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SEMI-AUTOMATIC COMPARATOR FOR EVALUATION OF STEREOPHOTOGRAPHS

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The device for evaluation of stereophotographs is described which permits to measure simultaneously three space co-ordinates of the track point with automatic punching on the tape.

Introduction

In high energy physics there exists lately a tendency towards increasing the experiments performed with bubble and diffusion cloud chambers. Thus the question arises to construct the effective devioes for fast and accurate evaluation of the large number of stereophotographs.

The use of reprojectors of different kinds makes it possible to evaluate stereophotographs quickly and with high precision. However, this method has serious difficulties in evaluating stereophotographs taken in bubble chambers. These diffioulties arise due to necessity to take into account the refraction effect of the liquid used in the bubble chamber. The difficulties arise also if the chambers are used in the magnetio field, when it is necessary to measure the curvature of spiral lines arbitrary oriented in space and angles between them.

The use of the electronic computers allows to obtain higher productivity in making calculations. This makes it favourable to use the methods based on calculation of curvatures and angles from co-ordinates of separate track points. It is natural that making the analytical calculations faster cannot solve completely the problem, as the process of taking the track co-ordinates with the aid of ordinary microscoopes or stereocomparators requires a great amount of time.

The development of automatic devices[1,2/] permits to increase sharply the productivity of taking and recording the co-ordinates. However, such devices are rather complicated and expensive. One of their drawbacks is that the reconstruction of the space co-ordinates of a track with introducing the corresponding corrections takes about half the time necessary for calculation of interaction event. By means of automatic devioes it is diffioult also to evaluate the photographs obtained under conditions of high background or high particle density.

Below the discription is given of a semi-automatic stereocomparator which makes it possible to measure simultaneously three co-ordinates (x,y,z) with automatio punching them on tape and to observe the space picture of track location.

D i s i g n

The principle of the described comparator's operation is that the reference mark is projected on the film with track images through the same optical system and observed through stereomagnifier[3/]. The mark can move in space along the x,y,z, axes. Co-ordinates of any track point are determined from the mark location in object space after superposing its image on the film with a track point. The optical diagram of the device is given in Fig. I. The application of the same optical system which was used in photographing, permits to compensate automatically the optical distortions and, thus, to save one from the necessity of introducing the corresponding corrections*. The advantage of the method is that the measurements are made in the object space and the requirements in the accuracy to a measuring system is ten times lower than those at measurements made on the film.

The device is schematically shown in Fig.2. The main parts of the device are: 1) The screen with mechanizm which move it along the x,y,z co-ordinate axes and pickups of digitiser reading systems; 2) the front panel of the device with a camera, stereomagnifier, buttons and direction control handle; 3) electrical and electronic systems for reading out the co-ordinates with punching them on tape as well as for necessary commutation of the electric circuits.

The screen (II) with the reference mark is mounted on a movable stage (16) which within ± 180 mm can move along the axis X. The guides of the stage are fixed on the other carriage (18) which can move along Y within the same limits. The screen weight and the parts (16) and (18) are balanced with the aid of a load operating by means of a cable and a block (19).

The system of a screen motion along the x and y axes is mounted on the carriage (13) moving on rails along Z within ± 75 mm.

The carriages move with the aid of screws (12), (15) and (17). The screw of the coordinate z can be fasten at any part of a shaft (21). This permits to evaluate photographs taken at 400-1000 mm distance. The screws are rotated by electromotors. To exclude the possibility of inertial motion of carriages after the motors were shut off, the brake electromagnets were automatically switched on. All the motors of the device are controlled with the handle (8) permitting to start the motors in any combinations. The speed of motor rotation is changed by a foot pedal.

The use of a cut-nut makes it possible to use a screw in a digitising reading system

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* This method may be used in evaluating stereophotographs obtained in bubble chambers. The reference mark in this case must move along the axis Z in a vessel with liquid of the same index of refraction as that used in the chamber.

as in this case it is possible to remove completely the clearance in the nut-screw system. The lead screws are directly coupled with disc-type rotary digitisers modulating the light falling on the photodiode (22).

The reference mark is projected from the screen on the film by means of a camera (5) mounted on a rotating tubus (7). The rotation of the tubus with a camera is provided to turn the co-ordinate system, if necessary, with respect to track images, i.e., to direct one of the axis along a track chord, thus providing fast determination of the track curvature by measuring three track points.

The photograph with the projection of a reference mark is scanned with a stereoscopic viewing system with a magnifier (3). A film (4) is fasten to a glass plate supplied with a spring clamps which provide close fitting of the film to the objective glass of a camera. For the rapid and perfect adjustment of the film in the camera the glass plate with the film fastened on it can move with the aid of screws(2). To obtain the uniform illumination of the frame the objective glass of the camera was replaced by an identical glass with a opaque surface.

A frame is illuminated with 13 green luminescent lamps mounted behind the opaque glass of a screen (II). The application of a lamp with green light makes it possible to work in a spectral region which is the most favourable for observation.

The read out devices of a comparator are the reversible electron counters which count the number of pulses from photodiodes. The block-diagram of the device for the reading out of one co-ordinate is given in Fig.3.

The counter is the four-discharging reading circuit assambled on decatrons 10-CГ-I(OE -1). Their maximum stable counting rate (5-8 kcs) is quite sufficient for the selected speed of the screen displacements. Each decatron is controlled with the aid of two univibrators: one for addition and the other for subtraction (Fig. 4). To determine the direction of the carriage motion, two photodiode are used. The second diode is placed in such a way that its pulse is displaced in phase with respect to the first diode as much as the half of its duration. The principle diagram of this assembly is shown in Fig. 5. The counter is supplied with a device determining the sign of a number (Fig. 6 and 7). This allows to start the counting at any point. The starting of the counting at the point of interaction makes the analytical calculation rather easier, since the purpose is to calculate spiral lines coming from the origin. Besides, the superimposing of the reference mark with interaction point after scanning every track permits to carry out fast control of the circuit operation. The counter's decatrons are mounted on the front panel of the device(9). This makes it possible for an operator, if necessary, to take the reading out easily.

