybrid effect, however, require higher intensities of the input optical signals. But because of the threshold characteristic and high contrast of the electrooptical response, these structures permit obtaining high signal-to-noise ratios in the converted images.

5.2. Spatial Filtration of Optical Signals

Many of the major algorithms for optical information processing reduce to spatial filtration operations (see section 1.3). The expeditious generation of the optical transfer function of the filter that is required in this case can be performed by using PC-LC structures [5, 6]. Thus, for example, the operation of a PC-LC structure with modulation of the transmitted light (see sections 4.1-4.3) as a tuneable spatial filter (PF) in the simplest circuit for optical information processing was studied.

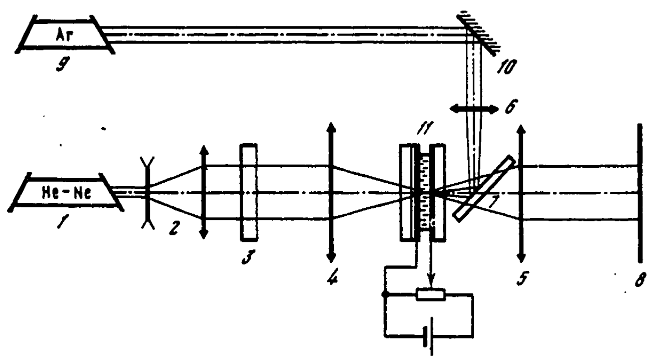


Fig. 42. Optical train for visualization of phase contrast

Key:
1. He-Ne laser
2. telescopic system
3. phase object
4-6. lenses
7. dielectric mirror
8. screen
9. argon alser
10. mirror
11. tuneable filter

An experimental train for spatial filtration is shown in fig. 42 and is intended for visualization of phase contrast. The beam from laser 1 was expanded and collimated by telescopic system 2 and illuminated phase object 3, arranged in the front focal plane of lens 4. The distribution of the complex amplitudes in its rear focal plane, where the tuneable filter is positioned, is a Fourier spectrum of the function of the complex transmittance of phase object 3. Under the effect of the exciting radiation from argon laser 9 with a wavelength of 514.5 nm, focused by lens 6, in the tuneable filter there occurred a shift by n/2 of the phase of the modulated light in the region of zero spatial frequencies of the phase object spectrum. Lens 5 effected an inverse Fourier transform, and in output plane 8, an image of the phase object was observed in which the nonuniformities of the phase changed into the nonuniformities of intensity [71, 77]. The voltage in the PC-LC structure was selected so that the amplitude contrast of the image in the output plane was maximum.

Used as the phase object in the experiment was a quartz base with a film of tin dioxide, in which grooves with a width of about 50 micrometers (see section 2.1) were etched by the method of photolithography. Used as the tuneable filter was a structure with a photoconducting layer of cadmium sulfide (number four from table 1) and with a planarly oriented layer of liquid crystal number one (see table 2) with a thickness of 10 micrometers.

A picture of the vizualized phase object is shown in fig. 43a [not reproduced]. For comparison, fig. 43b shows the image of the output plane of the optical train with no exciting radiation, and fig. 43c [not reproduced] shows the image of the same phase object visualized by using a Foucault cutter installed in the frequency plane instead of the tuneable filter.

Thus, the capability of using PC-LC structures as tuneable spatial filters has been demonstrated, particularly in a train for visualization of the phase contrast.

The optoelectronic circuit in question can easily be retuned to implement any type of spatial filtration by feeding an appropriate control optical signal to the tuneable filter. Thus, for example, a Hilbert transform can be obtained provided the complex transmittance of the tuneable filter equals

$$K(f_x, f_y) = -\operatorname{sgn}(f_x)\operatorname{sgn}(f_y). \tag{5.1}$$

This means that when the exciting radiation is switched on and off in the first and third quadrants of the spectral plane in the output plane of the circuit, either an image of the source spatial signal or its Hilbert transform (see section 3.2) will be generated. This circuit permits using for recognition of an image at the same time its Fourier and Hilbert transforms, thanks to which in certain cases, recognition efficiency is increased considerably [77]. A similar circuit was used in [40, 42] to generate a (Van der Luegt) matched filter.

5.3. Holographic Correlator with Converter of Input Images and Tuneable Spatial Filter Based on Photoconductor - Liquid-Crystal Structures

Correlation comparison of input signals is a powerful method of processing optical signals to detect and identify objects in images [39, 71]. A major problem in developing coherent optical correlators is expeditious input of information, as well as retuning of holographic matched filters when reference signals change (see chapter 1). Both these problems were solved in this work by using optically controllable transparencies based on PC-LC strructures, distinguished by rather high sensitivity and fine resolution (see chapter 4).

Simplest and most convenient from the viewpoint of using reflective-type optically controllable transparencies [OCT] is the holographic correlator circuit with combined conversion of the input and reference signal (KSP) [41, 42]. An experimental circuit of this correlator is shown in in fig. 44. In it, noncoherent light source 1 illuminated photofilm 2 with two images recorded on it that are the optical signals being compared, designated by f(x, y) and g(x, y), where x and y are the spatial coordinates in the plane of trasnparency 2. Lens 3 generated an image of the input transparency in the plane of the photoconducting layer of the OCT 4, which was used in the mode of a converter of input signals by type of radiation (noncoherent-coherent).

Used as the model of transparency 4 was PC-LC structure number three with the hybrid effect. Information from input converter 4 was read in the reflected convergent beam of the He-Cd laser, generated by telescopic system 6. OCT 4 was made with prism 7 in the form of an optical module (fig. 39).

In the focal plane of the optical reading system, where tuneable spatial filter 5 was placed, the spatial spectrum of the converted input signal was generated.

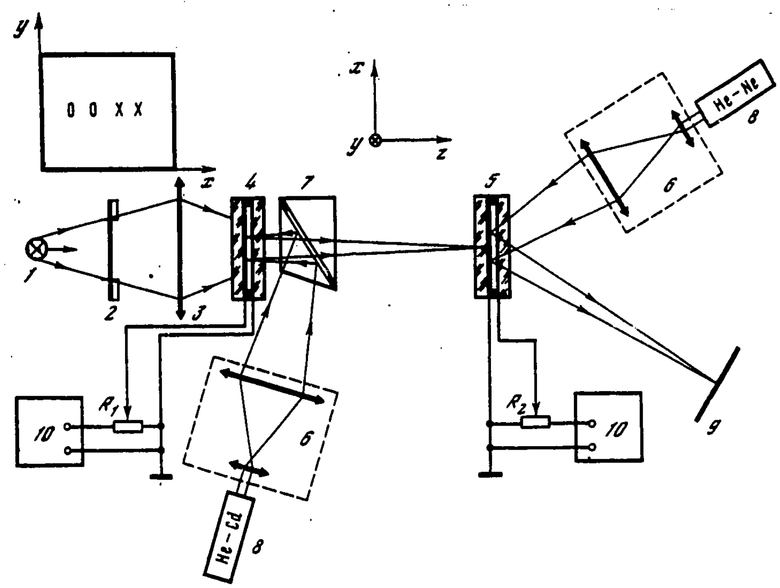


Fig. 44. Diagram of holographic correlator with optically controllable transparency on the basis of photoconductor - liquid-crystal structures in the input and spectral planes

Key:
1. noncoherent light source
2. transparency with input signal
3. lens
4. optically controllable transparency with the hybrid effect
5. optically controllable transparency with the S-effect
6. telescopic system
7. Glan-Thompson prism
8. lasers
9. output plane
10. optically controllable transparency power supply generator

Used as filter 5 was PC-LC structure number one based on the S-effect. The electro-optical response of filter 5 is proportional to the distribution of intensities in the spectrum of the input signal. Thus, recorded in the plane of OCT 5 is a hologram that is read in the reflected convergent beam of red light (radiation of the He-Ne laser). The distribution of amplitudes in focal plane 9 of the read circuit contains components proportional to the functions of autocorrelation and cross-correlation of signals f and g [41, 42].

Major characteristics of the correlator are resolution of the input transparency and spatial filter. Requirements for filter resolution are usually evaluated proceeding from the conditions of spatial division in the output plane of the circuit of signals of autocorrelation and cross-correlation [41, 42]. It has been shown [43] that the required resolution of the material of the filter, evaluated by the maximum spatial frequency ξ_{max} of the light field recorded in the hologram, is no higher in the circuit for the traditional (Van der Luegt) correlator (fig. 3) than in the KSP [correlator with combined conversion] circuit.

It is evident that the value of ξ_{max} equals the halfwidth of the filter transfer function [41, 43]

$$\xi_{max} \simeq A/\lambda_1 F_1, \tag{5.2}$$

where A is the full width of the input signal, λ_1 is the wavelength of the light generating the hologram, and F_1 is the focal distance. However, because of aperture limitations of real OCT's, their resolution should be described not by the maximum spatial frequency, but by the total number of resolvable elements:

$$N_F = 2\xi_{max}\lambda_1 F_1/\delta = 2A/\delta = 2N_A, \tag{5.3}$$

where δ is the size of the minimum resolvable element of the input signals and N_A is the total number of resolvable elements of the input signal (at length A).

Table 5 shows the basic calculated relations associating the dimensions W_f and W_g of signals f and g respectively with the required number of resolvable filter elements (in the unidimensional case) for the (Van der Luegt) and KSP schemes. Since in the recording scheme for the (Van der Luegt) filter there is a point reference source R, the useful dimension of the input converter here equals

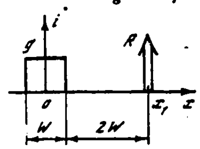
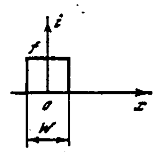
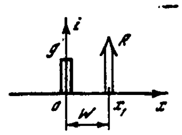
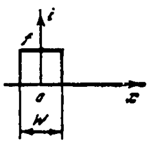
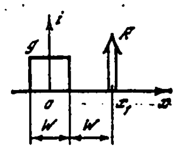
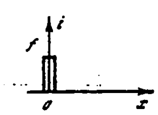
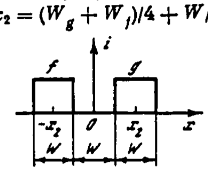
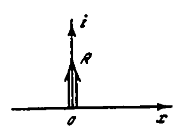
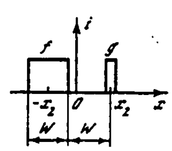
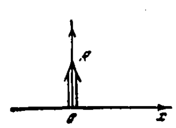
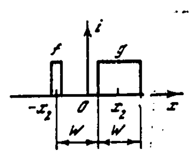
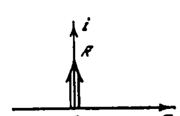
$$W = \max\{W_g;\ W_f\} \tag{5.4}$$

(let us designate the corresponding number of resolvable elements of the input converter by N_W).

