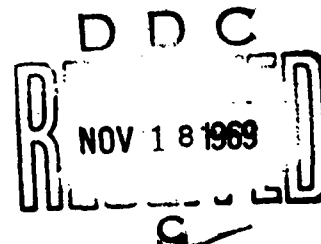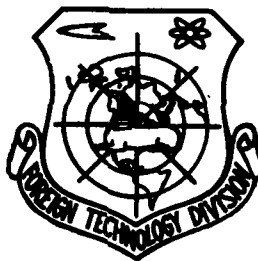AD696486

FOREIGN TECHNOLOGY DIVISION

A COMPLEX OF DEVICES FOR MICROFILMING AND INPUT OF INFORMATION
INTO ELECTRONIC DIGITAL COMPUTERS FROM MICROFILM
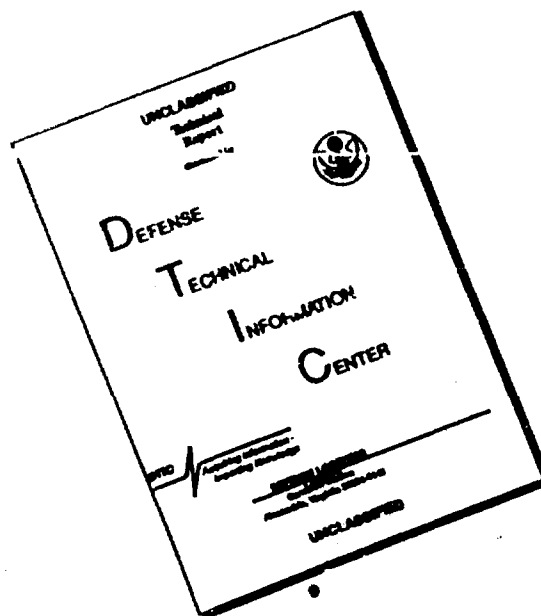OF PUNCHED CARDS

by

V. E. Zelikovskiy

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EDITED TRANSLATION

A COMPLEX OF DEVICES FOR MICROFILMING AND INPUT OF
INFORMATION INTO ELECTRONIC DIGITAL COMPUTERS FROM
MICROFILM OF PUNCHED CARDS

By: V. E. Zelikovskiy

English pages: 26

Source: Moscow. Nauchno-Issledovatel'skiy Institut
Aeroklimatologii. Trudy (Moscow. Scientific
Research Institute of Aeroclimatology), No. 39,
1967, pp. 63-83.

Translated under: Contract No. F33657-68-D-0865 P002

DATA HANDLING PAGE

01-ACCESSION NO.	98-DOCUMENT LOC	39-TOPIC TAGS
TT9000111		hydrometeorology, information storage and retrieval, punched card, microfilm

09-TITLE A COMPLEX OF DEVICES FOR MICROFILMING AND INPUT OF INFORMATION INTO ELECTRONIC DIGITAL COMPUTERS FROM MICROFILM OF PUNCHED CARDS

47-SUBJECT AREA

04, 09

42-AUTHOR/CO-AUTHORS	10-DATE OF INFO
ZELIKOVSKIY, V. E.	-----67

43-SOURCE		68-DOCUMENT NO.
MOSCOW. NAUCHNO-ISSLEDOVATEL'SKIY INSTITUT AEROKLIMATOLOGII. TRUDY (RUSSIAN)	FTD	HT-23-888-68
		69-PROJECT NO.
		6050202

63-SECURITY AND DOWNGRADING INFORMATION	64-CONTROL MARKINGS	97-HEADER CLASN
UNCL, 0	NONE	UNCL

76-REEL FRAME NO.	77-SUPERSEDES	78-CHANGES	40-GEOGRAPHICAL AREA	NO OF PAGES
1888 0132			UR	26

CONTRACT NO.	X REF ACC. NO.	PUBLISHING DATE	TYPE PRODUCT	REVISION FREQ
F33657-68-D-0865	65-AT7031673	94-00	TRANSLATION	NONE

STEP NO.	ACCESSION NO.
02-UR/2667/67/000/039/0063/0083 *	

ABSTRACT 02 PLUS 1 UNNUMBERED PAGE

(U) Equipment is briefly described for microfilming punchcards and introducing information from the microfilm into an electronic digital computer at speeds of 1.6, 10, and 100 cards/sec. The system is currently being tested at NIIAK. The external view of the microfilming equipment is shown. The drawing of the film transport mechanism and of the light source is shown. The optical part of the microfilm camera is a complex system of spherical and cylindrical lenses. This system is shown. The microfilming equipment is controlled from a panel. It is driven by a 180 watt type AOL-12-4 electric motor, operates from an ac source of 220/330 volts and has provision for emergency stoppage when the microfilm breaks, when the punchcards are deformed, when the lamp burns out or when the microfilm tension becomes weak. The operating principle of the equipment for reading information from the microfilm is shown. A block diagram of the reading system is presented and described. An extensive functional diagram of the register is also presented. A functional diagram of the control system for the photodiodes and horizontal series amplifiers is discussed. Additional features of the system and its shortcomings are also discussed. Orig. art. has: 11 figures, 3 formulas, 3 tables.

A COMPLEX OF DEVICES FOR MICROFILMING AND INPUT OF INFORMATION INTO ELECTRONIC DIGITAL COMPUTERS [EDC] (ЭЦВМ) FROM MICROFILM OF PUNCHED CARDS

V.E. Zelikovskiy

The paper briefly describes the principle, operation, and basic specifications of a complex of machines for microfilming punchcard libraries and putting the information into EDC from the microfilm of the punched cards.

INTRODUCTION

Hydrometeorological data accumulated over many years are an extremely valuable national asset. They are unusual in that they are used repeatedly to solve various scientific and practical problems and retain their value with the passage of time. As a result, very rigid requirements as regards wear resistance, indelibility, and density of notation apply to the mechanized hydrometeorological-data carrier. At the present time, the basic mechanized carrier for hydrometeorological information is the punched card. By 1965, the Hydrometeorological Service had accumulated about 200 million punched cards, and the average annual increase over the last two years has been about 40 million.

Because of the low attainable density of notation (0.5 decimal digits or 3.4 bits per 1 cm^2) and the appreciable size of the punchcards themselves (187.4 × 82.5), large areas in specially equipped storehouses are required for storage of the large volumes of information. According to conservative calculations, the average annual increase in storage floor space for 1965-1970 should come to about 400-450 m^2.

Up to the present time, most of the hydrometeorological punchcards have been processed on computer punches, whose operating speeds are low. As the punchcard libraries grow, therefore, not only do the direct costs for their preservation and storage increase, but the times required to solve vitally important scientific and practical problems also become longer.

The rates of information input into the EDC vary from 100 to 1500 cards per minute, depending on the type of input device. Hence the time spent on data input is nearly equal to the time to compute, and sometimes even considerably longer.

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Up to the present time, most of the hydrometeorological punchcards have been processed on computer punches, whose operating speeds are low. As the punchcard libraries grow, therefore, not only do the direct costs for their preservation and storage increase, but the times required to solve vitally important scientific and practical problems also become longer.

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- 1 -

Beginning in 1959, the Hydrometeorological Service took steps to resolve the above contradictions.

One of the possible solutions consists in designing and building a complex of devices to microfilm the punchcards and put the information into the computers from the microfilm. The design of the complex would be based on reducing the physical volumes of the information by use of a carrier that permits a higher notation density than the punchcard and comes closer to meeting the conditions of almost or fully automized processing of this information.

The volume and weight of the information carrier are reduced substantially on conversion to microfilm. Thus, for example, one standard 2580-cm^3 motion-picture-film storage can holds 300 m of microfilm, which accommodates 63,000 punchcard images. The skid volume for storage of the same number of punchcards is 430,976 cm^3. In other words, after microfilming the same amount of information is reduced in volume by a factor of more than 70 and, in addition, the input speed of the initial data into the EDC is several times higher. The information can be stored indefinitely on motion-picture film, and the film itself exhibits great toughness in use. If we add to this the simplicity and low cost of copying, the advantages of storage of information in the form of microfilm become obvious.