To feed the data into an electronic computer "Ural" the information written on counters can be automatically punched on tape in a binary-decimal code through the block of the operating memory system (Fig. 8) mounted on a gasdischarged lamps MTX-90[4]. The data of three co-ordinates are recorded into the block of the memory device during 0.1 sec. The recording of the data from all decatrons are realized simultaneously with the aid of a generator giving 10 pulses (Fig.9). In the course of this operation the carriage motion are blocked. From the block of the memory the co-ordinates are successively fed into tape puncher through the block of the puncher's registers (Fig.10) and punched on the tape for I-1.5 sec. In inputting the data into puncher the counters of the memory device are reset to zero. The succession of the operations in automatic recording of co-ordinates are realized by the relay-circuit.

The electric part of the device and electronic circuits are mounted in the frame of the device.

The general view of the device is shown in Fig. II.

The Main Characteristics of the Device

In the model described the linearity of the lead screws was better than I micron within 200 mm length and a clearance in the whole system screw-nut did not exceed 0.01mm. This value is equal to 20% of the 0.05 mm grating and practically does not affect the accuracy of measuring the co-ordinates. More essential errors are introduced in superimposing the reference mark with a track which depend upon the magnification of stereoviewing device (in our case 5), the quality of the track image, speed of the reference mark displacement and so on, as well as upon the individual qualities of an operator.

The speed of the screen motion along the x and y co-ordinates is 10 mm/sec, and along the z co-ordinate it is equal to 2 mm/sec. To increase the accuracy of superimposing the reference mark with a track point, the speed can be decreased by switching the foot pedal to I mm/sec and 0.2mm/sec, respectively.

The measurements made showed that the mean square root error in recording the x and y co-ordinates is ± 0.I mm, and the z co-ordinates are equal to ± 0.3 mm through the whole field of image. These results are related to the photographs of the test-objects taken with the stereocamera with the objectives "Yupiter 12", 120 mm base and parallel optical axis. The frames were taken from the distance 450 mm through the glass plate 25 mm thick on the "Panchrom-X" film.

The recording the co-ordinates of 30 points per three prong star takes in the average about 10 minutes including the time required for setting up the film into a camera.

The mathematical treatment of the data obtained on the electronic computer "Ural", consisting in determining, by the least square method, the track curvature and angles between them takes about 5 minutes.

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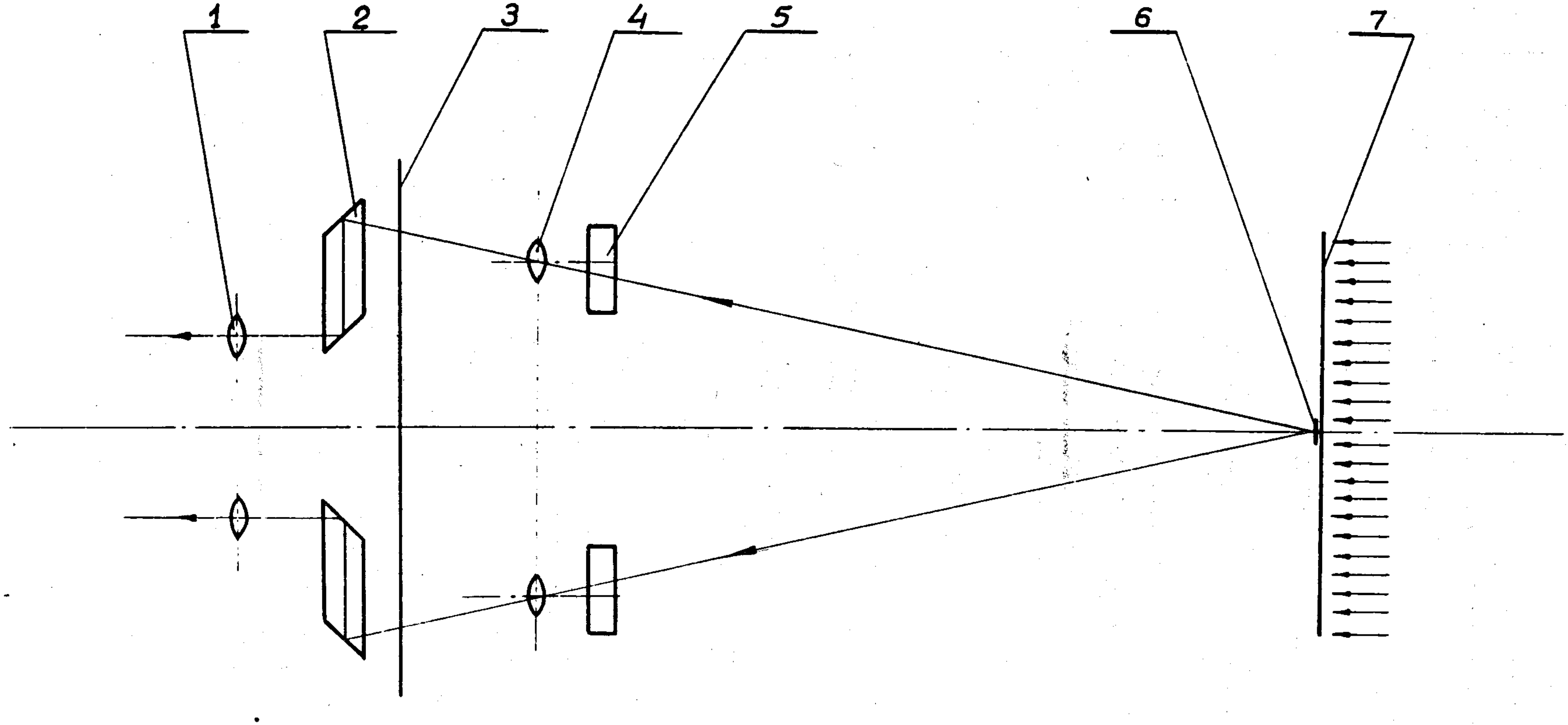

Fig. I. Optical diagram of the device.
I - the eyepiece of the stereomagnifier.
2 - the perioscopical prism, 3 - the film, 4 - the camera objective, 5 - the compensation glass, 6 - the reference mark, 7 - the screen.