In a KOG [expansion unknown] scheme, the useful dimension of the OCT always equals the full width of the signal A (with regard to the required interval between the signals f and g). Therefore, the required number of resolvable filter elements N_F in the KSP scheme is just twice the total number of elements in the input converter in any relations between W_f and W_g. But in the (Van der Luegt) scheme, the value of N_F may range from 2 N_W to 6 N_W as a function of the relationship between the dimensions W_f and W_g (see table 5). From the viewpoint of information theory, this doubled number of resolvable elements (i.e. quantity of information) in the filter compared to the input signal is due to the necessity of transfer by the filter of both the positive and the negative frequencies in the spectrum of the input signal [41].

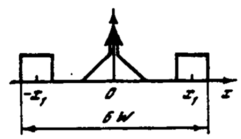
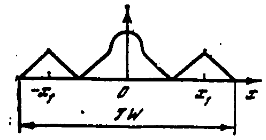
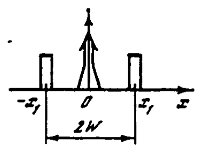
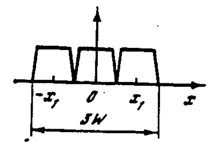
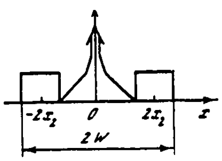
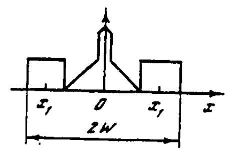
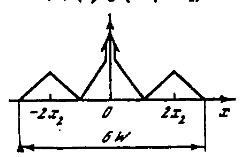
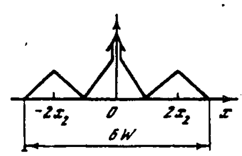
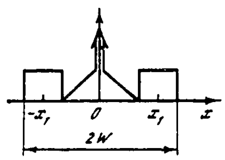
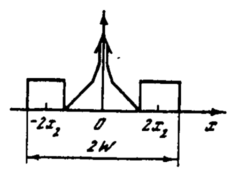
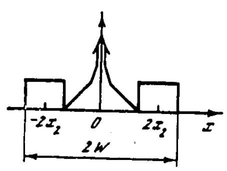
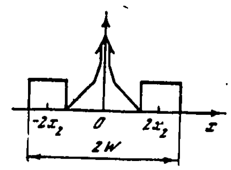
The found relation (5.3) between the values N_A and N_F permits using single-type OCT's in the input and frequency planes in the scheme, and the usable area of the filter can be increased by increasing the scale of the input signal spectrum. Thus, for example, in the experiment, the dimension W of the input signal in plane

Table 5. Requirements for maximum spatial frequency ξ_m and total number of resolv- elements N_F of spatial filters for two holographic correlator schemes

Scheme	Dimensions of input signals f and g	Amplitude of light in input plane: Recording	Amplitude of light in input plane: Restoration
Van der Luegt	$W = \max\{W_g; W_f\}$	$i(x) = g(x) + \delta(x - x_1)$ $x_1 = 1{,}5W_g + W_f$	$i(x) = f(x)$
	$W_f = W_g = W$		
	$W_g \ll W_f = W$		
	$W_f \ll W_g = W$		
Combined conversion correlator		$i(x) = f(x + x_2) + g(x - x_2)$ $x_2 = (W_g + W_f)/4 + W/2$	$i(x) = \delta(x)$
	$W_f = W_g = W$		
	$W_g \ll W_f = W$		
	$W_f \ll W_g = W$		

Note. Symbols ⊗ and * denote the operations of convolution and correlation respectively.

[Continuation of table 5]

Width of recorded signal A	Pulse response of filter	Amplitude of light in correlation plane	Number of resolvable elements of filter
($\xi m = A/\lambda_1 F_1$) $2W_g + W_f$	$g(x)*g(x) + \delta(x) + g(x - x_1) + g^*(-x + x_1)$	$f(x) + f(x) \otimes [g(x)*g_\wedge(x)] + g(x) \otimes f(x - x_1) + g(x)*(x + x_1)$	$N_F = 2\xi_m \times \lambda_1 F_1/\delta$
3W			$6W/\delta = 6N_W$
W			$2W/\delta = 2N_W$
2W			$4W/\delta = 4N_W$
$W_g + W_f + W$	$\delta(x) + f(x)*f(x) + g(x)*g(x) + g(x)*f(x - 2x_2) + f(x)*g(x + 2x_2)$	$\delta(x) + f(x)*f(x) + g(x)*g(x) + g(x)*f(x - 2x_2) + f(x)*g(x + 2x_2)$	$2\xi_m \lambda_1 F_1/\delta = 2A/\delta$
3W			$6W/\delta = 2N_A$
2W			$4W/\delta = 2N_A$
2W			$4W/\delta = 2N_A$

Note. Symbols $\otimes$ and * denote convolution and correlation operations respectively.

4 was about 1 mm, while the distance F_1 was about 400 mm. As a result, the value of ξ_{max} was just about 17 lines/mm, which is far less than the maximum resolution of structure number one and indicates the possibility of increasing the dimension of the input signal. Let us note that the total number of resolvable elements in a line of an image generated by the PC-LC structure number one (filter) can be over 2000. This same value for structure number three (input converter) is about 1000 which meets the requirements of matching, expressed by formula (5.3).

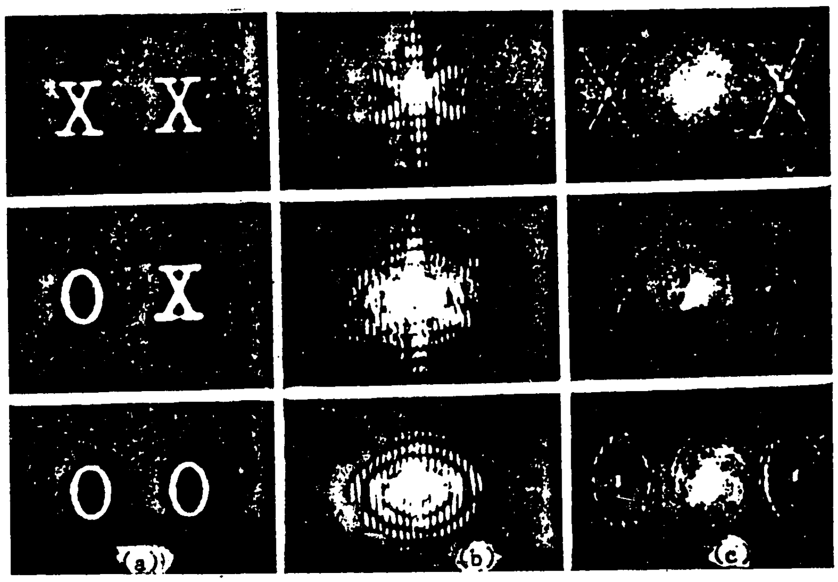


Fig. 45. Correlation comparison of two signals

a. image of input signals, converted by using an optically controllable transparency
b. image of spectral plane of correlator
c. images of correlation plane with two signals of cross-correlation (left and right) of input images

Fig. 45 demonstrates the operation of the optoelectronic holographic correlator. Fig. 45a shows the image of input signals, converted by using OCT 4. Fig. 45b shows the image of the spectral plane of the correlator. It can be seen in fig. 45c that when a signal in the form of exciting light appears in the input plane, a hologram is generated in plane 5, and observed in the scheme output plane are two eccentric signals proportional to the function of cross correlation of the images being studied. The ratio of intensities of the peak of the autocorrelation function to its side lobes was not less than 10:1 for identical letters and about 1.5:1 for different letters (X and O).

A major advantage of the correlator scheme described is that it maintains its operating capability during the effect of brief mechanical disturbances, like shaking, jolts, etc. This is due to the absence of long-term storage and the effects of storage in the filter material associated with it. As a result, mechanical disturbances affecting the circuit during generation of the hologram do not cause irreversible damage to the filter being recorded. In experiments, the time for restoration of diffraction effectiveness after removal of the mechnical disturbance matched in value the structure response time (about 20-40 ms).

5.4. Spectral Analysis and Correlation Comparison of Television Images

Television (TV) systems are one of the most effective and widespread means of sensing, transmitting and reproducting images. Combining TV and coherent optical information processing methods permits creating hybrid systems for expeditious processing of signals and images with extremely broad functional capabilities [4, 48]. In connection with this, in this section, the possibility is investigated of using PC-LC structures as devices for input and spatial filters in coherent optical schemes for processing TV images.

The holographic correlator scheme shown in fig. 44 can easily be adapted to process TV images if slide 2 is replaced by input signals from a cathode ray tube [CRT]. However, difficulties do occur in using this scheme, that are associated with the need of using blue light for reading information from input converter 4. Also, the lack of a blue-absorbing layer of cadmium telluride (see section 4.4) in the PC-LC strcutures used reduces the dynamic range of input converter 4 and the diffraction effectiveness of filter 5. Because of this, new schemes were proposed in which this difficulty was overcome by using the capabilities of television technology.