Below we present a brief description of a complex of devices for microfilming punchcards and information input into the EDC from the punchcard microfilm.

The complex was developed by the joint efforts of organizations in the USSR Ministry of the Radio Industry and the State Cinematography Committee in the Council of Ministers of the USSR.

At this writing, the complex is in trial operation at the Scientific Research Institute for Aeroclimatology.

PUNCHCARD MICROFILMING UNIT (УМП-35)

Principle of Microfilming

This unit is based on a dynamic exposure principle. During exposure, the punchcard is in motion at constant speed between the light and the motion-picture-camera lens, and a reduced image of the punchcard is projected onto a continuously moving cine film. The motions of the punchcard and cine film conform to the basic law of dynamic exposure, in which the speeds of the object being photographed and the film satisfy the relation

$$\frac{v_k}{v_n} = M, \qquad (1)$$

where v_k is the speed of the punchcard in the exposure-slit zone, v_n is the speed of motion of the film, and M is the optical reduction scale lengthwise along the film.

The exposures are made in transmitted rather than reflected

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light. As a result, an unpunched field on the card will produce a light transparent background on the film, while the punches and gaps between successive cards come out as dark rectangular marks and dark bands across the film, i.e., the film is a positive after development.

Design of the Unit

The unit (Fig. 1) consists of electromechanical and optical parts.

The electromechanical part incorporates the feed and transport mechanism for the punchcards, the film-transport mechanism and its drive, a control and monitoring console, and a removable cine-film cassette.

The feeder mechanism (Fig. 2) is a standard BY-700 input unit with the brush unit removed, a modified electric circuit, an enlarged (extended) bed, and changed number of rows. The feeder mechanism is equipped with three change-gear sets with which the exposures can be made at rates of 700, 500 and 300 cards per minute.
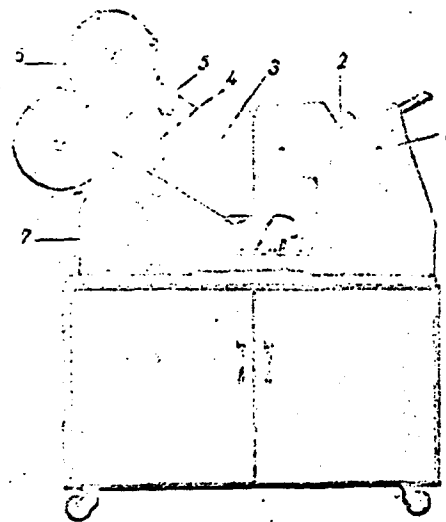
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Fig. 1. Device for microfilming punchcards. 1) Lamp; 2) feeder mechanism; 3) optical system; 4) film-advance mechanism; 5) exposed-film footage counter; 6) cassette; 7) control console.

The brush unit is replaced by a removable lamphousing whose exit slit, which is situated between the first and second pairs of transport rollers, faces the card channel and is covered with a ground glass. An exposure slit in the form of a 190 × 25-mm metallic frame covered with a protective transparent glass forms the other side of the card channel.

The film-advance mechanism (Fig. 3) is accommodated in a housing that is divided into two parts; one of the parts is opaque. The opaque part of the camera houses the film-transport mechanism, which consists of three guide and two pressure rollers, a friction drum, two geared drums and a framing window. The friction drum creates a constant tension on the film at the entry to the 32-tooth

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exposure drum, which has a filling tooth and winds the film from the supply cassette, moving it past the framing window. To prevent the takeup-cassette winder from tugging the film, a 24-tooth drum and a guide roller with a floating axle, which is connected to the unit's braking system at the end of the film, when tension is relaxed, or the film breaks, are installed behind the exposure drum.

The front side of the film-advance unit casing has a hinged cover for convenience in loading film. A counter that indicates the exposed-film footage is mounted atop the housing of the film-advance device.

The drive unit of the film-advance mechanism consists of two shafts and helical gears, which couple the main shaft of the BY-700 to the film advance.

The twin removable cassette is secured by a single screw to the housing of the film-advance mechanism and consists of two parts: the supply part at the top and the takeup part at the bottom. The takeup part has a shaft extension to receive an external slotted flange. When the cassette is mounted on the film-advance mechanism housing, the winder peg engages one of the flange slots.
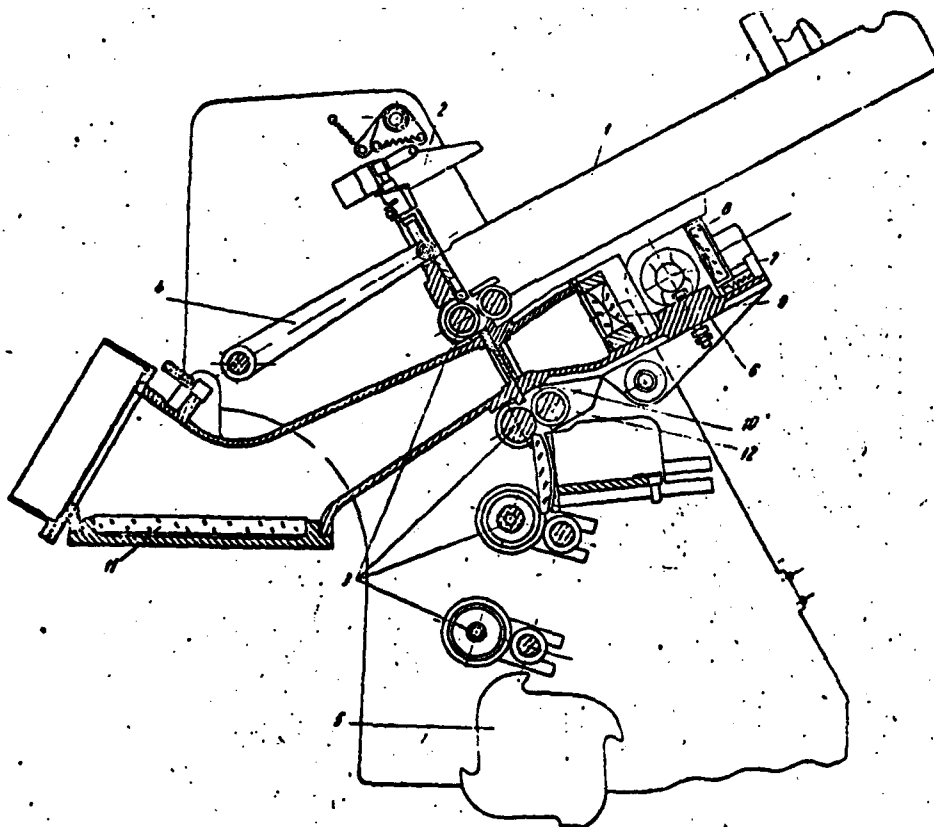
Fig. 2. Feed mechanism and light source. 1) Punchcard hopper; 2) feeder blade; 3) transport rollers; 4) double-arm lever; 5) stacking drum; 6) lamphousing; 7) lamp; 8) mirror back-reflector; 9) cylindrical condenser; 10) ground glass; 11) deflecting mirror; 12) exposure slit.

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Optical System

The optical part of the unit consists of the lamp, a rotary mirror, and the exposing optics, which form a complex optical system of spherical and cylindrical lenses.

The exposure lamp (Fig. 2) is enclosed in a cast ribbed housing and mounted on guide rails instead of the brush unit. The light source consists of two type K-27 lamps, which draw 50 W at 10 V. The lamp system has a cylindrical back reflector mirror, a two-element cylindrical condenser, and a ground glass for uniform illumination of the exposure-slit field.