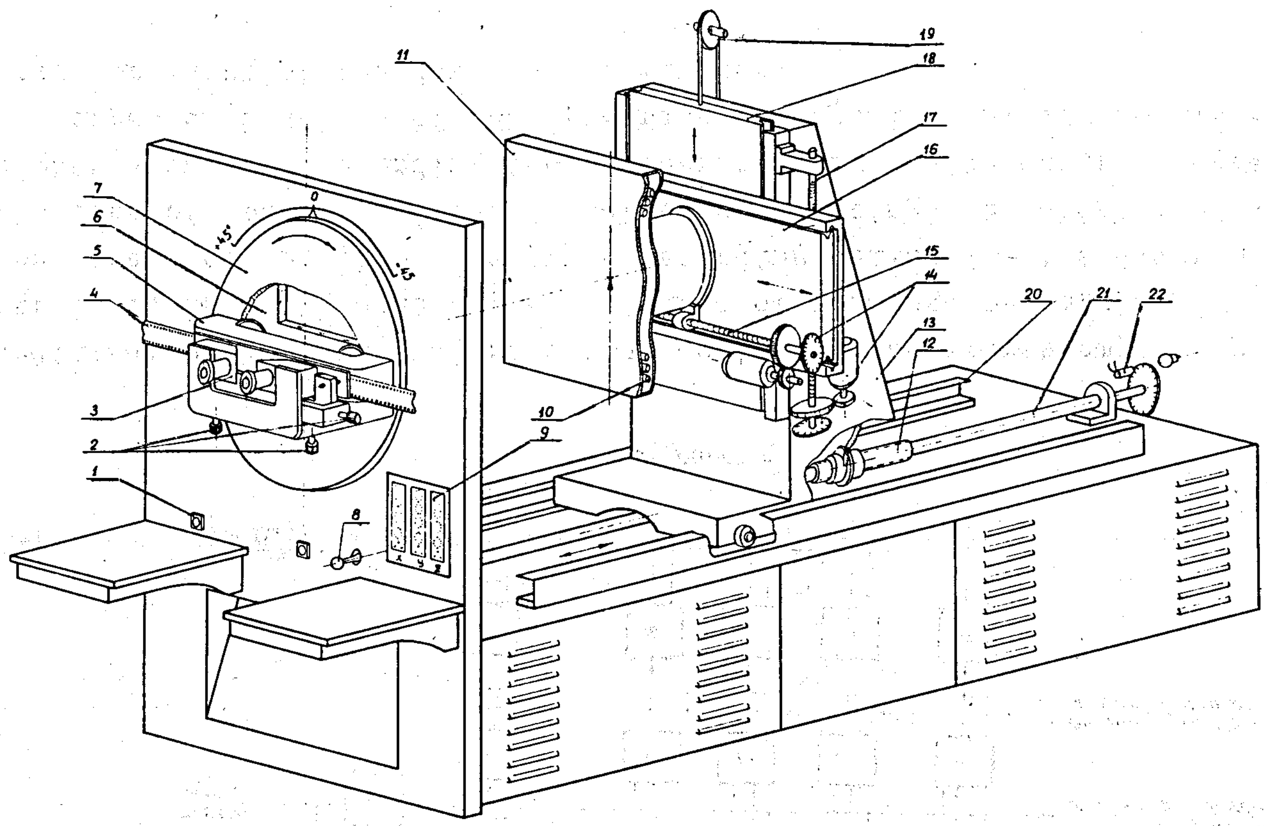

Fig. 2. Kinematic diagram of a comporator.

I - recorder button, 2 - regulating screws for adjusting the film, 3 - stereomagnifier, 4 - the film, 5 - camera, 6 - compensation glass, 7 - rotary tubus, 8 - control handle, 9 - co-ordinate counter panel, 10 - luminescent lamps, 11 - screen, 12,15 and 17 - leading screws, 14 - digitiser, 16,18 - movable carriages for driving a screen along the x and y axes, 22 - photodiode.