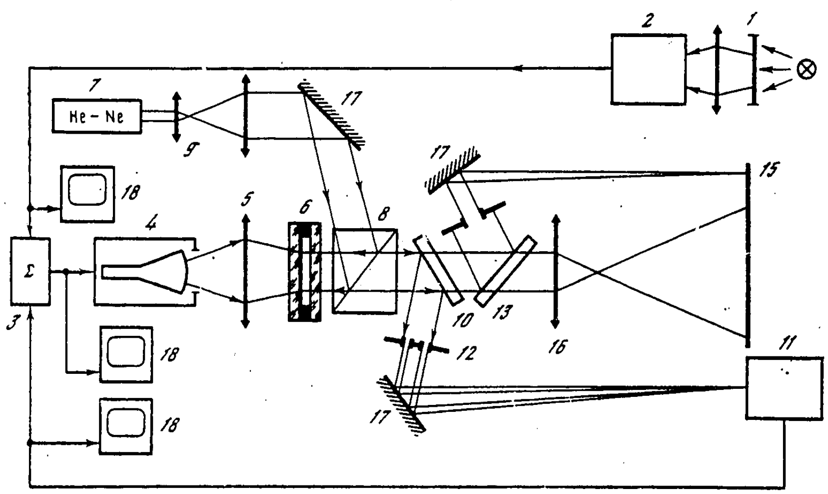


Fig. 46. Experimental scheme for correlator of TV images with one optically controllable transparency

Key:

1. slide with input signals
2, 11. transmitting telecameras
3. summer
4. teleprojector
5, 16. lenses
6. PC-LC controllable transparency
7. laser
8. Glan prism
9. telescope
10, 13. beam splitters
12, 14. diaphragms
15. screen
17. mirrors
18. video monitor units

In the scheme shown in fig. 46, the same model number five of the PC-LC structure was used as the input converter and spatial filter. This scheme was also the holographic correlator with combined conversion of the iamges, the correlation of which it is neccessary to determine (see section 5.3). The source image 1 (slide), containing the reference signal f (x, y) and that to eb identified g (x, y), was sensed by television camera 2 and sent through summer 3 to the input of television projector 4. From the screen of the projection CRT, type 13 LK 11 B, the iamge was projected by lens 5 onto the photoconductor layer of optically controllable transparency [OCT] 6. The converted image was read by radiation from laser 7. Glan prism 8 was used as the polarizer and analyzer in the reading scheme.

Telescopic system 9 generated a converging reading beam, part of which was reflected from semitransparent mirror 10 and focused in the plane of the photocathode of television camera 11. Since there must be space between signals f and g to separate the correlation signals in space (see section 5.3), part of the useful area fo the frame and the OCT remain free. Installed behind mirror 10 was diaphragm 12 that passes only the reading light reflected from the OCT sections occupied by input signals.

Thus, television camera 11 sensed the combined spatial spectrum of signals f and g, which permitted using the scheme in the mode of a spectrum analyzer. The signal from television camera 11 went to the second input of the summer. As a result, the image fo the combined spectrum (hologram) was projected from the CRT screen to the free section of the photoconductor layer, in the space between signals f and g, which was sued as a tuneable holographic filter. The light reflected from this section was isolated by mirror 13 and diaphragm 14 and focused in the plane of screen 15. Here a Fourier transform was generated of the transmission function of the filter that contains components proprotional to the functions of autocorrelation (in the center of the field) and of cross-correlation (on the sides) of the signals f and g. On this same screen, lens 16 generated a check image of the OCT working area.

The arrangement of the spatial spectrum between the input signals imposes limits on the maximum number of resolvable elements in signals f and g and on their relative position. From table 4, it is easy to find the relations between the dimensions W of the input signals (let us assume $W_f=W_g=W$) and the minimum size of a resolvable element Δ in them in the final size δ of the minimum element in the image projected from the CRT screen. The relation between the number of resolvable elements of the input plane and the filter in this case can be notaced as

$$(2W + B)/\Delta = 0{,}5\, B/\delta,$$

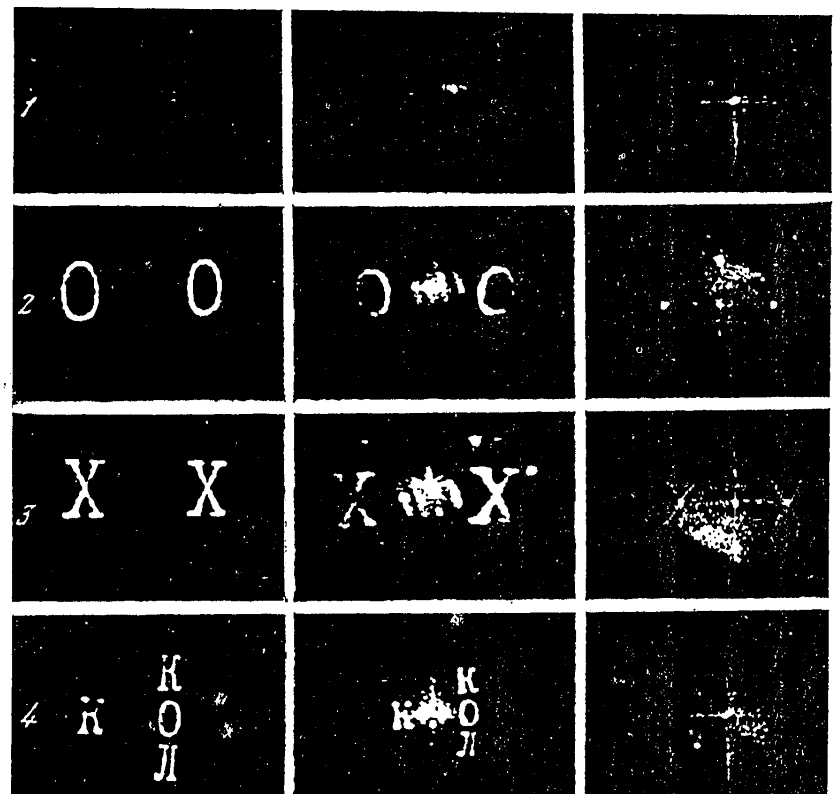
where B is the width of the space between signals f and g. Then

$$\Delta = 2\delta\,(1 + 2W/B).$$

Thus, the value of Δ varies from 2 δ when W/B $\rightarrow$ 0 to 6 δ when W=B (B can not be less than W from the condition of spatial separation of correlation signals in the output plane). This means that in the scheme under consideration, the CRT resolution in the sections occupied by input signals cannot be fully utilized.

This shortcoming can be overcome by using different OCT's as the input converter and filter (see section 5.3) or when an OCT with a resolution margin is used, by projecting the images of input signals and the filter from different CRT's.

Used as input signals in the experiments were slides with an image of machine-printed letters with a size relation of B = 2W. With that, $\Delta = 4\delta$, which is entirely sufficient for accurate reproduction of the letters. The images of the input and correlation signals, as well as the spectra obtained from the screens of the video monitor units are shown in fig. 47. The signal-to-noise ratio in the correlation plane did not exceed 5:1 with an estimated ratio of the correlation function peak to side lobe intensity of about 10:1. This is due primarily to the increase in noise and distortion of the signal when it passes doubly through the TV system.



(a) (b) (c)

Fig. 47. Images from screens of video monitor units in the scheme with one optically controllable transparency [OCT]

a. input signals b. image of OCT plane c. correlation plane

The numbers designate the signal ordinal number

Key:
1. slide with input signals
2, 7, 8. transmitting telecameras
3, 5. teleprojectors
4, 6. PC-LC OCT's
9. Sl oscillograph
10. LG-38 laser
11. telescope
12. lenses
13. video monitor units
14. beam splitter
15. OCT power supply generator

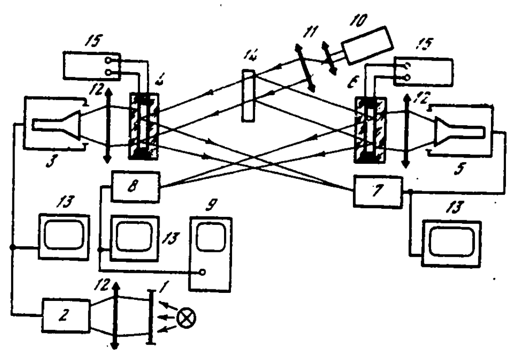


Fig. 48. Correlator scheme with two CRT's and OCT's

Higher capacity was achieved in the correlator scheme shown in fig. 48. In it, the input signals and filter were generated in different experimental OCT models (5 and 6) from the screens of two different CRT's (3 and 5). However, information in both OCT's was read by the radiation from the same LG-38 He-Ne laser 1. Input converter 4 operated in the mode of amplitude (image from teleprcjector 3) to phase contrast conversion, since binary masks based on M-series [7, 8, 54] with known correlation properties were used as test input signals 1 in the scheme. The OCT 4 operating mode was selected so that the mean value of transmission was reduced to the minimum, to which corresponds the minimum intensity of light in the region of zero spatial frequencies of the spectrum of the generated signal. This intensity was measured by photodetector 14.

The hologram filter was generated in the plane of the photo cathode of television camera 7 by the radiation reflected from the plane of OCT 4. From camera 7, the signal went to the second teleprojector 5 with a ZLK2B CRT and from its screen was projected to the OCT-filter 6, similar to transparency 4. The camera 8 photo cathode was placed in the correlation plane, and the signal from it went to the input of the Sl-57 oscillograph 9 with a line signal separator, which allowed measuring the correlation maximum I_m and side lobe I_s intensity ratio.

The test signals 1 had 32 x 32 elements and were a two-dimensional recording of the M-series with a length of 1023 elements (with the addition of one element). The calculated ratio of I_m/I_s exceeds 10^3 [78].

In the experiment, the correlation maximum exceeded noise by about 48. With that, OCT Noise was about 0.3 percent of the correlation maximum, while the telecamera noise was not over 0.1 percent according to the same criterion. At the same time, attenuation of the zero spatial frequency in the spectrum of the input signal was about 120. Consequently, the main source of degradation of the correlation maximum was concentrated in the aberations (raster distortions), which in the first teleprojector 3 reached 7.5 percent over the area of the input signal (corresponding to over a 20-fold degradation [79]).

Thus, the capability of correlation comparison of TV signals in optoelectronic circuits with PC-LC OCT's was demonstrated. The proposed and studied schemes for converting TV images can also be used to perform other spatial filtration operations, for instance, picking out object contours, increasing the contrast of major or minor details and others. With that, the lack of phase-frequency distortions in the spatial structure of the converted wave fronts is very important (see section 4.5). Also, the phase nonuniformities, unavoidable in other types of OCT's, can be reduced to the minimum with good processing of the surfaces orienting the liquid crystals [9].

The results presented above can be summarized as follows.

1. The capability of effective use of OCT's based on the PC-LC structure as multifunctional image converters has been demonstrated experimentally. With that, over 100-fold intensification of the brightness of the converted images was achieved. Calculations showed that the intensification factor can be extended to several thousands. Contrast of the images converted by the PC-LC structure with the hybrid effect exceeded 100:1.

A structure based on the S-effect permits easy switching from the mode of repetition of the contrast to inversion and back.