For structural reasons related to the use of the standard BY-700 input unit, and with a view to reducing the dimensions of the filming device, a deflecting mirror, which turns the principal optical axis through 120°, is placed between the exposure slit and the lens.
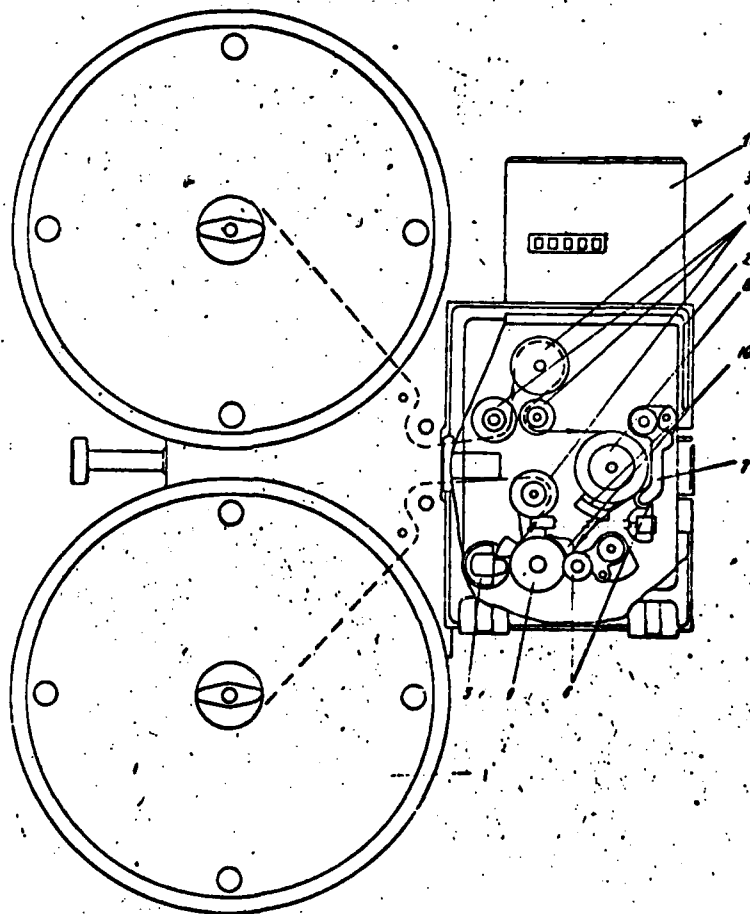

Fig. 3. Film-advance mechanism. 1) Cassette; 2) housing; 3) friction drum; 4) guide rollers; 5) interlock contact; 6) pressure rollers; 7) frame window; 8) thirty-two-tooth gear; 9) twenty-four-tooth gear; 10) choppers; 11) counter.

The collimator-type photographing optical system (Fig. 4) consists of an OKC-1-A-50 short-focus lens, a type HAC-4-1 anamorphic attachment, and a slip-on lens with a focal length $F = 387.5$ mm, which forms a parallel beam at the entry into the anamorphic attachment. The latter is built up with cylindrical lenses, has an anamorphosis factor of 2, and further changes the scale of the purchcard image only lengthwise along the film strip. The total reduction of the optical system is 18 times along the film and 7.75 times across it.

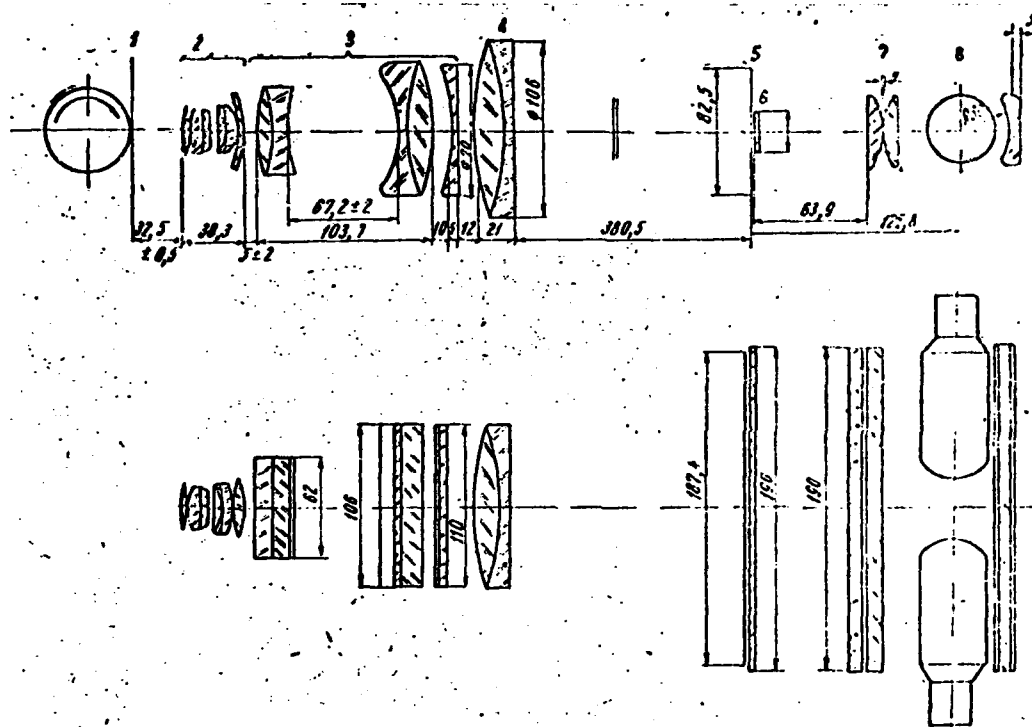The mount design of all optical elements makes adjustments possible.

Fig. 4. Optical system. 1) Film plane; 2) lens; 3) anamorphic attachment; 4) slip-on lens; 5) plane of punchcard; 6) ground glass; 7) cylindrical condenser; 8) lamps; 9) back-reflector.

Controls of the Unit

The machine is controlled from its console, which houses the main-line, lamp and ready switches and buttons for switching the motor on and off. Three pilot lights are provided to monitor the operation of the lamp, the punchcard feed mechanism, and the film-advance device. The knob of the filament-control choke and a panel voltmeter are used to regulate lamp power at the console. Lamp filament voltage can be varied in the 4-12-V range.

The unit has an emergency-stop switch that operates when the film breaks or runs out, the supply of punchcards runs out or one is deformed, when the receiving pocket overflows, lamps burn out, or film tension is too weak.

The device is powered by a 180-V type АОЛ-12-4 motor that operates from a 220/330-V ac line.

Certain Additional Characteristics of the Machine and the Microfilm

The machine has three film-advance speeds, 1425, 2375 and 3325 mm/min, respectively, for the three processing speeds (300, 500 and 700 punchcards per minute). The linear speeds of the punchcards with a constant 3.2-mm (0.5-position) interval between them will be 25,710, 42,850 and 60,000 mm/min, respectively.
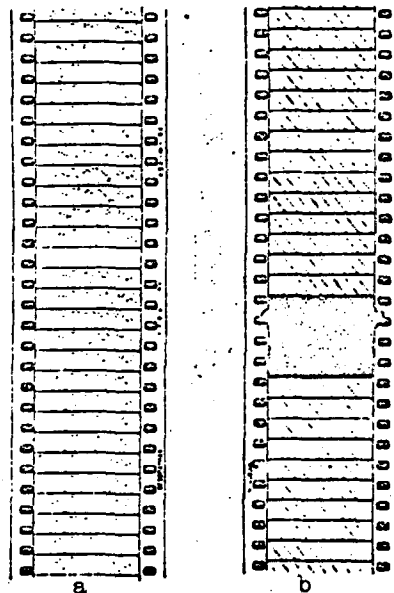

Fig. 5. The microfilm. a) Without zone marker; b) with zone marker.

Punchcards can be microfilmed onto cine film with a definition capable of producing a line boundary sharp enough so that no transition zone is observed at a magnification of 10-20. The best results are obtained with "Mikrat-300" film. The lilac background of this film has no effect on microfilm quality, since the background density is within acceptable limits. When microfilm is used for long-term data storage, it is desirable to use films with a noninflammable low-shrinkage base.

One meter of film has 210 frames, one for each perforation of the film. The punchcard images are placed on the film with the long side across the film and the chopped corners facing the same way. The punchcard images are 4.58 mm high and 24.2 mm wide. The punch image is square, 0.18 mm on a side. The dark space between frames is 0.18 mm wide.

The pitch between punch images is not uniform. It is 0.30 mm

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at the middle and increases smoothly toward the edges to 0.34-0.35 mm.