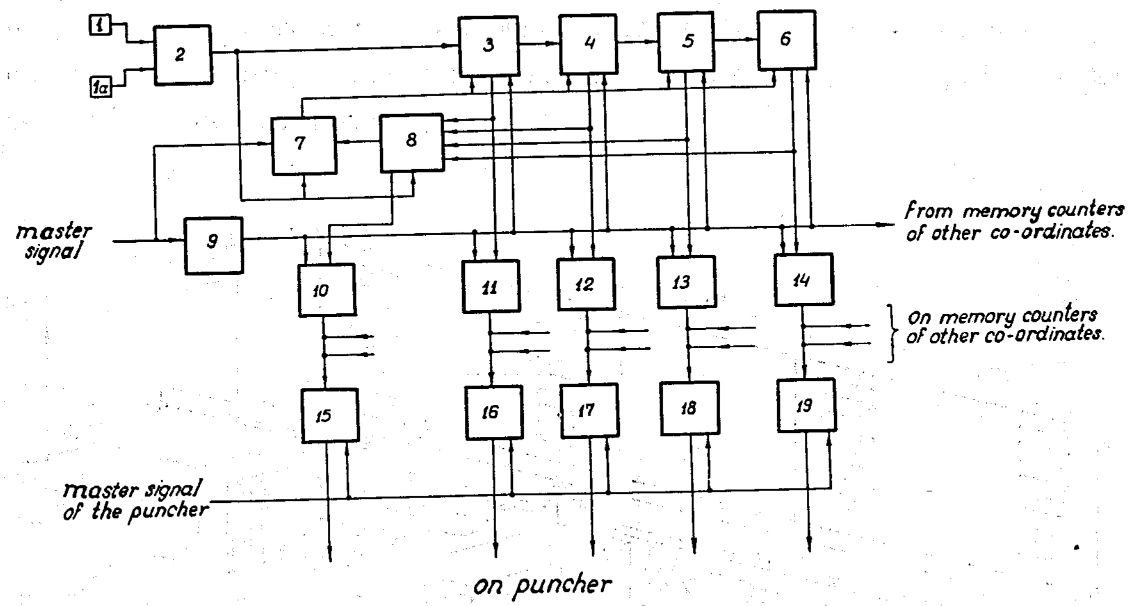

Fig. 3. Block-diagram of counting and recording device of the stereocomparator (for one co-ordinate), I, Ia - photodiodes, 2 - diagram of forming the impulses in a definite roation direction, 3,4,5,6 - decatron recording cells, 7 - the diagram of determining the sign of operation (the direction of counting), 8- diagram of determining the number sign, 9 - recording punch generator, 10 - sign memory diagram, 11, 12, 13,14 - types of counters of the operating memory, 15, 16, 17, 18, 19 - types of register for input of the data into a puncher.

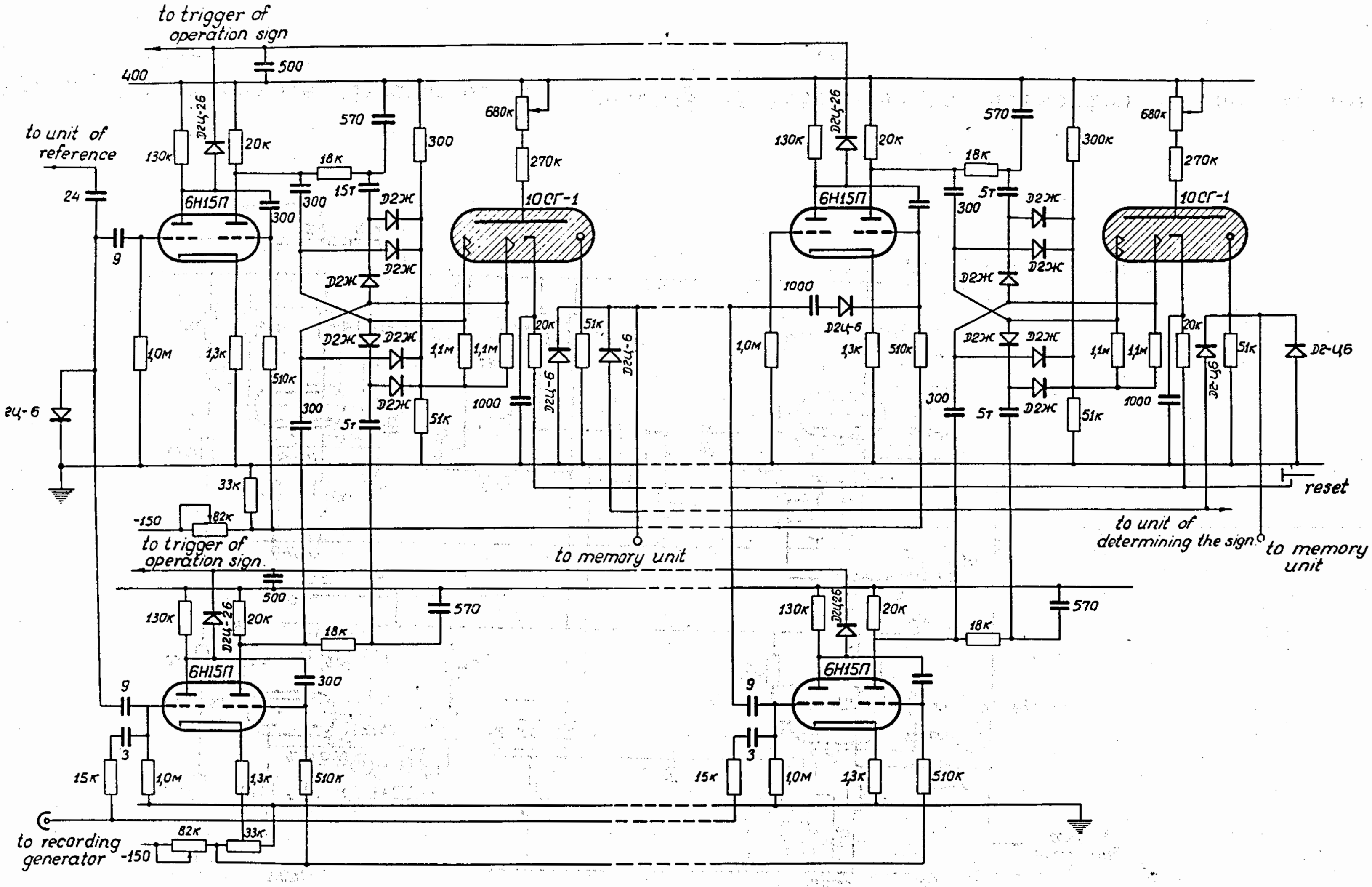

Fig. 4. The principle diagram of motion.