The capability of converting amplitude spatial modulation to phase by using structures based on the hybrid and S-effects was demonstrated.

2. PC-LC structures were used for the first time as tuneable spatial filters in a coherent optical device for visualization of phase contrast and in a promising correlator scheme with combined conversion of the input and reference signals, in which the PC-LC structure was also used as the input converter. Analysis of holographic correlator schemes shows that the total required number of resolvable elements of the filter in a scheme with a generalized hologram is just double the number of elements in the input plane. This permits using single-type OCT's in the input and spectral planes of such a scheme.

3. The possibilities were studied for using PC-LC structures as devices for input and a spatial filter in the holographic correlator scheme with combined conversion of television images. A new correlator scheme that uses one OCT was proposed and studied. It was shown that degradation of the correlation maximum in this scheme was due primarily to raster distortions in the TV system.

4. It was shown that the PC-LC structure enables the capability of normal operation of a holographic scheme with a spatial filter under the conditions of mechanical disturbances. This important advantage, caused by the nature of storage in the structure investigated, is realized most fully in the correlator scheme selected.

Conclusions

The main results of this work are summarized as follows.

1. The behavior of nematic liquid crystals in nonuniform electrical fields has been studied theoretically and experimentally for the first time. Confirmed experimentally was the hypothesis on the lack of a threshold of the electrooptical response in the planarly oriented layers of nematic liquid crystals with positive

dielectric anisotropy with a component of the electrical field along the initial direction of molecular orientation.

2. The anisotropic nature of the spatial distribution of the electrical response of the planarly orientec liquid-crystal layers was established, and the dependence of the resolution of the liquid-crystal layer on its parameters was investigated. It was shown that resolution increases considerably with the decrease in dielectric anistropy of the liquid crystal.

3. The dependence of the electrooptical characteristics of photosensitive liquid-crystal - semiconductor structures on the structure material parameters was studied theoretically and experimentally. The important role of matching impedances of the layers of photoconductor and liquid crystal was shown for attaining maximum sensitivity. As a result of structure optimization, a record value of sensitivity, about 0.1 microJoule/cm^2 (with maximum depth of amplitude modulation of the light) and resolution of more than 120 lines/mm were achieved.

4. Holographic and projection techniques were offered to measure PC-LC structural resolution, which permit obtaining together the total spatial-frequency characteristics of the phase light modulation in these structures. As a result of these measurements, it was shown that the scattering function (pulse response) of these structures has a symmetrical shape, indicating the lack of phase-frequency distortions in the wave fronts converted by the structures.

5. Based on analysis of results of research on the electrooptical properties of planarly oriented layers of nematic liquid crystals, the method of addressing of the matrix light modulator, which reproduces with high accuracy the binary sign-variable factorable transmission factors (two-dimensional Walsh functions, the Hilbert "phase cutter," pseudorandom signals and others), was proposed and realized in experiments for the first time.

Optical schemes with matrix-addressable phase transparencies, that realize Walsh and Hilbert transforms, were proposed and researched theoretically and experimentally for the first time.

6. Demonstrated experimentally was the capability of using effectively PC-LC strcutures as multifunctional image converters, and appropriate recommendations were generated for specific types of structures and forms of conversion.

7. Demonstrated experimentally for the first time was the capability of using PC-LC strcutures with phase light modulation as tuneable spatial filters in a scheme for visualization of phase contrast and in the promising scheme for a holographic correlator with combined conversion of the input and reference signals. Analysis of the correlator scheme selected showed the expediency of using single-type OCT's in the input and spectral planes of this scheme. Correlation comparison of television images was also performed in it in real time.

Thus, as a result of research carried out, the effectiveness of spatial light modulation in electrically and optically addressable liquid-crystal structures was demonstrated. The promise of nematic liquid crystals as materials for electrically and optically controllable transparencies--image converters, spatial filters and coding elements--was demonstrated.

In many practically important schemes for optical information processing, transparencies based on liquid crystlas have a number of indisputable advantages over other types of controllable transparencies. Primarily, these advantages are: high sensitivity and effectiveness of light conversion with small supply voltages and powers, relatively high resolution and the lack of phase-frequency distortions in the converted optical signals. It has been shown that the advantages of liquid-crystal controllable transparencies are especially clearly manifested when they are used as spatial filters and coding elements. In the process, processing rates correponding to the television standard are easily achieved.

The research performed lays the required foundation for formulating experimental design work to develop electrically and optically controllable transparencies to use them in real optical information processing systems. Based on the liquid-crystal strcutures investigated, spatial light modulators can be developed with the following parameters:

more than 10^8 resolvable elements (for OCT's);

threshold sensitivity no worse than 10^{-8} J/cm^2 (for OCT's) with maximum amplitude modulation no worse than 10^{-5} J/cm^2;

response time no more than 20 ms, and full cycle time no more than 30 ms;

amplitude contrast no worse than 150;

depth of phase modulation to 2 or more; and

dynamic range of intensification of image brightness (for OCT's) no less than 30 dB.

In each specific information rpocessing scheme, the highest efficiency of operation of these controllable transparencies can be achieved by selecting optimal parameters of liquid crystals applied and the type of electrooptical effect in them that best meet scheme requirements. In doing so, a parameter group can even be improved by reducing the requirements for another group. Thus, for example, PC-LC strcutural sensitivity can be increased by reducing resolution, and effective contrast inversion is achieved by reducing the signal-to-noise ratio.

Let us note that only the first steps have been made in terms of using liquid-crystal structures in information processing schemes. Systematic research is needed on materials and particularly on methods and schemes for information processing; development of optoelectronic systems using controllable transparencies for information input, conversion and coding is required. It is no exaggeration to say that spatial light modulators based on liquid crystals will play a prominent role in these systems.

This work was performed in the Quantum Radiophysics Laboratory of the FIAN AN SSSR [Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences] and in the Department of Electronic Instruments, Moscow Institute of Electronic Machine Building. A deep expression of gratitude for support and continual attention to this work is due my research supervisor, I. N. Kompanets, candidate of physical and mathematical sciences; and also to V. V. Nikitin, doctor of engineering sciences; Professor Yu. P. Pchel'nikov, doctor of engineering sciences; and Professor Yu. M. Popov, doctor of engineering sciences. The authors thanks V. N. Morozov, candidate of physical and mathematical sciences, and P. D. Berezin for discussions on the work; L. M. Blinov, doctor of physical and mathematical sciences, and M. I. Barnik, candidate of physical and mathematical sciences, for advice; and P. V. Vashurin, S. P. Kotova,

A. V. Parfenov, L. P. Savost'yanova and V. G. Chigrinov for help on the work. The author thanks V. T. Lazareva and V. V. Titov for synthesis of liquid crystals, A. I. Zhindulis for making photosensitive layers, and R. M. Savvina and V. N. Poluboyarov for help in making the experimental models of photosensitive structures. The author expresses his gratitude to all the associates at the Laboratory of Optoelectronics and other organizations that contributed to the performance of this work, and to O. N. Vasil'yeva and M. Ye. Rumyantsev for help in putting the work in final form.

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CSO: 1863/37

UDC 621.382

ELECTRICALLY CONTROLLABLE LIGHT MODULATION IN LANTHANUM MODIFIED LEAD ZIRCONATE TITANATE CERAMICS

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IM. P. N. LEBEDEVA AKADEMII NAUK SSSR in Russian Vol 126, 1981 (signed to press 1 Jul 81) pp 76-119

[Part 2 by I. N. Kompanets, P. N. Semochkin and A. G. Sobolev]

[Excerpts] Introduction

Controllable transparencies (spatial-time light modulators) are key elements in optical storage and peripheral devices, coherent optical processors and other major assemblies in information and computing systems that are being developed. They are used for input and conversion of two-dimensional information arrays [1, 2]. The functional role of controllable transparencies (UT) [CT's] here is quite varied. Based on them, one can perform depiction of information (displays, including projectional), input and output, generation and conversion of digital arrays, realization of logic operations, coding and identification of optical signals, etc.

The efficiency of applying a CT in systems for storage and optical processing of information is primarily determined by the properties of its operating material. In turn, selection of a material for a CT with some concrete function is governed by the aggregate of the properties of the material most suitable for a given CT application. In the process, the transparency material must meet the following basic requirements: highest efficiency in conversion of the optical signal ($\eta = I_{out}/I_{in}$, where I_{in} is signal intensity at input of transparency, and I_{out} is the modulated component of the output signal) with maximum optical contrast and depth of modulation; high sensitivity to the control signal to reduce energy inputs for switching of transparency elements; a switching speed providing the needed rate for input/output and conversion of the entire array (for the majority of applications, this rate must not be below the television standard: 1/30 s for 500 x 500 resolvable elements); availability of the storage effect (long-term storage requiring a special signal for returning the material to the initial state, or relaxation storage), i.e. the capability of maintaining the switched-on state for the time needed to read the entire information array; absence of fatigue during the CT operating period (more than 10^4 hours or 10^8-10^{10} switchings); adaptability to manufacture of the CT's that best incorporate the advantages of the optical media selected for them.

Using materials in electrically controllable transparencies [ECT] intended for processing digital information dictates the necessity of their having threshold properties or a substantially nonlinear characteristic of the switched element. This permits raising the signal-to-noise ratio and reducing the probability of false switching of the ECT elements. This characteristic is especially important in matrix addressing of the elements by electrical voltage, since it permits reducing the so-called "cross-effect" to the minimum. Matrix addressing (also called line) is effected over the minimum number of channels 2N, where N^2 is the number of ECT elements that may vary from 10^2 to 10^6 as a function of its purpose.

A large number of media have been suggested as the operating material for ECT's. A detailed analysis of them, with regard to specific applications, is given in [2]. Based on this analysis, electrooptical TsTSL [lanthanum modified lead zirconate-titanate = LMLZT] ceramics are the most promising materials for ECT's with matrix and individual addressing.

Indeed, they can be used to develop high-speed (with a frequency band $\omega \geqslant 1$ MHz) and highly efficient deives (with close to 100 percent efficiency in light signal conversion). LMLZT ceramics are adaptable to manufacture and production costs are low (compared to monocrystals). They have satisfactory optical contrast, sufficient spatial resolution, a wide range of operating temperatures and a large operating aperture. They are also noted for diversity of optical effects that determines a broad range of possible applications [3, 4].