The microfilm does not carry any special synchronizing markers. The dark dividing strip between frames is used in reading to count punchcard positions. To obtain the first synchronizing strip, it is necessary that the first card in the stack to be photographed be clean, i.e., unpunched.

To prepare microfilm with a zone marker, a solid black space five to six frames long is left between groups of frames of two adjacent zones, serving essentially as a zone marker. Zones are not numbered on the microfilm. An empty frame must appear at the beginning of each new zone, i.e., an unpunched card must be recorded.

The density of the punch images and the separating strip vary from 1.8 to 2.5. The background density is no greater than 0.2.

Figure 5 shows the microfilm.

MICROFILM READER [MR] (УСВ)

Principle and Operating Conditions of the Unit

This unit is based on the principle (Fig. 6) of photodiode-matrix reading. The microfilm carrying the punchcard images is drawn at constant speed between a lamp and a lens, the latter pro-
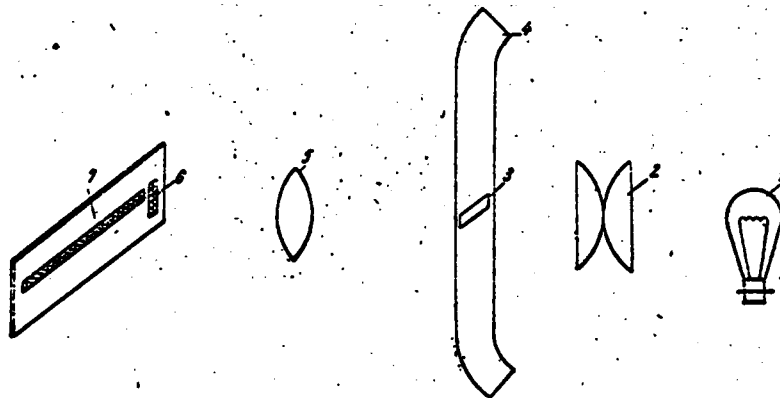
Fig. 6. Principle of reader. 1) Lamp; 2) condenser; 3) frame window; 4) microfilm; 5) lens; 6) vertical-row photodiodes; 7) horizontal-row photodiodes.

jecting a magnified (13×) image of the punchcard onto the matrix, which has two rows of photodiodes. The horizontal row consists of eighty photodiodes and has the function of reading the digit punches; the vertical row consists of thirteen photodiodes, whose function is to sense the number of the position being read, reset the circuit, and stop the device during operation in the zone-input mode.

During reading, the microfilm is advanced with the ninth numeric row in front.

The distance between the horizontal-row photodiodes conforms exactly to the distances between the punch images projected onto the matrix. Here the matrix is adjusted in such a way that as the microfilm moves, the vertical axes of the digit punches will coincide with the photodiode axes. The step between the vertical-row photodiodes is equal to the distance between the positions on the punchcard image in the plane of the matrix, and the photodiodes themselves are adjusted so that as the microfilm moves they are covered successively by the edge of the black strip separating punchcard images. The digit punches are not projected onto the vertical-row photodiodes.

The signals from the vertical-row photodiodes go to a position counter, which establishes the number of each position read, a necessary step for conversion of the read numbers from decimal to binary-coded decimal. Together with the output-register input gates, the position counter forms the corresponding encoder.

The photodiodes function as nonlinear variable-resistance arms of voltage dividers at whose center points are connected the transistor bases of the first readout-amplifier stages.

The periodic shadowing of the photodiodes by the punch images creates a variable voltage at the input to the amplifiers, and this is amplified and shaped into rectangular signals. The information is read in this manner.

The machine provides for two principal operating modes: the continuous and zone-by-zone input. The former can be used when simultaneous processing of the information on many microfilm frames is not required by the conditions of the problem, but processing of one frame repeats in full the processing of all the others. Many climatological problems, such as problems of complex and simple recurrence, can be solved in this mode. The latter mode is applicable when the content of many frames is involved in the computing process. In this mode, the film-advance mechanism stops at each zone marker on the microfilm. Input of the next zone begins only after the reader has received a control signal from the EDC. The machine does not make zone searches. Input of selected zones whose boundaries are defined by one or more criteria that they have in common can be effected from a microfilm not having the zone marker by programing on the EDC.

In either mode, the machine can read with and without decimal-to-binary-coded-decimal conversion of the numbers.

Information is read from the microfilm only in the "start" mode; the film is rewound in "reverse."

Twenty-four columns from any part of the punchcard and in any combination can be read simultaneously during input with code conversion. Here, two ninety-six-place numbers, the first of which contains the numeric part of the frame read (positions 0-9), while the second contains the zone punches and characters (positions 11

and 12), will be put into the EDC from each frame.

During input without code conversion, all eighty columns are read simultaneously, and twelve eighty-place codes will be put out into the EDC from each frame scanned, in accordance with the twelve rows, or positions, of the punchcard.

The machine provides three speeds of reading and information input into the EDC: 1.6, 10 and 100 frames per second.

Block Diagram of the Unit

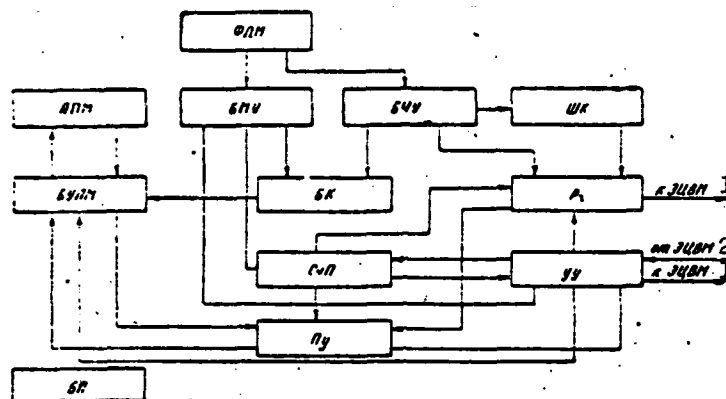Figure 7 shows a block diagram of the machine.

Fig. 7. Block diagram of reading unit. ФДМ) Photodiode matrix; БЧУ) digit amplifier block; БМУ) marker amplifier block; ШК) switchboard; РГ) output register; СЧП) position counter; УУ) control unit; БУЛМ) film advance mechanism control block; БК) monitoring block; ЛПМ) film-advance mechanism; ПУ) control console; БП) power supply. 1) To EDC; 2) from EDC.

The machine is started by a signal from the EDC or from the control-panel button. The start signal goes to the film-advance-mechanism control unit, which switches the mechanism on, together with the projection lamp inside it. A monitor photodiode is mounted in the housing of the projection lamp to signal the film-advance control unit whenever the lamp is out. The latter control block then stops the machine and switches on a pilot light on the control console.

When the film-advance mechanism is switched on, the film begins to move, and, as they pass over the windows of the matrix photodiodes, the dark marks vary the voltage at the inputs of the reading amplifiers.

From the marker-amplifier block, the signals go to the control unit for the position counter. The signals from the same amplifiers are used to interrogate the register input gates. Permission to enter in the register is given by signals from the digit

amplifiers, which pass through the switchboard if reading is being done with code conversion and bypass it if no code conversion is involved. The numeric-punch reading amplifiers have two types of connection with the unit's output register. The first type permanently connects all eighty reading amplifiers digit by digit with the input gates of the register's eighty highest digits (direct input). The latter type can connect any of the eighty reading amplifiers with any tetrad of the register (switchable input). For this purpose, all digit amplifiers have outputs to jacks on the switchboard, and the twenty-four tetrads of the output register have one plug each at the switchboard. The two types of connection are effected through separate gates.

The circuit is also set to its initial state (the output register and position counter are set to [zero]) by signals from the marker-amplifier block.

The output register has ninety-six binary digits and is divided into two halves, each with forty-eight digits. Only the left half is connected to the EDC. Transfer of the contents of the right half to the EDC occurs after it has been shifted into the left half. The two halves of the register are connected through special input gates of the left half. The position counter is connected with the register through the gates of the switchable input.

