JOINT INSTITUTE FOR NUCLEAR RESEARCH

Laboratory of Nuclear Problems

I.M. Vasilevsky, V.V. Vishnyakov

HODOSCOPE SYSTEM OF GEIGER COUNTERS WITH CONTROLLED PULSE SUPPLY FOR INVESTIGATION π^--PROTON SCATTERING

ПТиЭ, 1960, № 2, с 58-63.

D u b n a 1959

I.M. Vasilevsky, V.V. Vishnyakov

P-287

HODOSCOPE SYSTEM OF GEIGER COUNTERS WITH CONTROLLED PULSE SUPPLY FOR INVESTIGATION π^--PROTON SCATTERING

Summary

The hodoscope system of gas-discharge counters with controlled pulse supply which was used on the synchrocyclotron for investigation of π^--proton scattering is described. The system consisted of 426 hodoscope counters. The paper gives the details of the use of such systems in some experiments made on accelerators.

* * *

In experiments on investigation of angular distributions of scattered pions the scintillation counters, thick photographic emulsions and track chambers are usually used. The two latter methods perfectly describe the event but their drawback is the difficulty in treatment of the data obtained. For the investigation of angular distributions of scattered π-mesons a method of scintillation counters is used which permits to perform investigations at considerably higher intensities of π-meson beams than it was in experiments with chambers. Most results of good statistical accuracy are obtained by the scintillation counter method. However, the disadvantage of the method is that in obtaining the necessary angular resolution one must use counters subtending small solid angles.

In investigating the cosmic radiation the hodoscope systems of self-quenching counters are used. Such systems are self-controlled and at great solid angles they make it possible to find out where the particle has passed although the continuous trajectory is not obtained. The defect of the hodoscope system is also the difficulty in treatment of the photographs which in some degree is as difficult as the treatment of photographs obtained by track chambers. However up to now the hodoscope systems of self-quenching counters could not be used for the work on the accelerator, as great errors would appear in the system due to dead time of the counters and to a high radiation background. To eliminate these errors A.A. Tyapkin[1)] suggested to realize the controlled pulse supply of counters with high voltage. He pointed out the possibility of the effective registration of particles which passed through the counters before the pulse of high voltage appeared on them with the time resolution of the order of some microseconds. The investigation of gas-discharge counters operation in the regime of the controlled pulse supply[2)] showed the possibility of the use of hodoscope system of counters in experiments carried out on charge particle accelerators. Such a hodoscope was used in the work on investigation of the elastic scattering of 300 MeV π^--mesons on hydrogen[3)]. The plan view of the hodoscope is shown in Fig.1.

Figs. 2 and 3 represent the hodoscope system device. The device consists of two parts: a control system selecting events of π^--meson interaction in a hydrogen target and a hodoscope system detecting trajectories of scattered particles. The control system consisted of scintillation counter telescope and a group of gas-discharge counters with small dead time. The π^--meson beam was selected by the telescope of three scintillation counters in coincidence. As scintillators the tolan crystals of 25 x 15 x 5 mm^3 were used. They were connected with photomultiplier ФЭУ-19 by means of a hollow light pipe with walls of aluminium foil. The fourth scintillation counter was placed behind the hydrogen target, the solution of terphenil in phenilcyclohexane (3g/l) poured into plexiglass container, measured 135 x 135 x 15 mm^3, being the scintillator. The container was connected with two photomultipliers by means of plexiglass light pipes. Around the liquid hydrogen target for detection of π^--mesons scattered at solid angle subtended by hodoscope counters, the fast gas-discharge counters were placed (Fig.3)[4]. Their cathodes 10 mm in diameter and 0.15 mm thick were made of stainless steel. The molibdenum wire 0.1 mm thick was taken as an anode. The counters were filled with metilal vapour at the pressure 160-200 mm Hg. In the device 138 metilal counters were used which were devided into 12 groups symmetrically about π^--meson beam. The wires of the counters in each group were connected together. The counters detected π^--mesons scattered in the angular interval from 20° to 160° in the laboratory system. These counters were placed with overlapping which eliminated the registration non-efficiency conditioned by passing the particles between counters.

Fig.2 shows the vertical section of a liquid hydrogen target. The container for liquid hydrogen made of stainless steel 0.2 mm thick was devided into 2 parts: the working and the additional ones which were connected with a tube 20 mm in diameter. The working part of the hydrogen target was a cylinder 80 mm in diameter, 100 mm long, the thickness of the front and back walls being 0.1 mm. The cylinder axis coincided with the beam direction. The hydrogen container of stainless steel was surrounded by three styrofoam vessels. Evaporating hydrogen passed through the vessels cooling them. To reduce the rate of hydrogen evaporation the casing contained the liquid nitrogen was inserted between two styrofoam vessels. The target permitted 10 hour's operation with liquid hydrogen. The quantity of liquid hydrogen in the target was determined by means of styrofoam floating level. In the pass of a meson beam the target walls were of 0.6 g/cm^2 thick.