TsTSL-ceramics is a polycrystal of lead zirconate-titanate Pb(Zr, Ti) O_3, alloyed with lanthanum. The following designation is used in the literature for ceramics as a function of their technological composition: X/A/B, where A indicates the percentage content of lead zirconate, B the percentage content of lead titanate, and X the percentage content of lanthanum. It is very important that a change in the ratios of components in ceramics causes a substantial change in their physical properties.

Electrooptical ceramics are made by the hot-molding method that has a number of substantial advantages over conventional ceramic technology. A major indicator of quality of sintered polycrystal (ceramic) materials is density, upon which the basic electrophysical parameters depend. In hot molding, because of the simultaneous application of high temperature and pressure, material density increases significantly, approaching the theoretical [5]. Hot-molded specimens have a uniform structure, which facilitates the best packing of crystallites [6]. Optimization of the atmospheric sintering process improves the transmittance of LMLZT ceramics [7].

Conclusion

The main results of this work can be summed up as follows:

1. An analysis was made of the works on the study of electrooptical ceramics and their application in optoelectronic devices. We studied the opticophysical properties of LMLZT ceramics with compositions of 8/65/35 and 9/65/35 under quasistatic and dynamic conditions during the effect on them of electrical and optical signals. Comparison of the results for ferroelectric ceramics with a composition of 8/65/35

shows that the greatest change of double refraction, equal to $2.2 \cdot 10^{-3}$, occurs in the case of the cross electrooptical effect.

2. For the edge effect, the relation of change of double refraction under the effect of an electrical field was studied for the first time, and the efficiency of electrooptical conversion was determined. The maximum double refraction change was $1.2 \cdot 10^{-3}$ with an optical contrast of 12:1. Studied for the edge effect for the first time was the distribution of vectors of polarization in the switched regions of paraelectric and ferroelectric ceramics; it was shown that in ferroelectric ceramics, the orientation of the ferroelectric domains is the result of the mechanical effect associated with the inverse piezo effect, while in paraelectric ceramics, the directly applied electric field is responsible for the edge effect.

3. The effect of asymmetrical deformation was offered in which the double refraction change was

$1.4 \cdot 10^{-3}$ with an optical contrast of 50:1; increasing the electrical field in this case does not cause irreversible polarization of the switchable regions of the ferroelectric ceramics.

4. Investigated for the first time was the mechanism of the effect of a variable electrical field of small amplitude on LMLZT ferroelectric ceramics, which brings the specimen from the electrically polarized to the thermally depolarized state. Two interrelated processes were considered: disorientation of the previously aligned domains of the ferroelectric ceramics and heating up of the specimen in the repolarization process. A satisfactory match of estimated data with experimental was obtained. The method of the effect of a variable electrical field permitted realizing optically isotropic orientations of the ferroelectric domains, which caused an increase of the optical contrast of the electrooptical effects to a value greater than 100:1.

5. Suggested was the method of creating by an electrical field an optically isotropic state of the ferroelectric ceramics with a uniform 90-degree reorientation of the ferroelectric domains to a direction perpendicular to the specimen plane which prevents irreversible polarization of the switchable regions.

6. The basic capability of making use of the cross electroooptical effect in LMLZT ceramics in matrix addressable controllable transparencies; this enabled a considerable gain in light conversion efficiency (over 50 percent) while keeping the high rate of information array generation inherent to the matrix method of transparency element switching.

7. Based on the edge effect in ferroelectric ceramics, we developed and studied a model of a high-speed electrically controllable transparency with a capacity of 32 x 32 elements, that provided information array generation time of 160 microseconds and erasure of 100 microseconds with a voltage pulse amplitude of up to 250 V; light conversion efficiency was 15 percent in the mode of matrix addressing of all transparency elements; optical contrast at light wavelength of 633 nm exceeded 100:1 in the wide angular range of transparency illumination of ±20°. Based on paraelectric ceramics, we developed and studied a high-speed unidimensional spatial-time light modulator which is characterized by light modulation efficiency

to 100 percent in the modulation frequency band to 1 MHz. The parameters of these and other experimental models of high-speed electrically controllable transparencies developed on the basis of LMLZT ceramics are given in the table.

Ceramic type		Electrooptical effect used	Addressing type	Number of elements	Valve dimensions, microns	Model thickness, microns
without storage (9/65/35)	[1]	cross	individual, digital	64	0.2 x 0.2	100
	[2]	cross	individual, analog	64	0.2 x 0.2	100
	[3]	edge	special type of matrix	16 x 16	0.45 x 0.45	100
with storage (8/65/35)	[4]	edge	matrix	32 x 32	0.45 x 0.45	100
	[5]	cross	matrix	4 x 4	0.8 x 0.8	100

Control voltage	Element switch-on time, micro-seconds	Array generation time, micro-seconds	Storage	Erase time, micro-seconds	Optical contrast	Light conversion efficiency (without considering reflection)
[1] 450V	0.4	0.4	none	0.4	500:1	96%
[2] 450V	0.4	0.4	relaxation	5-10 mins.	5:1	96%
[3] 250V	0.4	0.4	none	0.4	50:1	15%
[4] 250V	2	64	long-term	0.1	100:1	15%
[5] 650V	2	8	long-term	0.1	100:1	80%

General conclusion: the results obtained allow drawing the conclusion that electro-optical ceramics are some of the most promising materials for high-speed amplitude and phase electrically controllable transparencies; the research performed is the necessary basis for organizing experimental design work on ECT development to make use of them in real information processing systems.

Along with this, further study of the physical properties of polycrystal LMLZT ceramics is required. For example, there is still no strict theoretical or analytic model of the double refraction properties of polycrystal LMLZT ceramics that considers the diffraction and scattering of light on the individual domains and boundaries of the granules. The interrelated pyroelectric and piezooptical phenomena have not been studied tehoretically and experimentally. There is no theory for the photovoltaic effect. A profound understanding of the physical properties of polycrystal LMLZT ceramics will allow finding optimal methods for control of their electrooptical properties, and raise even higher the efficiency, speed and sensitivity to the control signal of the controllable transparencies based on them.

Needed too is further purposeful research on improving the physical and technological processes of making LMLZT ceramics with reliable monitoring of their composition at all stages of preparation, which will provide the capability of fine reproducible production of specimens with properties specified in advance. In doing so, worthy of attention is the possibility of obtaining new interesting properties in LMLZT systems made in the planar structure by the high-frequency spraying method.

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CSO: 1863/37

UDC 621.382

RESEARCH ON DEVELOPMENT OF OPTICALLY CONTROLLABLE STORAGE ELEMENTS BASED ON MULTILAYER SEMICONDUCTOR-INSULATOR STRUCTURES

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IM. P. N. LEBEDEVA AKADEMII NAUK SSSR in Russian Vol 126, 1981 (signed to press 1 Jul 81) pp 120-156

[Part 3 by A. F. Plotnikov and V. N. Seleznev*]

[Excerpts] Introduction

Much attention has been paid recently to optical methods of information processing. Applying optical methods in new-generation computers will undoubtedly have the effect of increasing their speed and throughput and raising noise-immunity and reliability.

The advantages of assemblies with optical information processing now being proposed are bound to show up most fully in the future with the development of computers with a substantially new organization designed for application of coherent optics. However, a number of assemblies for an optical computer, such as information input/output units and reversible optical storage units can also be successfully applied in modern computers in various classes for various purposes.

Reversible optical storage units (ZU) with a capacity exceeding 10^8 bits and high parallelism in processing, retrieval of and access to any part of stored information ($\sim$1 microsecond) may be of interest for use in modern computer equipment. Development of this optical storage unit is possible at the current state-of-the-art if the medium, the reversible carrier of information, meets a number of rather severe requirements: the necessary sensitivity to the light effect, spatial resolution, speed, etc. [1].

In this work, we have studied the capability of reversible optical recording with MIS structures of the metal-silicon nitride-silicon oxide-silicon type (Me - Si_3N_4 - SiO_2 - Si), the so-called MNOS structures (metal-nitride-oxide-semiconductor).

* Based on the dissertations: V. N. Seleznev, "Research on Processes of Optical Reversible Recording of Information on Multilayer Structures of Metal-Insulator-Semiconductor [MIS]," dissertation ... candidate of physical and mathematical sciences, Moscow, FIAN, 1975; A. F. Plotnikov, "Photoelectric Phenomena in MIS Structures," dissertation ... doctor of physical and mathematical sciences, Moscow, FIAN, 1977.

MNOS structures are widely applied for reversible electrical storage, have a high swicthing speed of $\sim 10^{-7}$s and can store recorded information for several thousands of hours after power is disconnected [2]. The planar technology for manufacture of the structures is convenient and well developed. MNOS structures operate at room temperatures and consequently require no special vacuum low-temperature systems. The following is required to study the capabilities of developing an optical storage unit with these structures: 1) further study of the physical mechanisms determining the processes of accumulation, storage and readout of information in these structures; 2) research on the effect of light on switching of the structures; 3) study of parameters of teh elements in an optical storage unit and the physical factors limiting their maximum values; and 4) development of a structural scheme for optical storage.

This work is devoted to an examination of these questions.

The experiments performed in this work have shown that the energy of a light pulse from a semiconductor laser made with GaAs crystal is sufficient for simultaneous recording of an array of 10^3 bits of information within 10^{-7}s.

A structural scheme for an optical storage unit with high capacity ($\sim 10^8$ bits) has now been developed in which information is recorded in binary code and in arrays (just as in holographic storage units). Light addressing for individual pages is used in the scheme, which enables rapid access to any part of the recorded information [32]. We used a photoconductor - ferromagentic film structure to store information.

Using a photolayer and the need of using a magnetic field limit the speed of this unit to the millisecond range. We examined the possibility of using the basic ideas of this scheme to implement an optical storage unit based on MIS structures [33].

Using an MIS structure as a storage medium permits developing a high-speed optical storage unit highly sensitive to the control light.

A block diagram of the storage is shown in fig. 41. The main components are: laser, optical addressing system and the storage medium. The scheme is based on using a gas laser with minor (close to diffraction) beam divergence. Powerful argon lasers have now been developed that provide continuous radiation with a power to 5 W with beam divergence not over 0.5 millirad (for example, the ILA series lasers from the GDR).

The light-sensitive medium is divided into individual sections--chips--each having one common control electrode. Information is coded by electrical pulses and recorded only in the illuminated section of the chip. During readout, the signal being recorded is also determined only by the state of the illuminated cell of the chip.