In addition to these connections, the digit amplifiers are connected by the system monitoring the operation of the photodiodes in the horizontal row of the matrix. In the event that one of the photodiodes or an amplifier fails, a stop signal goes from the monitor circuit to the control unit of the film-advance mechanism and a pilot light lights up on the control panel.

Numbers are transferred from the reading-unit output register to the EDC by a signal from the control unit, which first prepares the EDC for reception (clears its input register) and then transmits.

Mode and speed switches are situated on the control console, together with monitoring instruments and the signal-system pilot lights.

The following signals are provided for connection of the reading unit to the EDC: "start EDC" and "write" to the EDC and "start," "stop," and "reverse" from the EDC.

Operation of Reading Unit

Before the machine is started, the desired operating mode and reading speed are set up with the switches on the control panel. If the work is to be done with code conversion, the columns required for operation are connected at the switchboard. The program is put into the EDC, after which the film-advance mechanism is started with the "start" button on the machine's control console.

Let us examine the operation of the reading unit with reference to the functional diagrams of the control unit (Fig. 8) and
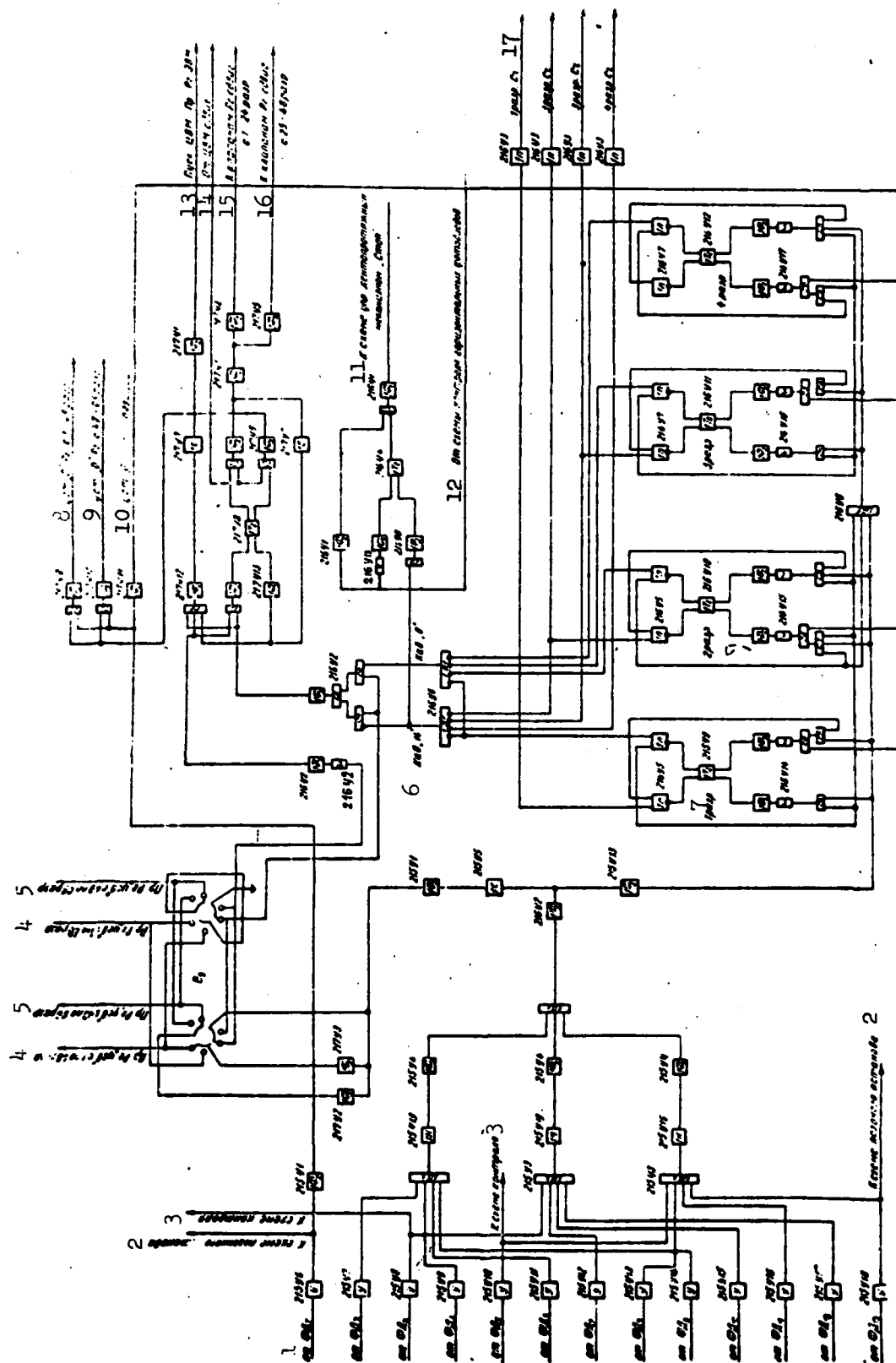
[Fig. 8]. 1) From ФД₁; 2) to zone-stop circuit; 3) to monitor circuit; 4) receive MR register from digits 1 through 48; 5) receive MR register from digits 49 through 96; 6) [cable]; 7) 1st digit; 8) set register to "0" from 1st to 48th digit; 9) set register to "0" from 49th to 96th digit; 10) set to "0" ([illegible] positions); 11) to "stop" control circuit of film-advance mechanism; 12) from horizontal photodiode monitor circuit; 13) start EDC; receive EDC register; 14) from EDC — shift; 15) to gates of shift register, digits 1-24; 16) to gates of shift register, digits 25-48; 17) 1st digit of counter.
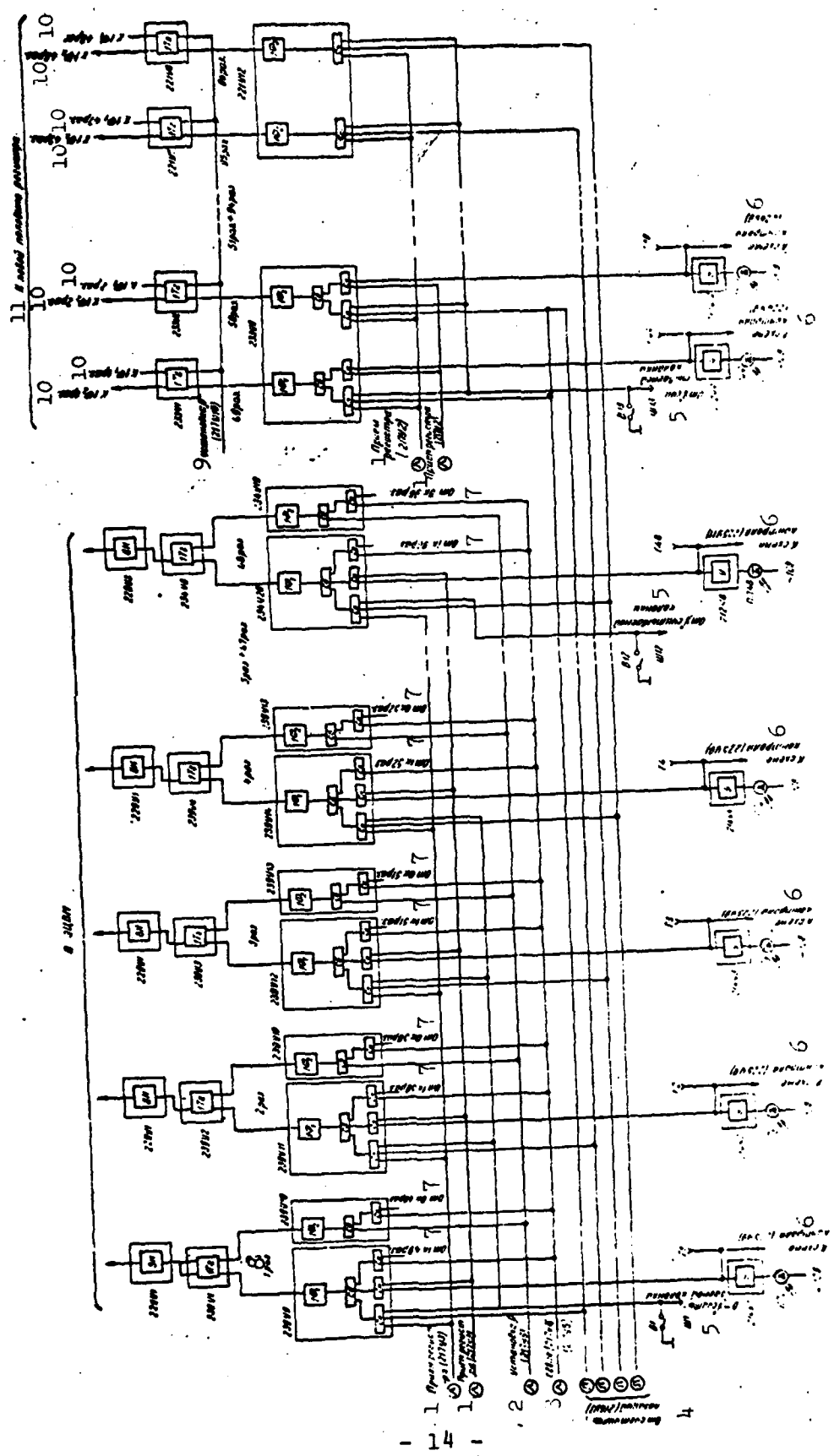
Fig. 9. Reading unit register. Functional diagram. 1) Receive register; 2) set "0"; 3) shift; 4) from position counter; 5) from "y" of column being read; 6) to monitor circuit; 7) from ... to ... digit; 8) 1st digit; 9) set "0"; 10) to 1Φ ... of ... digits; 11) to left half of register.