Fig. 4 gives the block-diagram of the electronic apparatus controlling the operation of the hodoscope system of counters. The pulses from photomultipliers of scintillation counters 1,2,3,4 were fed to amplifiers with distributed constants (passband is 80 mHz) and then to a circuit which registered coincidences and anticoincidences of the type (1+2+3) and (1+2+3)-(3+4) where the figures denote the numbers of scintillation counters. The coincidences of the first type correspond to π^--mesons hitting the liquid hydrogen target and the coincidences of the second type to π^--mesons interacting in the target.

The pulses from the metilal counters placed around the liquid hydrogen target were fed to amplifier-former, then to the mixer and further to double coincidence circuits. The double coincidence circuit with the resolving time 5×10^{-7} sec separated the coincidences between the pulse of the type (1+2+3) - (3+4) and the pulse with a mixer, formed a pulse controlling the operation of the hodoscope part of system. By means of 12 coincidence circuits a group of counters was separated through which a particle has passed and the neon lamps switched on*.

The control pulse triggered a high voltage pulse generator and the circuit of controlling the additional devices. The generator circuit was like that described in[2]. To increase the power of a supplying pulse eight lamps ГИ-30 were switched on in output cascade. The pulses of 0.8 μsec long with an amplitude of about 2 kV were fed from a generator to hodoscope counters.

The hodoscope counters were placed in four rows behind the control counters filled with metilal. In the first row the counters of the type MC-4 with the anode 100 mm long and 20 mm in diameter were placed and in the rest of three rows there were counters MC-6 with an anode 20 mm in diameter and 190 mm long. In all there were used 426 hodoscope counters in the device. These counters like the metilal ones were placed with overlapping. To detect the discharges in hodoscope counters the use was made of the cold cathode thyratrons MTX-90 in which the third electrode was not employed. The neon lamps were arranged on the panel in the same way as the hodoscope counters. On the same panel two neon lamps were placed as markers which made the treatment of photographs easier (see Fig.6).

Fig. 5 represents the diagram of one hodoscope cell. Usually the neon lamps did not light as the anode voltage V = 100 v was taken to be lower than that of lighting but higher than the voltage of putting out. In lighting up the neon lamp strongly shunted the load resistance. This led to high current flowing through the counter in a moment when there was the high voltage pulse on the counter as well as to the distortion of supplying pulse form. To eliminate this phenomenon the additional resistance of 10 KΩ was switched on in series with the resistance of 20 KΩ.

The circuit of controlling the additional devices fulfilled the following functions: a) put into operation the electromagnet mechanizm triggering the photoregister; b) switched on the blocking of the control pulse for 0.3 sec in the course of photographing; c) put out the neon lamps after photographing; d) made the electromechanical counter of stills placed on the panel with neon lamps work.

---

* The electronic circuit for metilal counters was taken from [4].

A camera KC-50б used as a photoregister in order to take the photographs with the aid of additional electromagnet. The turning of the image of the neon lamp panel by 90° by means of a mirror made it possible to place the photoregister below the telescope.

Fig. 6 gives one of the pictures taken at the work with a hodoscope. It represents the elastic scattering of the π^--meson on hydrogen; the recoil proton passed through two rows of hodoscope counters and stopped in a copper filter. The elastic scattering process was identified by determining the correlation between scattering angles of a meson and a recoil proton which follows from the energy and momentum conservation laws.

In treating the photographs the measurement was made of the angle Ψ between horizontal projection of the direction scattering and that of π^--meson beam, instead of measuring the real scattering angle θ. However, the difference between angles θ and Ψ is not great; so, for instance, if the scattering occured in the center of the target then at $\Psi = 20^\circ$ $\theta_{max} = 22{,}5^\circ$, at $\Psi = 90^\circ$ $\theta = 90^\circ$, and at $\Psi = 160^\circ$ $\theta_{min} = 157{,}5^\circ$. Inaccuracy in determining the scattering angle of mesons in horizontal plane at the given location of the hodoscope counters is equal to $\pm 4^\circ$.

To determine the solid angle subtended by the metilal counters the effective length of these counters was measured. For these purpose the metilal counters placed into meson beam separated by a telescope of scintillation counters with crystals 3 mm wide, moved perpendicularly to the beam. Their effective length was found to be equal to 72 mm. The solid angle overlapped by all the metilal counters for particles scattered in hydrogen target was 1.73 sterad.

For determining efficiency of metilal counters group the measurements were made at which counter N 2 was placed instead of scintillation counter N 4, and the triple coincidences of the type 1 + 2 + 3 were registered. In a hodoscope system the block at which the metilal counters were placed, was made in such a way that it was possible to rotate it around the vertical hodoscope axis with a speed of 1 turn per 6 min; the metilal counters were placed into the meson beam separated by scintillation counters. The number of control pulses was registered by an electronic recorder ЭПП- 09. The registration of coincidences of the type 1 + 2 + 3 was made by the same way. From the ratio of these two values the efficiency of metilal counters was found to be equal to 98%.