Each storage chip is addressed by one beam that moves to another cell on this same chip when the deflector is switched.

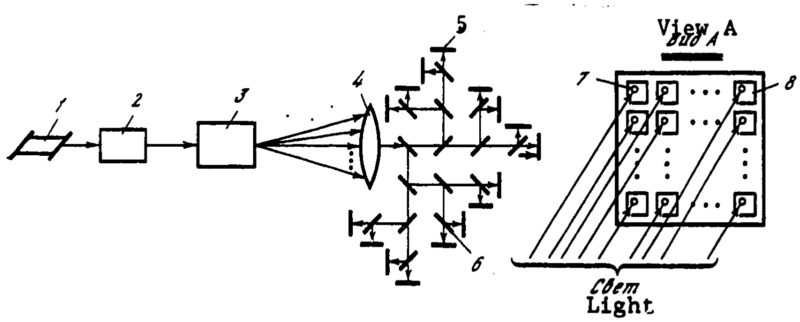

Fig. 41. Diagram of organization of a high-capacity optical storage device

Key:

1. laser
2. deflector
3. first splitter
4. objective
5. storage card
6. beam splitter of additional splitter
7. storage cell
8. chip

The optical addressing system consists of a deflector and light beam splitter focusing the optics. The splitter is intended for parallel reference to many cells in the storage medium placed on the various chips.

The laser beam is split according to the following scheme.

At each deflector position, the light beam is split into 64 beams forming a matrix of 8 x 8 beams.

Splitting is performed by the system of double refraction prisms made of calcite arranged in series over the beam course. The focusing optics generate on the cards of the storage medium 8 x 8 light circles with a diameter of 6 microns equidistant from each other. The storage medium chips are arranged so that one storage cell is illuminated on each of them.

Thus, 64 bits of information can be recorded simultaneously on a card. Beam splitters are placed between the focusing objective and storage medium to increase the capacity of each page. Thus, identical images are obtained on several cards of the storage medium. However, in the general case, a different numeric code goes to each of the cards. Page capacity increases in proportion to the number of cards used. The number of storage cells in each chip equals the number of deflector positions, and the total capacity of the storage device is defined as $N_0 = N_p N_g N_k$, where N_g is the number of storage cells in each chip, N_p is the number of chips on each storage card and N_k is the number of storage cards.

It is easy to show that the capacity of one storage card N_1 can be represented by the expression [34]

$$N_1 = (\varkappa, \xi_b \xi_c / 2{,}44 a\lambda)^2 (D^2/f)^2,$$

where D is the size of a side of a square storage card (let us assume that the diameter of the focusing objective $D_{ob} = \sqrt{2D}$); f is the objective focal distance, λ is the light wavelength, $\varkappa D$ is the diameter of the light beam incident on the focusing objective after the first splitter ($\varkappa$ is a numeric factor < 1), xi_b is the storage cell spacing factor within a chip ($xi_b = b/s_b$ and b is the storage cell diameter), s_b is the step of the layout of the storage cells within a chip, xi_c is the factor for filling a storage card with chips ($xi_c = c/s_c$), c is the size of a chip side and s_c is the step of the layout of chips on a storage card.

The given expression for capacity of a card matches the corresponding expression that defines the capacity of a holographic main storage unit [35].

However, in contrast to holographic schemes for a storage unit with a fixed objective diameter, the capacity of the device under consideration increases rapidly with an increase in the number of beam splitters

$N = N_1 2^k$, where k is the number of beam splitters on the path of any beam from the objective to the corresponding storage card. At the same time, it is true that the required laser power increases as well.

Given in [34] is an estimate of various alternatives for building a storage device according to the scheme under consideration to optimize the storage device parameters.

The main results of the estimate are shown in the table. The data cited indicate that with an attainable laser power, it is possible to build a storage device with a capacity exceeding 10^8 bits.

The functional capabilities of the optical storage device in question correspond in many parameters to those of modern reversible holographic storage devices: recording and readout of information in arrays, the fundamental capability of rapid addressing for the different information arrays while sacnning over the structure by light, and recording of information with high density.

At the same time, this scheme for an optical storage device using MIS structures has advantages too. The sensitivity of MIS structures exceeds considerably that of the majority of holographic reversible media [1, 36]. This permits operating with information arrays of 10^4 bits within units of microseconds, while using series lasers. The problems associated with development of high-speed transparencies with a capacity of 10^4 bits and matrices of photodetectors with the same capacity are superfluous in the scheme under consideration.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
N_k	N_p	$D_{об}$, мм	f, мм	N_1, бит	N_0, бит	$N_{стр}$, бит	n, бит/мм²	$P_л$, Вт	b, мкм	s_b, мкм	c, мм	s_c, мм
64	256	118	346	$3{,}7\cdot10^7$	$3{,}3\cdot10^9$	$3{,}6\cdot10^4$	$2{,}4\cdot10^3$	0,65	10	14	3,8	5,2
256	64	78	308	$4{,}2\cdot10^6$	$3{,}3\cdot10^9$	$1{,}6\cdot10^3$	$1{,}4\cdot10^3$	1,15	13	19	5	7
512	16	44	194	$1{,}1\cdot10^6$	$5{,}4\cdot10^8$	$8{,}2\cdot10^3$	$1{,}1\cdot10^3$	0,72	15	21	5,5	7,8
2048	4	27	145	$2{,}6\cdot10^5$	$5{,}4\cdot10^8$	$8{,}2\cdot10^3$	$0{,}73\cdot10^3$	1,1	18	26	6,7	9,5
4096	1	15	86	$6{,}6\cdot10^4$	$2{,}7\cdot10^8$	$4{,}1\cdot10^3$	$0{,}61\cdot10^3$	0,64	20	28	7,3	10

Key:
1. N_k [number of storage cards]
2. N_p [number of chips on each storage card]
3. D_{ob} [focusing objective diameter], in mm
4. f [objective focal distance], in mm
5. N_1 [capacity of one storage card], in bits
6. N_0 [capacity of storage device], in bits
7. N_{page} [number of bits on one page]
8. n [recording density], in bits/mm²
9. P_l [laser power], in W
10. b [storage cell diameter], in microns
11. s_b [storage cell layout step within a chip], in microns
12. c [size of a chip side], in mm
13. s_c [chip layout step on a card], in mm

The shortcomings of this storage device are the high requirements for precision of execution of the individual elements and the adjustment of them.

In the suggested storage device, a certain amount of electrical power also has to used to write, read and erase information, in addition to the light energy defined above. It follows from the physics of the phenomenon that the highest amount of electricity has to be used in writing and erasing information when the capacitance of the insulation layer has to be charged practically to the peak of the voltage recording pulse. The electricity stored in the process, accounted for by a unit of structural surface area, equals

$$\mathcal{E}_{01} = \tfrac{1}{2}C_i V^2,$$

where C_i is the capacitance of a square centimeter of the insulation layer and V is the peak of the recording pulse.

In the case when a voltage pulse is applied to the structure electrodes, but the structure is not illuminated, the stored electric energy will be

$$\mathcal{E}_{02} = \tfrac{1}{2}C_{d1}V^2 + \tfrac{1}{2}C_i(0.1V)^2.$$

The first term here considers the energy stored in the capacitance of the semiconductor depletion layer, and the second term considers the relaxation of the nonequilibrium capacitance of the semiconductor depletion layer in darkness. (Voltage on the insulator essentially does not exceed 10 percent of the peak of the pulse being applied.) The dielectric losses in this case are minor and essentially may be ignored (the dissipation factor for

Si_3N_4 is $\sim 10^{-3}$).

The energy given off at the contacts of the structure and determining the heat conditions for operation of the element of the storage device equals

$\mathcal{E}_c = \mathcal{E}_0 R_c/R_g + R_g + R_1$, where $\mathcal{E}_0$ is the energy dissipated at the active elements of the structure capacitance charging circuit, R_c is the resistance of the contacts, R_g is the resistance of the control voltage generator and R_1 is the load resistance.

Energy consumed per bit will be: during illumination of the structure, $\mathcal{E}_{01} = \frac{1}{2} C_i V^2 s_{bit}$, and under dark conditions, $\mathcal{E}_{02} = \frac{1}{2}(C_{d1} + 10^{-2} C_i)V^2 s_{bit}$, where s_{bit} is the area occupied by one bit of information.

Let us make a numeric calculation, assuming V = 50V, $C_i = 10^{-9}$ F/mm^2; $C_{d1} = 2 \cdot 10^{-11}$ F/mm^2 ($n = 10^{15}$ cm^{-3}), $s_{bit} = 10^{-4}$ mm^2: $\mathcal{E}_{01} = 1.2 \cdot 10^{-10}$ J/bit; $\mathcal{E}_{02} = 3.6 \cdot 10^{-12}$ J/bit.

The energy dissipated directly at the structure will be about one-tenth of these values, since in typical cases

$R_g + R_1 \sim 10^3$ ohms and $R_c \sim 10^2$ ohms.

In the read mode, the voltage at the structure electrodes as a rule does not exceed 30 percent of the write voltage; consequently, in this case $\mathcal{E}_{01}$ and $\mathcal{E}_{02}$ will be: $\mathcal{E}_{01} \sim 10^{-11}$ J/bit and $\mathcal{E}_{02} \sim 3.6 \cdot 10^{-13}$ J/bit.

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PERSONALITIES

INSTRUMENT-MAKING WINNERS OF 1981 USSR STATE PRIZES IN TECHNOLOGY NAMED

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 1, Jan 32 p 1

[Article: "We Congratulate Specialists in Instrument Making Who Were Awarded the 1981 USSR State Prize in Technology"]

[Text] We congratulate specialists in instrument making who were awarded the 1981 USSR State Prize in technology for development and setting up series production of SM-3 and SM-4 complexes of hardware and software for the international system of small computers. They are the following:

Boris Nikolayevich Naumov, corresponding member of the USSR Academy of Sciences, director of INEUM [Institute of Electronic Control Machines of the USSR Academy of Sciences], and project director;

Yevgeniy Nikolayevich, Filinov, candidate of technical sciences, deputy director of INEUM:

Yuriy Nikitich Glukhov, candidate of technical sciences, department head at INEUM;

Aleksandr Nikolayevich Kabalevskiy, candidate of technical sciences, department head at INEUM;

Valentin Petrovich Semik, candidate of physicomathematical sciences, department head at INEUM;

Apollinariy Fedorovich Nezabitovskiy, general director of the Kiev Elektronmash Production Association imeni V. I. Lenin;

Vilya Antonovich Afanas'yev, chief of the special design bureau of the Kiev Elektronmash Production Association imeni V. I. Lenin;

Stanislav Sergeyevich Zabara, doctor of technical sciences, deputy general director of the Kiev Elektronmash Production Association;

Vladimir Porfir'yevich Fedorin, candidate of technical sciences, director of the Moscow Energopribor Experimental Plant;

Yevgeniy Borisovich Smirnov, chief of the Soyuzelektronmash All-Union Production Association.