the output register (Fig. 9). We shall first consider the operation of the device without code conversion, i.e., line-by-line or position input. In this operating mode, the position of switch B9 shown on the diagram corresponds to the mode selected. The switchboard is not used.

As the microfilm moves, the black strip separating frames covers the vertical-row photodiodes one by one. The signal from the first photodiode ($\Phi\text{Д}_1$) goes to the control unit, where it resets the position counter (through 217У11) and generates a "register 0 set" signal (through 217У9 and 217У10), preparing the register to receive the first number.

While the second photodiode of the vertical row ($\Phi\text{Д}_2$) is covered by the strip, punches present in the ninth position of the punchcard will cover photodiodes in the horizontal row. The signals from the digit amplifiers of the shaded diodes go to the potential inputs of the register's direct-input gates, permitting readin.

Readin is initiated by a pulse from the second photodiode of the vertical row. Passing through the amplifier-shaper network via switch B9 (left gang), it goes to the pulse inputs of all direct-input gates and writes ones in those places of the register with the permit-write potential on their gates.

The same pulse passes through delay unit τ, 216У6, and network 216У2-217У12-217У7-217У1 to the EDC, where it clears the input register of the machine and writes in the first (left) half of the number (with "start EDC" and "receive EDC register" signals). Simultaneously, it switches trigger 217У8 to the one state through 217У13, thus permitting passage of the response signal from the EDC through 217У6, 217У4 and 5 ("from EDC — shift") to the gates of the left half of the register for execution of the right-half shift.

After a delay τ 217У7 equal to the time required for the shift, this same shift pulse sets trigger 217У8 to "0" and retransmits the "start EDC" and "receive EDC register" signals to the EDC via network 217У12-217У7-217У1, but this time for reception of the second half of the number.

Since trigger 217У8 is now at "0," the response signal from the EDC does not pass through the shift network, but to 217У9 and 217У10 and thence to set the output register of the reading unit to "0." This prepares the output register of the machine to receive the code of the next row.

When the separating strip crosses the third photodiode of the vertical row, the punches in the eighth position of the punchcard will be on the horizontal row, and the entire cycle of reading the number and transmitting it to the EDC is repeated. Thus, the cycle will be repeated twelve times for each frame.

In reading information with conversion of code (written in decimal), switch B9 must be thrown to the left, and the necessary columns connected at the switchboard. This provides for passage of the "receive EDC register" signal from the vertical row of photodiodes to the pulse inputs of the decimal-input gates to the register and passage of the signal from the horizontal row to the potential inputs of the same gates (through the right gang of switch B9).

The signals are fed simultaneously to four register places from each readout-switchboard plug.

As in the zone-input mode, the "receive MR register" signals go to the register gates for each position of the punchcard.

Signals from the output buses of the four-place position counter go to the second potential inputs of the switching-input gates. An entry is made in the register only when all three signals coincide.

Let us consider the process of reading decimal numbers and the operation of the control unit in this mode in greater detail (Fig. 9).

As in the former case, the signal from the first photodiode of the vertical row resets the position counter, for which the code "1010" is taken as the initial state, and sets the output register to "0." The counter is reset through network 215У1-217У11 — the ones inputs of the second and fourth places and the zero inputs of the first and third places.

The signals from the remaining photodiodes ($\Phi\text{Д}_2$-$\Phi\text{Д}_{13}$) pass to the counter input through 215У13. Each new signal to the counter sets the reading to one less than the preceding reading. After arrival of the signal from the second photodiode at the counter, the "1001" code (the number 9) has been set up on the counter, and the code "0000" after arrival of the signal from $\Phi\text{Д}_{11}$. The signal from $\Phi\text{Д}_{12}$ to the counter will set the code "1111," and that from $\Phi\text{Д}_{13}$ the code "1110." These last two codes correspond to the eleventh and twelfth positions of the punchcard.

The ones collectors of the counter are connected to the permit buses of the gates of the register switching input. Here the collector of the first counter place transmits the permit potential to the gates of the first digits of all tetrads of the register, that of the second transmits it to the gates of the second digits, that of the third transmits to the gates of the third places, and that of the fourth to the gates of all four digits of the register triggers.

Concurrently with this, the ones outputs of counter trigger

digits 4, 3 and 2 and the zero output of the first digit are transmitted to the left-hand coincidence circuit 216У6. The right-hand circuit receives the outputs of all zero counter outputs. When the counter indicates "0000" and "1100," the outputs of these circuits will be at high potentials, which set up the coincidence circuits 216У2 to permit passage of pulses from the vertical-row photodiodes to the control circuit. For other counter readings, signals from the vertical-row photodiodes will not be passed to the control circuit.

The position counter also operates in the position (line-by-line) input mode that we examined above, but in this case the pulse inputs of the coincidence circuits 216У2 are grounded through selector В9 and no signals pass from their outputs to the control circuit. In reading with code conversion, passage of signals from the vertical photodiode row to the control circuit through delay τ 216У6 is forbidden.

In this mode, therefore, pulses go only twice for each frame to the control circuit to generate the "start − EDC," "receive EDC register," and "shift" signals: once when the zero position of the punchcard is read and once for its twelfth position. The codes are written into the output register at each position.

When the separating strip crosses the second photodiode of the vertical row, the "1001" code is set up on the position counter, and the permit-write will appear at the potential inputs of the tetrad gates for writein into the first and fourth places of all tetrads. Simultaneously, the ninth position of the frame is read by the horizontal row of photodiodes and if there were punches at this position in any one or several of the switched columns, the permit-write will appear on all of the second potential inputs of the corresponding tetrads. Ones will be written into the first and fourth places of these tetrads by the pulse from the second photodiode through selector В9 (right-hand gang), i.e., the numeral 9 will be written.

The remaining digits are written into the register in a similar manner.

When the zero position of the frame is read, the code "0000" is set on the position counter, going to the control unit and generating the "start EDC," "receive EDC register," and "shift" signals. The response signal from the EDC (after reception of the contents of the second half of the unit's register at the EDC) clears the register, preparing it to receive the codes of the eleventh and twelfth frame positions.

At the "1110" (14) code, transmission from the machine's register to the EDC is repeated, at which point a pulse from the first photodiode (it is shadowed by the separating strip for the next frame) sets the position counter to its initial state (code "1010") and sets the output register to "0."

It follows from the above that when the machine is operated in the code-converting mode, there may be no more than two punches in each column of the frame: in the digit field (positions 9-0)

and in the zone-punch field (positions 11 and 12). In operation in the line-by-line input mode, on the other hand, each column may have punches in all positions.