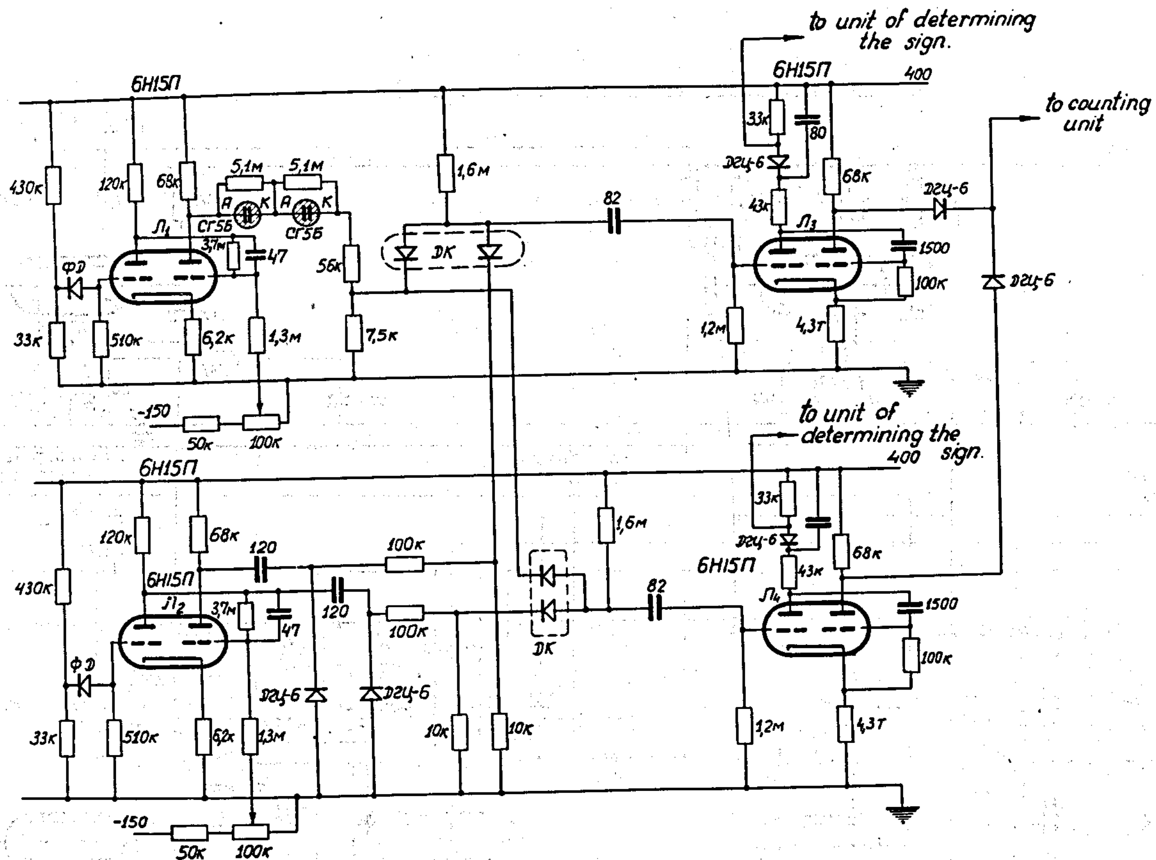

Fig. 5. The principle diagram of the assambly of determing the direction of the carriage motion.

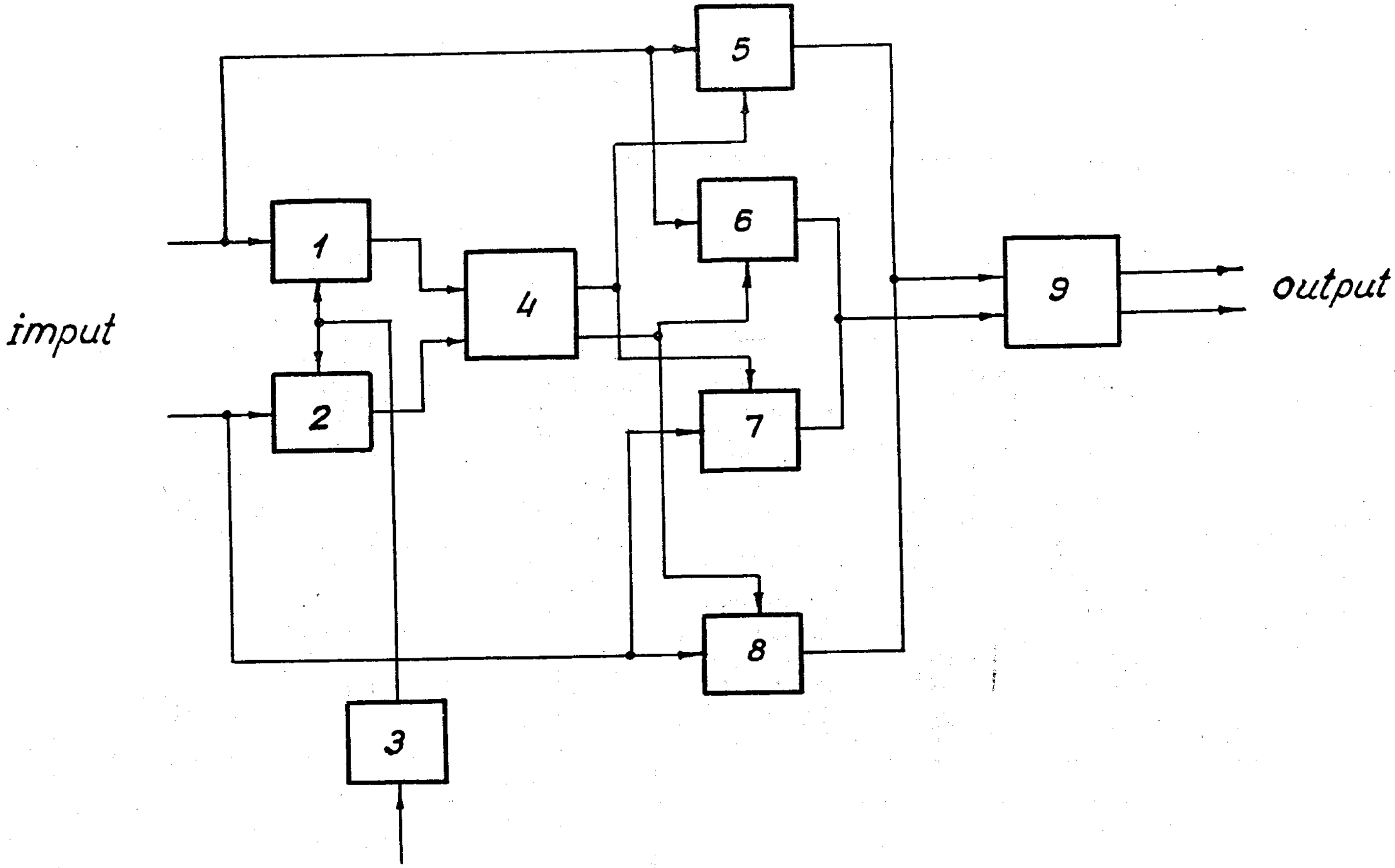

Fig. 6. Block-diagram of a cell for determining the sign of a number and an operation. 1,2 - the diagram of transmission, 3 - the indicator of decatron zero state, 4 - the trigger of the operation sign (the counting direction).