We further congratulate Leonard Abramovich Sul'man, candidate of technical sciences and chief engineer of the Central Planning-Design Bureau of Production Automation Systems, who received the State Prize for participation in rapid construction of blast furnace No 6 of the Novolipetskiy Metallurgical Plant, incorporating projected capacity ahead of schedule there, and attaining high technical-economic indicators.

We wish these people continued creative successes and achievements to benefit development of domestic science and technology.

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EXHIBITIONS AND CONFERENCES

UDC 681.322

NEW COMPUTER TECHNOLOGY EXHIBITED AT LEIPZIG FAIR

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 1, Jan 82 pp 12-13

[Article by engineer-economist M. Grünewald, GDR: "New Articles of Computer Technology from VEB Kombinat Robotron"]

[Text] VEB Kombinat Robotron exhibited a number of new articles of decentralized computer technology at the Leipzig spring fair. The enterprise had shown some of the articles of this program at the fair earlier.

These articles are based on the K1520 (SM 1626) and K1620 or K1630 (SM 1630) microprocessors.

The A6402 Commercial Base Computer System

System A6402 is a small computer unit based on a K1630 microprocessor, which differs from the K1620 microprocessor because its internal storage capacity of 128 K words (256 K bytes) is four times larger. It is possible to connect in an arithmetic processor for high-speed processing of 32-bit and 64-bit numbers with floating points as well as 16-bit and 32-bit numbers with fixed decimal points; this increases computational productivity. Microprocessors of the SM 1630 series are compatible with SM-3 and SM-4 computers with respect to software.

At Leipzig system A6402 was shown with the following peripheral units: K8911 operator console with display and keyboard (East Germany); SM 5400 cassette disk store (Bulgaria); SM 5300 magnetic tape store (Bulgaria); K6200 punched tape complex (East Germany); cassette external memory with K5261 magnetic tape (East Germany); VT 27065 parallel printer (Hungary); quasigraphic color display (East Germany).

It is possible to connect other peripheral units to the system in addition to those exhibited at the fair: a punched tape input unit; a storage unit on floppy disks; a series printer; teletypes, and other terminals

System A6402 may work in an autonomous regime or within a hierarchy of computers, alongside more powerful machines such as the YeS 1055 or YeS 1055M. In this case it is connected to the computer through remote data processing channels.

The MOOS 1600 operating system was developed for system A6402. Thanks to its modular structure the operating system permits generation of different operating systems oriented to internal or external memory units. The MOOS 1600 system includes a control program and the following system programs: Assembler, Linkage Editor, Editor, Debugging System, Library Program, auxiliary input-output Programs, programs for access to files, and translators. The operating system is generated on the basis of recording on disks in the cassette store and it can work in different regimes: control by several users, multiprogramming, control by priority, time-sharing, batch processing, and execution of background problems for program development parallel with realization of applied programs.

The FORTRAN, COBOL, and CDL languages and the interpreter language BASIC are proposed for use of translators. The system also has software linkage with YeS computers.

Problem-oriented software has been developed for the following areas of application: data organization, collection of data and compiling of protocols; standard mathematical functions; mathematical techniques; and, economic processes (material-technical supply, calculation of labor resources, and the like).

The software was designed on the modular principle of construction and the principle of structured programs on a uniform technological basis.

System A6401, built on the basis of the K1620 microprocessor, was exhibited at the fair for the second time. Its new feature was a linkage with two K8931 terminals installed nearby. In principle the same peripheral unit can be connected to the junior model A6101 as to the model A6402. In view of interaction speed it is possible to connect as many as eight terminals.

Quasigraphic Colored Display

Visitors at the fair showed great interest in the quasigraphic colored display. This device has a tube that is 56 centimeters on the diagonal and a slit mask. It is designed to display quasigraphic information. The displays are used mainly at operator positions to monitor continuous processes, for example at power plants, chemical enterprises, and metallurgical plants. Using this unit the process can be represented in the form of alphanumeric and simple graphic images.

The display format is 24 by 80 and the set of characters includes 128 fixed characters and 128 programmable characters. A raster of 5 by 7 points is used to display alphanumeric characters, while a raster of 7 by 9 points is used for other symbols. Eight different colors are envisioned, both for the foreground and the background.

The quasigraphic colored terminal can be connected to the K1520 and K1620/K1630 microprocessors.

New Articles Based on the K1520 (or SM 1626) Microprocessor

A broad assortment of articles of decentralized computer technology has been developed on the basis of the K1520 microprocessor. Of them the devices reviewed below were exhibited at Leipzig for the first time.

The A5220 data collection system is used to collect mass data, for example to replace punched card units in all areas of the economy. It is a multiterminal system that includes a system control unit (controller) and up to eight remote K8913 data points. The system provides for collection, sorting, preliminary processing, and transmission of the data collected at the individual terminals. It can serve as a terminal for other large computers and can be connected to a computer of any hierarchy. The linkage is accomplished through a V24 interface. Data are collected by magnetic tape and floppy disk stores connected to the controller. Information can be outputted to a monitor and printed on a standard printer.

The controller is a working desk constructed of system K1520 microprocessor modules and uses the SIOS 1526 operating system. The simple language of instructions makes it possible to formulate various applied programs. The system contemplates installation of terminals at distances up to 500 meters and connecting a series printer to them. In Leipzig programs for data collection in the field of material-technical supply and for calculation of wages were demonstrated using the data collection system.

The A5310 electronic writing system. Work with written texts takes up a large part of labor expenditures in all fields of engineering, so the demonstration of the A5210 electronic writing system, which is designed to streamline this work, aroused great interest among specialists. The electronic writing system can be used in all areas of the economy because it can be put together with different sets of equipment.

The basic variation is the table-model display with a 24 by 80 format. Its electronic part consists of K1520 microprocessor system modules. The keyboard, which is similar to a typewriter keyboard, uses international standard keys; this gives the work a graphic quality and makes control simple.

The base model of this writing system works with floppy disk storage and a disk printer with solid script characters. This makes it possible to perform the following functions: preparation and processing of text; copying, correcting, and cursory control functions; and printing. These functions are the basis for automatic page printing when outputting and correcting a text or for interaction between internal and external memory.

Expanded models of system A5310 have the capability of connecting in additional floppy disk stores, using two storage units on floppy minidisks in the primary unit, and broadened printing principles. Compared to the base model, they use almost all types of text processing. Efficient work is achieved in this case by one file of text modules, addresses, masks, formulas, and assignments.

The 1157 (SM 6309) mosaic printer is a new, high-speed column mosaic printer, the A1157. It is designed for very diverse fields of application; for example it can be used with office processors, base computer systems, and as an assembly built into another unit (OYeM).

The microprocessor-control model 1157 printer prints much faster than the widely known printers. It is built in four variations which differ by width (132 or 210 characters per line) and speed (150-180 or 320-360 characters per second). The printer has a set of 96 characters and can be expanded to 192 characters. Printing can be done backward and forward. The raster of a character is 9 by 7 points in slow printing and 7 by 7 points in fast printing. Up to five copies can be made. The following work regimes are contemplated: printing on journal rolls; printing with accordion-type layout; printing on blank bills; and, work with a magnetic card attachment for calculations.

It is possible to order the item with Latin and Russian (Cyrillic) script in normal, cursive, and broad faces.

The A5100 series office processor (three models of it were exhibited at the fair) aroused great interest among visitors despite the fact that similar units were demonstrated there in 1980. Different variations of the set of equipment were displayed: the A5110 (SM 1617) office processor designed chiefly for bookkeeping, with the capability of processing text information; the A5120 (SM 6908) office processor that is oriented chiefly to data collection and processing; and, the A5130 (SM 6907) office processor which is the high-productivity unit of the data group unit and is designed for collecting and processing data, bookkeeping, invoice preparation, and autonomous computations.

The K1520 microprocessor is used as the computing unit in all the models, and a display, printer, and storage unit on floppy disks or cassette magnetic tapes can be connected to all of them.

The office processors may be connected through remote data processing channels with central computing machines of types A6401 or A6402, or the YeS 1055/1055M.

The linkage between an A5130 processor and a YeS 1055M computer was exhibited at the Leipzig fair.

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CONFERENCE ON SECOND-GENERATION ROBOTS PLANNED FOR FALL 1982

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 1, Jan 82 p 13

[Notice: "The Central Board of Directors of the Scientific-Technical Society of Instrument Making Industry imeni Academician S. I. Vavilov, Section on Adaptive Robots and Artificial Intellect, Announces an All-Union Scientific-Technical Conference Named 'Adaptive Robots,' in Nal'chik in September 1982"]

[Text] The Central Board of Directors of the Scientific-Technical Society of Instrument Making Industry imeni Academician S. I. Vavilov is planning to hold an all-Union scientific-technical conference in Nal'chik in September 1982. The subject of the conference will be problems of adaptation and control in robot engineering systems. The conference will be called "Adaptive Robots — 82."

The conference will be devoted to an exchange of experience and discussion of a broad range of issues that arise in the development and use of second-generation robot engineering systems, adaptive robots for different purposes.

The program of the conference envisions discussion of reports and conducting debates in the following main areas:

1. problems of development and operation of robot engineering systems in instrument making;
2. technical means of different types of sensitization in robot engineering systems;
3. data processing and computer processes in the functioning of adaptive robot engineering systems;
4. problems of adaptation in robot engineering;
5. system aspects of research and theoretical foundations of robot engineering.

In order that timely preparations can be made for the conference, requests to participate and abstracts of reports (not more than two typewritten pages, double-spaced, in two copies, and with appropriate documents) must be sent in before 1 March 1982. This applies also to information about the author(s) on a separate sheet that gives the title of the report, the author's first, middle, and last names, learned degree, position, organization, telephone number, and address for correspondence.