Zone Stop

In the zone-by-zone input mode, the machine is stopped by signals from the first and last photodiodes of the vertical row. The signals from these end photodiodes go through coincidence circuit 225У5 (Fig. 10) to the film-advance-mechanism control block to stop the machine.
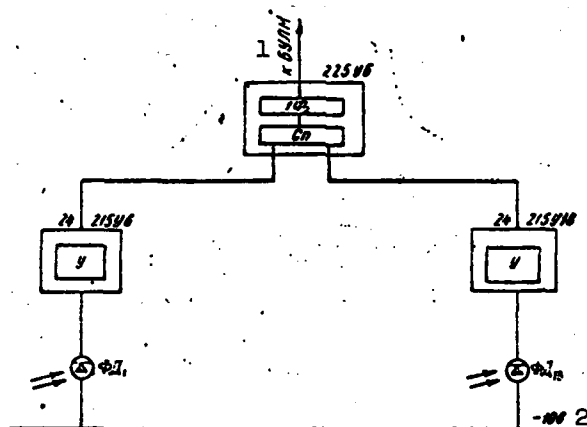

Fig. 10. Zone stop. Functional diagram. 1) To film advance mechanism control block; 2) -10 V.

Monitoring Operation of Unit

The machine provides for monitoring the operation of the photodiodes and digit and marker amplifiers. Figure 11 shows the monitor circuit for the photodiodes and horizontal-row amplifiers.

The dividing strip between frames covers simultaneously all of the horizontal-row photodiodes, the signals from which go through the stepped "AND" gates to the ones inputs of triggers 225У1-225У5.

The initial zero state of these triggers is set up by a signal from the fifth vertical-row photodiode through the circuit: 215У10-224У3-zero trigger inputs. The same signal, going to trigger 224У2 at its ones input, sets to it "1" (high level on right collector).

If all horizontal-row photodiodes and digit amplifiers are in proper working order, all triggers 225У1-225У5 are set to "1" as the separating strip crosses the photodiodes, and the high potential from the ones collectors set trigger 224У2 to "0" through coincidence circuit 225У7 and 224У4. The interrogation signal from

Fig. 11. Monitoring photodiodes and amplifiers of horizontal row. Functional diagram. 1) To film advance mechanism control block; 2) "у" of 215УВ; 3) to vertical photodiode monitor circuit; 4) from digit amplifiers.

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the third photodiode of the vertical row through network 215y8-224y1 does not pass through 224y5 in this case. Unless at least one photodiode of the horizontal row or one digit amplifier has been tripped, the output of gate 224y4 will be at low level and trigger 224y2 will remain in the "1" state. In this case, permission will go from the ones collector of the trigger to 224y5 to pass the interrogation signal, which, arriving at the film advance mechanism control block, stops the machine.

Thus, a check of the horizontal diodes and digit amplifiers is run by each black separating strip between frames. The first control point is setting of trigger 224y2 to the "one" state through 224y3, by the signal from the fifth photodiode of the vertical row when it is crossed by the separating strip of the frame being read at the given moment. The second control point is change or confirmation of the state of trigger 224y2 when the next separating strip crosses the photodiodes of the horizontal row. The third is interrogation of the state of trigger 224y2 by the signal from the second photodiode when it is crossed by the same separating strip.

Figure 8 shows the vertical-row photodiode monitor circuit. The "14" code from gate 216y6 sets control trigger 216y4 to "0" (low level on pulsed collector) through 216y8 at each frame.

The horizontal-row photodiode monitor circuit (zero collector of trigger 224y2) sends a pulse through 216y1 to the "AND" circuit 216y1; this pulse does not pass to the film advance mechanism control block if the monitor trigger is at "0." After a delay 216y18, the same pulse sets the monitor trigger to the "1" state, preparing it to monitor for the next code.

If one of the photodiodes or amplifiers of the vertical row has failed, the "1110" code will not appear at the counter output, the monitor trigger will remain in the "1" state, and the signal from trigger 224y2 will pass to stop the film-advance mechanism.

This type of monitoring works in the same way on each frame, checking not only the operation of the vertical-row photodiodes and their amplifiers, but also the performance of the position counter.

Both types of monitoring can be switched in in any operating mode of the machine, by use of the appropriate selectors on the control console.

Certain Additional Characteristics of the Machine

The unit provides for automatic stop at the end of the film or if the film breaks, or if the lamp fails. In the latter case, a buzzer sounds when the film advance mechanism stops.

Provision is made for independent adjustment of the matrix, for which the control console has a "run-tune" selector. When the selector is in the "tune" position, the film-advance mechanism does not operate, but the projection lamp is on.

The microfilm is advanced by two 32-tooth drums with a filling tooth. One of them transports the microfilm in the "start" mode, and the other in the "rewind" mode.

The tape-advance mechanism is driven by a single type АОЛ-012/4 motor powered from a 220/380-V single-phase alternating-current line.

The gearbox is a three-speed sealed oil-filled unit that provides for advancing the microfilm at 1.6, 10 and 100 frames per second.

The numbers of digits read at these speeds are indicated in Table 1.

TABLE 1

1 Скорость движения микрофильма (кадр/сек)	2 Количество считываемых знаков в режимах	
	3 двоичный код	4 десятичный код
1,6	1600	36
10	9600	240
100	96000	2400

1) Microfilm transport speed (frames/s)
2) Number of digits read in
3) Binary-code mode   4) Decimal-code mode.

TABLE 2

1 Параметры	2 Уровни
3 Начальный уровень	4 $И_0$, —2+—8 в
5 Амплитуда	6 $И_с$, 1 в
7 Форма	8 Колоколообразная
9 Амплитуда макс. допустимой помехи	10 $И_п$, 0,4 в
11 Частота	12 20+1,5 кгц
13 Полярность	14 Положительная

1) Parameter
2) Level
3) Initial level
4) $И_0$, -2 to -8 V
5) Amplitude
6) $И_s$, 1 V
7) Shape
8) Bell

9) Amplitude of maximum permissible noise
10) $И_p$, 0.4 V
11) Frequency
12) 20 to 1.5 kHz
13) Polarity
14) Positive.

TABLE 3

Parameters of Output Signals at 20 ± 5°C

1 Параметры	2 Уровни
3 Амплитуда	4 5,8÷6 в
5 Длительность	6 200 мксек÷50 мсек
7 Длительность фронта	8 0,6 мксек
9 Длительность спада	10 6 мксек
11 Форма	12 Прямоугольная
13 Полярность	14 Положительная

1) Parameter
2) Level
3) Amplitude
4) 5.8 to 6 V
5) Length
6) 200 µs to 50 ms
7) Leading-edge length
8) 0.6 µs
9) Trailing-edge length
10) 6 µs
11) Shape
12) Rectangular
13) Polarity
14) Positive.

The speed and direction of microfilm motion are switched by five electromagnets supplied by 30-V current and drawing a maximum power of 60 W.

The type К-22 projection lamp is supplied by a voltage $u =$ = 30 V and draws a power P_{maks} = 400 W. The lamp filament can be step-regulated from 15 to 30 V. The regulation interval is 1.5 V. It takes 1-1.5 s for the lamp to warm up.

The machine uses a "Yupiter-9" lens with a focal length $F =$ = 8.5 cm. The average distance of the lens from the photodiode matrix is 1200 mm.

The matrix field is nonuniformly illuminated. The illuminance is about 2.5 thousand lux at the center of the matrix and 1.5 thousand lux at the edge.

The device is semiconductorized. Printed circuits are used to wire the cells and the subblocks.

The "start," "rewind," and "stop" instructions from the EDC are applied to the machine in the form of steep positive-going pulses of amplitude И = 6 V.

The parameters of the input and output signals of the digit and marker amplifiers are given in Tables 2 and 3.

At subfreezing temperatures (-10 to -50°C), the output parameters of the amplifiers undergo no change except for the amplitude, the lower limit of which drops to 5.4 V.