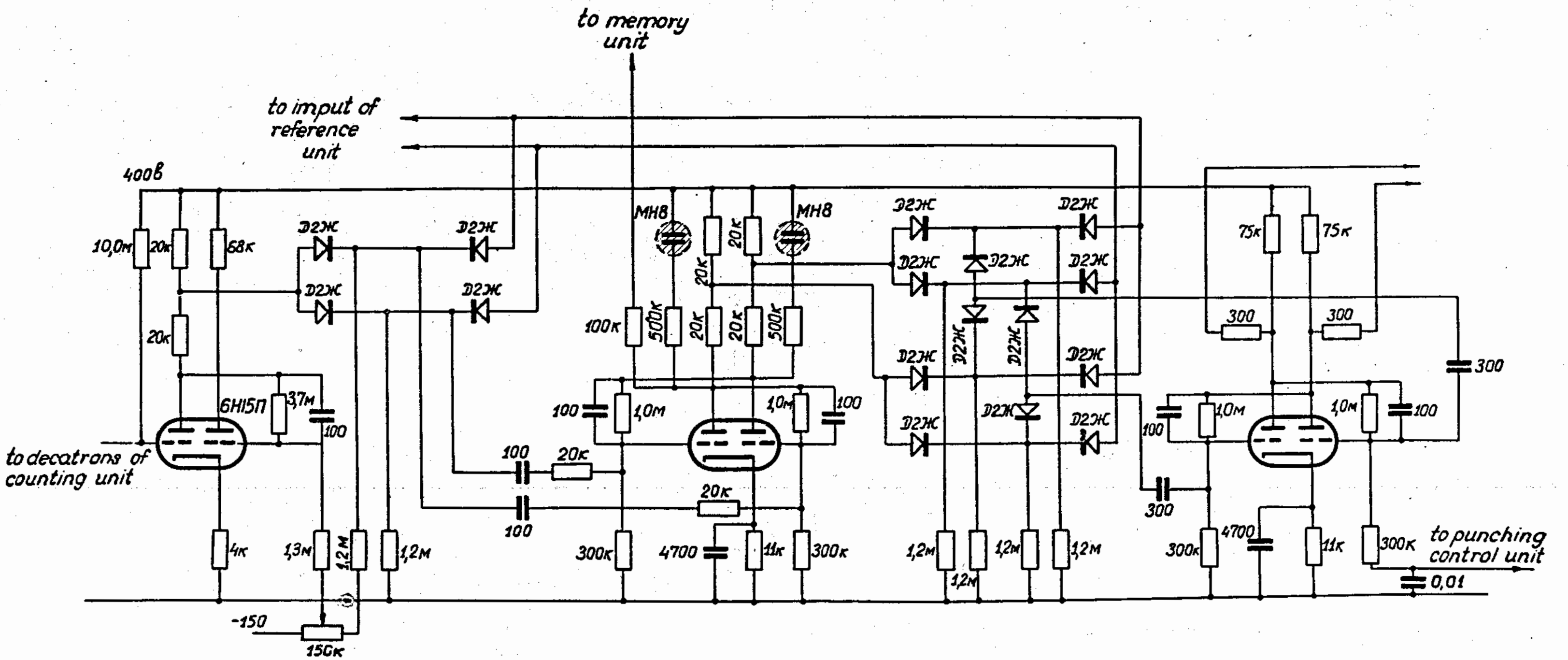

Fig. 7 . The principle diagram of a cell of determination of number and operation sign.