We ask that abstracts of reports and requests for participation from organizations be sent to the following address: 121019, Moscow, Prospekt Marksa, 17, Central Board of Directors of the Scientific-Technical Society of Instrument Making, Comrade A. N. Chekhonadskiy, learned secretary of the organizing committee.

Information is available at the telephone number 202-14-73.

Professor K. A. Pupkov is chairman of the organizing committee.

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FRANCO-SOVIET COMPUTER PROGRAMMING SYMPOSIUM PUBLISHED

Novosibirsk TEORIYA I PRAKTIKA PROGRAMMNOGO OBESPECHENIYA EVM in Russian 1981 (signed to press 15 Jul 81) pp 3-4

[Foreword and table of contents from book "Theory and Practice of Computer Programs (Proceedings of a Franco-Soviet Symposium), September 1968," Part 1, edited by Andrey Petrovich Yershov and Igor' Vasil'yevich Pottosin, Computer Center, Siberian Department, USSR Academy of Sciences, Vychislitel'nyy tsentr SO AN SSSR, 500 copies]

[Text] Foreword, by A. P. Yershov and I. V. Pottosin

The works contained in this collection are based on reports given at the fourth symposium on Subject 7 of the problem "Automation of Information Processing and Application of Mathematics and Computer Technology to Research in Economics, Planning and Control (Information)" of Franco-Soviet Scientific-Technical Cooperation, which was held in October 1978 in Paris. It is one of three directions of cooperation between the computer center of the Siberian Department, USSR Academy of Sciences and French organizations--theoretical programming, translation methods and the methods of computer communication in natural language. The reports were revised somewhat and updated by the authors during preparation of this collection.

Some of the reports presented at the symposium by Soviet authors have already been published, and therefore they are not included in this collection, which is why the size of the French part of the collection is significantly greater.

There is no clear distinction between the two volumes of the collection in terms of subject matter, though it may be said that the first volume is devoted for the most part to programming methodology, languages and translation methods, while the second is concerned with theoretical programming and the methods of computer communication in natural language.

This collection is the second of Franco-Soviet works published by the computer center of the Siberian Department, USSR Academy of Sciences within the framework of cooperation in Subject 7. The first collection, "Teoriya programmirovaniya i metody translyatsii" [Programming Theory and Translation Methods], was published in 1977.

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PUBLICATIONS

UDC 51:681.3:007:519.1

SPECIAL FACILITIES FOR SYSTEM DESIGN AND SIMULATION

Kiev SPETSIAL'NYYE SREDSTVA PROYEKTIROVANIYA I MODELIROVANIYA SISTEM /PROYEKT-YeS/ in Russian 1981 (signed to press 29 Jul 81) p 100

[Table of contents from book "PROYEKT-YeS Special Facilities for System Design and Simulation", editor-in-chief Academician V. M. Glushkov, Institute of Cybernetics, UkSSR Academy of Sciences, 550 copies, 107 pages]

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CSO: 1863/89

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000500060066-8

CONTENTS OF 'JOURNAL OF THE USSR ACADEMY OF SCIENCES: TECHNICAL CYBERNETICS', JANUARY-FEBRUARY 1982

Moscow IZVESTIYA AKADEMII NAUK SSSR: TEKHNICHESKAYA KIBERNETIKA in Russian No 1, Jan-Feb 82 pp 1-2

[Text] Contents Page

Systems Analysis and Optimum Control

Queuing and Reliability

Automata and Computer Systems

Artificial Intelligence and Robots

Automatic Control

Brief Communications

Chronicle

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CSO: 1863/135

UDC 621.311:681.5

POWER SYSTEM AUTOMATION FUNDAMENTALS

Moscow OSNOVY AVTOMATIKI ENERGOSISTEM in Russian 1981 (signed to press 24 Nov 81) pp 2-7, 431-433

[Annotation, foreword, introduction and table of contents from book "Power System Automation Fundamentals", by Mikhail Arnol'dovich Berkovich, Anatoliy Nikolayevich Komarov and Vladimir Aleksandrovich Semenov, Energoizdat, 25,000 copies, 433 pages]

[Text] The purpose and area of application of the basic hardware for automating power systems are discussed. Circuit diagrams and descriptions of the operating principles of APV [automatic reclosing], AVR [automatic emergency power switching], ARV [automatic excitation control], AChR [automatic frequency relief] and ARChM [automatic frequency and active power control] equipment are presented, as well as of automatic synchronization and counteremergency automation equipment. Methods of calculating parameters of the adjustment of automation equipment are discussed.

The first edition was published in 1968. New equipment is discussed in the second edition.

For engineering and technical personnel involved in designing and servicing system automation equipment. Can be used by students at VUZ's and technical schools.

Foreword

The further development of the USSR Unified Power System (YeES), the largest centrally controlled power company in the world, is foreseen in the "Main Guidelines for Economic and Social Development of the USSR for 1981-1985 and for the Period to 1990," adopted by the 26th CPSU Congress. The entry into service of high- and ultrahigh-voltage electrotransmission lines and high-power electric power plants, the intense development of principal and distributing networks, the connection of new power pools to the USSR YeES for parallel operation through relatively poor connections--all this has exceedingly complicated the problem of controlling the normal, and especially the emergency, operating modes of power systems.

Having received considerable development in recent years are equipment and systems for automatically controlling normal modes, making possible the optimum conduct of a mode taking into account restrictions with regard to the quality of electric power. A centralized automatic frequency and active power control (ARChM) system has been created and is operating successfully in the USSR YeES. Local equipment for automatic voltage control at substations has become ever more widespread.

Great attention is being paid to the automation of distributing networks and substations. Various kinds of automation equipment have made it possible to automate networks totally, to optimize the normal mode with respect to voltage, and to restore power automatically to consumers during accidental failures.

A rapidly developing area of automation--counteremergency automation--is of especially important significance for preventing the development of emergencies in power systems.

The improvement of automation equipment and the heightening of specifications for their reliability, speed of response and operating selectivity have governed the need to involve modern hardware in their design, such as semiconductor elements, remote cutoff devices and analog and digital computer technology elements.

In connection with this the second edition of this book has been revised substantially; it includes descriptions of new automation equipment and systems designed with modern hardware. The chapter on counteremergency automation has been expanded considerably and a new chapter has been added, devoted to automatic frequency and active power control.

The material of this book is presented in such a manner as to give the reader an idea of the purpose of each kind of automatic equipment, of the basic principles of its design and of the design structure of individual automation equipment and systems. Mathematics is brought in to a minimum where this is necessary to explain the physical fundamentals of the equipment discussed.

This book is intended for specialists involved in designing and servicing automation equipment for power systems and contains a description of automation circuits and equipment widely used in our country. The material of this book is discussed to a fairly complete extent, which makes it possible for it to be used by students at secondary and higher technical educational institutions, taking the appropriate courses, who are learning the fields of specialization of automation technician or electrical engineer.

The authors are grateful to the reviewer, U.K. Kurbangaliyev, and to the editor, V.V. Ovchinnikov, for their valuable comments and help in preparing the manuscript.

All comments and inquiries regarding the contents and design of this book should be sent to the following address: 113114, Moscow, M-114, Shlyuzovaya nab., 10, Energoizdat.

Introduction

A powerful energy base has been created in the USSR, which has made possible speedier development of all sectors of the national economy and the wide introduction of various electrical appliances for the personal needs of the urban and rural population.

Eleven united power systems (OES's) have been created within whose structure almost all of the country's electric power plants are operating already at this time, and electric power networks of various voltages up to 750 kV inclusive cover a great part of its habitable area. Formation of the USSR Unified Power System--the USSR YeS--is being completed.

The nature and content of problems relating to ensuring reliability and operating stability of power systems within the structure of the USSR YeS have changed considerably as it has developed. Furthermore such specific aspects of energy production as the interrelatedness and interdependence of modes and the continuity and indivisibility of the technological process of generating, transmitting and distributing electric power have manifested themselves to an ever greater extent, especially in interruptions of normal operating conditions.

Violation of the normal operating mode of one element of a power system, e.g., the cutoff of a power generator or heavily loaded electrotransmission line, can be reflected in the operation of many other elements of the power system, and under unfavorable conditions result in breakdown of the entire production process.

In this connection the need has arisen to restore as quickly as possible the normal operating mode of a failed element or to replace it quickly with another standby element, as well as to restore the balance of generated and consumed electric power.

Another no less important aspect consists in the fact that electromechanical processes in the failure of an electrical circuit or violation of normal conditions usually originate and take place so quickly that the service personnel of power plants and substations are in no position to detect the beginning and prevent the development of these processes in good time. Therefore monitoring and controlling the operating conditions of a power system represent highly complicated technical problems. Fulfillment of these objectives without using special equipment proves to be impossible in many instances.

The aspects of power production discussed above, as well as others, have made it necessary to automate power systems to a wide extent.

By the automation of power systems is meant furnishing them with automatic equipment which controls the technological process of the production, transmission and distribution of electric power under normal and emergency conditions without the participation of a human being in keeping with a program assigned to this equipment, and the adjustment of this equipment.

Isolated automation equipment began to be used at individual electric power plants and substations in the USSR as early as 1935-1936. However the beginning of the mass introduction of various kinds of automation equipment in power systems must be set at 1943-1944. Because of the great job done by Soviet scientists and the personnel of planning organizations and power systems, energy today represents a highly automated production process.

All automation equipment can be divided into two groups in terms of its purpose and area of application: technological and system automation equipment.

In turn, automation equipment in each of these groups is divided into automatic control equipment and automatic regulation equipment.

Technological automation equipment makes possible automatic control or regulation basically in the normal operating mode, e.g., automatic switching on of a synchronous compensator or automatic voltage regulation (ch 3) and automatic synchronization of generators (ch 4). Technological automation equipment is as a rule of local importance.

System automation equipment makes possible automatic control or regulation basically under emergency conditions. Therefore under its heading comes equipment making possible the prevention or most efficient localization of failures originating in a power system, e.g., equipment for automatic regulation and boosting the excitation of generators (ch 5), for automatic frequency relief (ch 7) and for counteremergency automation (ch 8).

APV (ch 1) and AVR (ch 2) equipment usually also comes under the heading of system automation equipment. However, this equipment in many instances is of local importance.

Automatic regulation of frequency and active power overcurrent (ch 6) comes under the heading of system automation of normal conditions.

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