Certain Shortcomings of the Complex

The weakest link in the present system is ensuring that the information punch will pass across the sensing window of the pho-

todiode. Reading information with a fixed photodiode matrix requires highly precise operation of the УМП-35 and MR mechanisms. Actually, isolation of the photodiode useful signal is possible only if the punch image covers at least half of the photodiode sensing window as it moves. If less of the area is covered, the photodiode signal will be difficult to distinguish from the noise. In other words, the center of the moving punch image may not deviate from the center of the photodiode by more than half its own width. It is obvious that if the widths of the marks vary, a minimum dimension must be imposed in calculating the tolerance for shifting of the mark.

The minimum width of the punch image on the microfilm is 0.16 mm. This means that the maximum permissible displacement of the mark center from the center of the photodiode sensing window is ±80 μm. This quantity can be resolved into three components corresponding to the three mechanisms whose operating precision must ensure that the mark encounters the photodiode.

According to the technical specifications for the microfilm, the permissible imprecision of alignment of the punchcard images across the width of the film with respect to the perforations into which the width-filling teeth of the film advance mechanism drum fit may not exceed ±0.025 mm. The tolerance for transverse displacements of the film in the MR film advance mechanism is then $0.080-0.025 = 0.055$ mm.

In high-quality filming equipment, the lateral shifting of the film in the exposing part of its path varies from ±0.01 to ±0.02 mm. In the УМП-35, it is about ±0.015 mm. The permissible deviation of the punch from the base edge of a punchcard is ±0.15 mm, and the permissible imprecision of stacking of the cards in the feed-mechanism loading box is ±0.09 mm.

Thus, the total error of the punchcard feed mechanism is found to be ±0.24 mm, which amounts to ±0.031 mm on the microfilm scale, and the total error of the УМП-35 as a unit will be ±0.046 mm. Thus the permissible transverse shifting of the film in the MR must be not ±0.055 mm, but only ±0.034.

It is seen from the example given above that the УМП-35 transport mechanisms cannot ensure the necessary precision of the microfilm and therefore cannot guarantee that the punch images will meet the photodiode.

However, it should be noted that the above example considered the maximum permissible deviations, the probability of which would appear to be small, like the probability that all deviations will have the same direction. Nevertheless, when we speak of a system whose error must not exceed 10^{-6} (one error per million digits read), such caution must be regarded as justified.

Experimental operations carried out during 1965 and the first half of 1966 have pointed up the very poor reliability of the complex in operation.

The factors that cause the images to deviate from the photo-

diodes can be divided into two groups. The first of these consists in imprecise placement of the punches on the cards themselves, which results from the imperfections of the cardpunches and the technology of producing punchcard catalogs. As we noted above, the second factor is related to the operating imprecision of the photographing and reader transport mechanisms.

The sensitivity of the reading unit to constancy of the vertical frame dimension is a result of the following. Owing to the absence of row markers on the microfilm, row synchronization depends on the black separating strip between frames. For this purpose, an auxiliary matrix, the so-called vertical matrix, which consists of 13 ФД-2 photodiodes, is used. The spacing between the photodiodes of this matrix is so computed that their signals, which appear as the separating strip passes, will coincide in time with the signals from the digit photodiodes and permit writein of the number into the register. Hence the requirement of constant vertical frame size, since any violation will change the spacing between the rows of the frame and, consequently, the digit and synchronizing signals will not coincide in time.

The technical specifications for the microfilm allow variation of frame height by no more than ±0.75% of its average value, for which we take the film perforation interval of 4.75 mm. Measurements made on microfilm have shown that the maximum deviation from this dimension is -0.26 mm, or 5.5%. Constancy of the vertical size of the punchcard image on the microfilm depends exclusively on the condition of the УМП-35 transport mechanisms. It follows from the basic law of dynamic filming that with

$$\frac{v_k}{v_n} < M \qquad\qquad (2)$$

the frame will be elongated and the distance between positions will increase, while with

$$\frac{v_k}{v_n} > M \qquad\qquad (3)$$

the frame will be compressed and the distance between positions will become smaller.

Departures from (1) may be caused by the presence of large clearances, radial excursions of the transport rollers, or slippage of the punchcard and film. This error is random and cannot be compensated by adjustment of the synchronizing matrix.

The availability of three reading speeds (20 and 120 Hz and 1.2 kHz) complicates the design of the MR film-transport mechanism and makes it difficult to match the operating modes of the stages in the amplifier circuits and to shape the photodiode signals. If one of the speeds is switched in, the reading and rewinding of the film will take place at the same speed.

One last remark: the microfilm obtained from the УМП-35 is a positive, i.e., it has a transparent background and dark punch images. In the machinery complex described, the same film is the working film for the MR. A positive is inferior to a negative as

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regards noise immunity. Most opaque specks of dust and dark inclusions in the emulsion of motion-picture film are comparable in size to the information marks, or even considerably larger. If they occur on clear areas, they become a source of errors. The Scientific Research Institute for Aeroclimatology (НИИАК) punchcards are punched in decimal, i.e., there can be only one punch in a column of the digit field, and no more than twenty punches in the entire zone field. This means that on a positive microfilm, the field of black punch images (assuming that all eighty columns have marks) is approximately one-ninth the size of the image-free field and, consequently, the probability that dust or dirt will fall onto the open area is nine times greater. The picture will be the opposite on negative microfilm: the probability that noise will occur on a transparent marker will be one ninth the probability of its occurrence on the dark unoccupied areas of the frame.

CONCLUSION

Despite the defects of the first prototypes of the machines for microfilming punchcards, reading the information from the punchcard microfilm, and putting it into the EDC, work to improve these machines should not only be continued, but should be expanded.

Since the nature of the carrier (the punchcard) and the design features of the feed and transport mechanisms make it impossible to improve the performance of the УМП-35 substantially, subsequent work should, in our opinion, be directed toward lowering the sensitivity of the MR to various microfilm defects.

It would appear to be possible to lower sensitivity to horizontal frame displacement in two ways. The first approach follows from the analysis given above of the tolerances for horizontal frame displacement. This indicated that the larger (wider) the information mark on the microfilm, the wider will be the limits of permissible frame displacements. Marker width can be increased substantially if the punchcards are placed with their long side along the film during photographing. The decrease in density of notation on the film will be compensated by the high operating reliability of the system that can be attained as a result. The second possible solution consists in designing a matrix and MR logic circuit whose final effect will be equivalent to enlarging the punch images. This would preserve microfilm notation density.

The two solutions are equally competent and the НИИАК and the Hydrometeorology Center (ГМЦ) are pursuing research in both directions.

If row markers are introduced on the microfilm, the MR will be practically insensitive to changes in vertical frame size. The НИИАК has developed a synchronization circuit working from row markers and is testing it on an MR.

Row markers can be produced on the microfilm if all 12 positions in the 80-column punchcard are punched before photographing. In most НИИАК models, the last column of the punchcard is free. In the basic weather and agrometeorological models, where the 80th

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column is occupied, one of the recurrent-identification columns (for example, the catalog digit) may be used as markers.

The three reading speeds in the MR are excessive. Obviously, the unit should have one speed, that most suitable for the type of machine with which it is working. This simplifies the mechanical part of the machine and selection of operating mode for the control circuit and the photodiode signal shaping circuit. The film-rewind speed should be as high as possible for the carrier type in question and the design of modern film-advance mechanisms. This is necessary to reduce unproductive operating time of the reading units. For this purpose, it would be desirable if reading and information input into the EDC were possible during both the forward and rewind motions of the film.

When the MR is converted to read negative microfilm, the improved noise immunity should be accompanied by improved performance of the photodiodes (since they will be lighted for less of the time). This simplifies coding of the films (no duplicate is needed).

SYMBOLS ON FUNCTIONAL DIAGRAMS:

ФД	photodiode	τ	delay
Д₂	"OR" circuit	СП	coincidence circuit ("AND"
Д₁	"AND" circuit		circuit)
Т	trigger	П	follower
Ф	shaper	СБ	gate
У	amplifier	1К	ones collector
		ОК	zeros collector.

Manuscript Page No.	Transliterated Symbols
21	с = s = signal = signal
21	п = p = pomekha = noise
22	макс = maks = maksimal'nyy = maximum

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