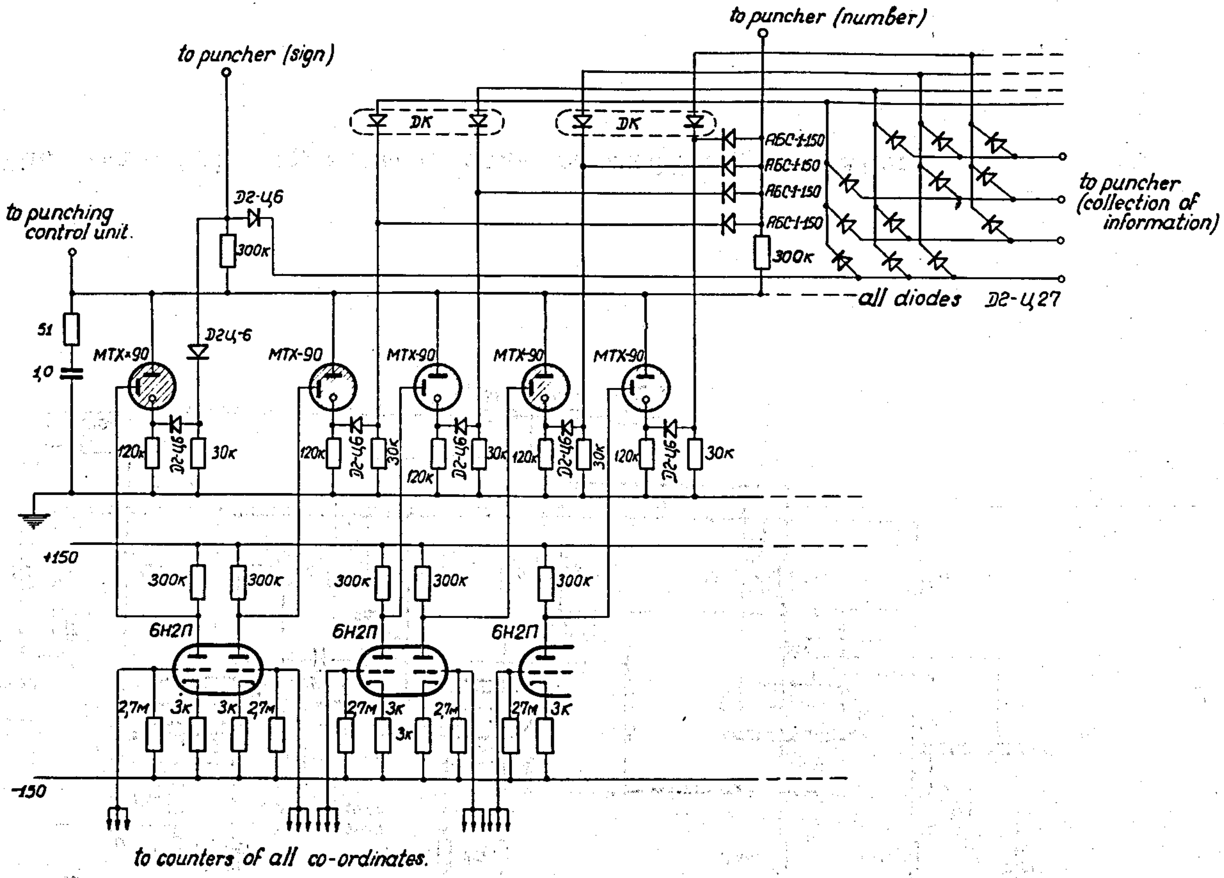

Fig. 8. The principle diagram of a cell memory for sign and type of number.

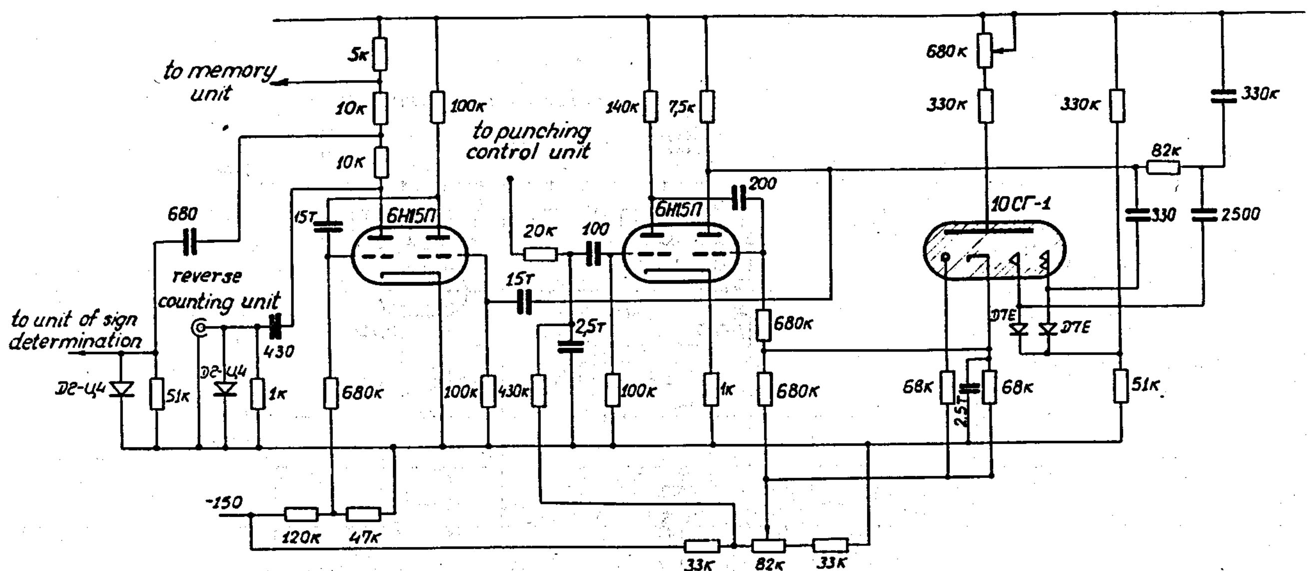

Fig. 9. The principle diagram of the recording generator.

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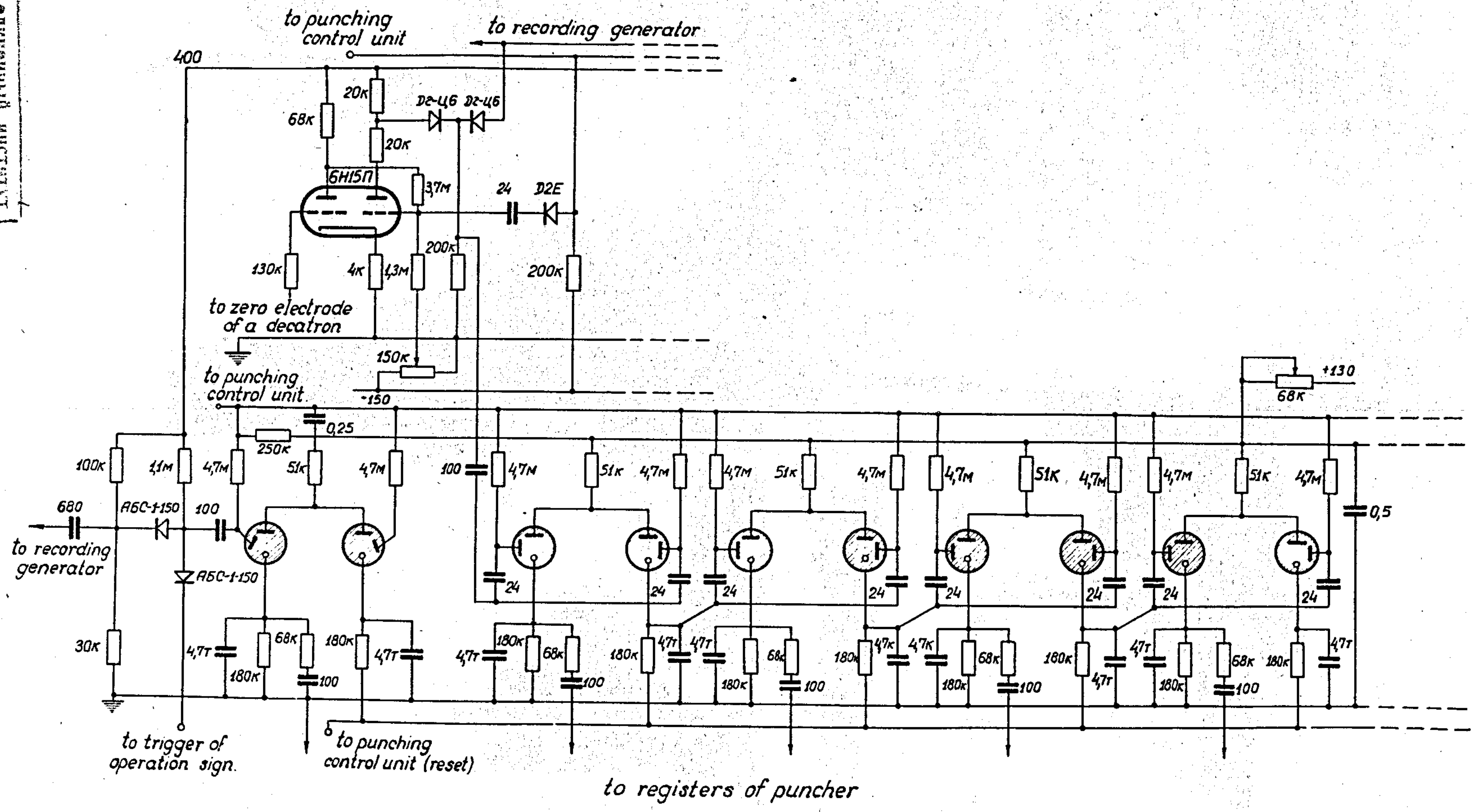

Fig. 10. The principle diagram of the register for input of the number and a sign into a puncher.

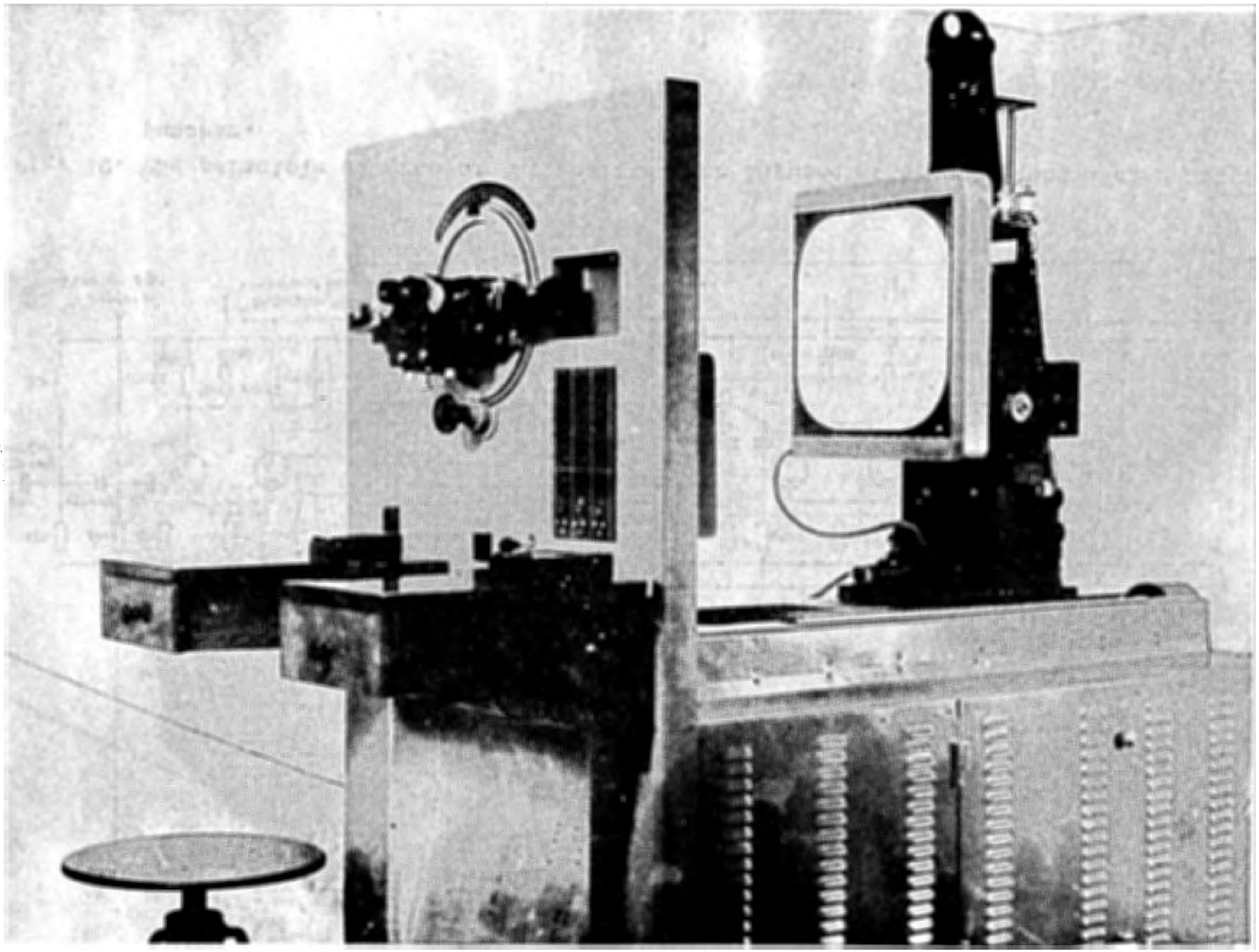

Fig. 11. General view of the semi-automatic comparator.