To study the efficiency of hodoscope counters, the block with these counters was turned at an angle Φ so that the meson beam passed through the hodoscope counters. The scintillation counters were located in the same manner as it was at the measurement of the metilal counters efficiency. The measurements were made at several values of the angle Φ. The efficiency was measured at different values of the constant voltage of counters and different supplying pulse delays. At the chosen constant voltage $V_0 = -$ lv the individual efficiency of the hodoscope counters at the resolving time 3 μsec turned out to be about 85%. The reduction of efficiency as compared to that obtained in investigation of one counter[2] was made due to insufficient pulse power. In future it is planned to use more powerful generator with hydrogen thyratron.

The experience of the work with hodoscope system having controlled pulse supply has shown that it is very reasonable to use the similar systems for investigating such phenomena as, for instance, the elastic scattering of π-mesons at small intensities of incident beams of the order of several particles per sec; the measurement of the recoil proton polarization in the scattering of π-mesons on hydrogen and other processes the investigation of which by the scintillation counter method would take much time of work on accelerators.

In conclusion the authors wish to express their gratitude to A.A. Tyapkin for guidance and help in the work, N.M. Kovaleva for designing the main parts of the device and Yu.D. Bayukov for help in work.

References

1. A.A. Tyapkin, Pribory i Tekhnika Eksperim. N 3, 51, 1956.
2. V.V. Vishnyakov, A.A. Tyapkin, Atomnaya energiya N 10, 298, 1957.
3. I.M. Vasilevsky, V.V. Vishnyakov, JETP (in press).
4. Yu.D. Bayukov, M.S. Kozodaev, A.A. Tyapkin A.A. Markov, A.N. Sinaev, Pribory i Tekhnika Eksperim. N 6, 30, 1958.

* * *

Received by Publishing Department on January 15, 1959.

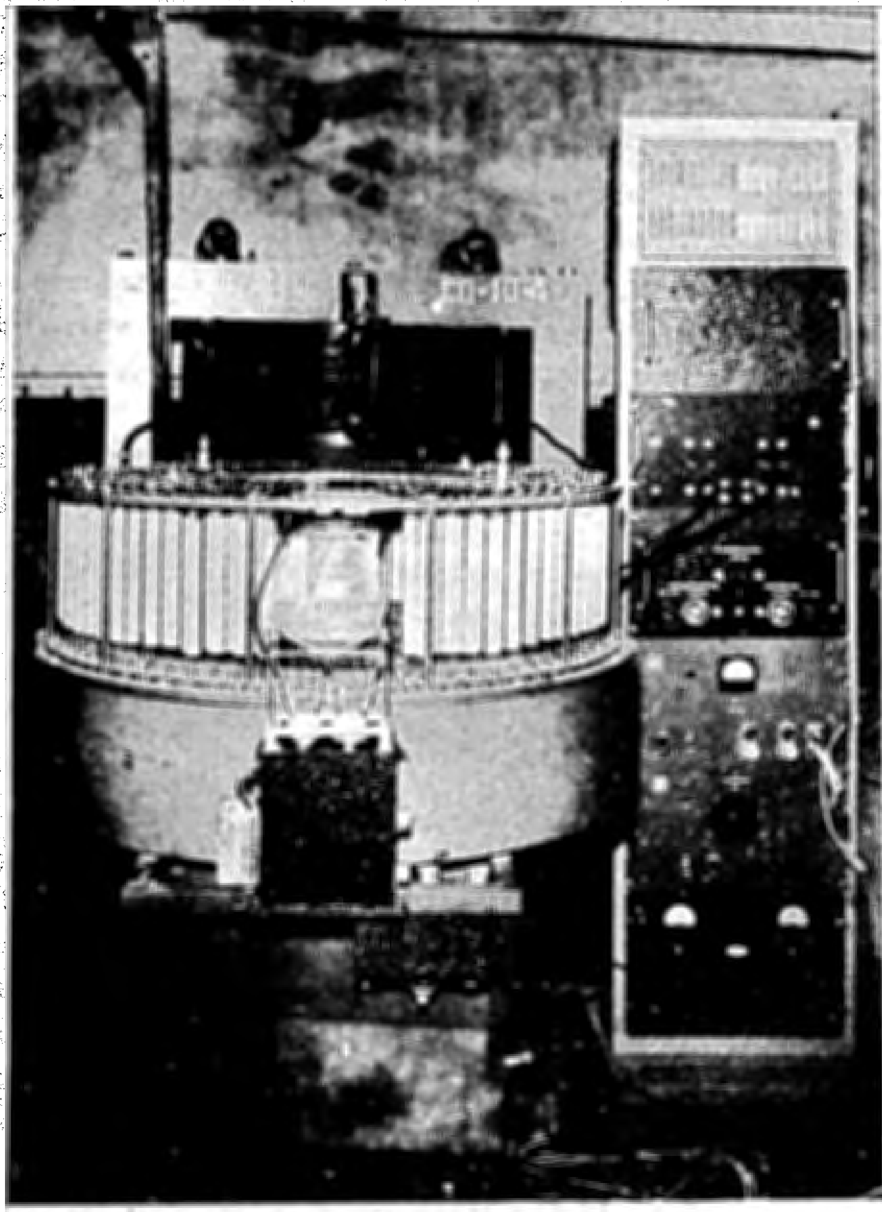

Fig.1. Exterior view of hodoscope.

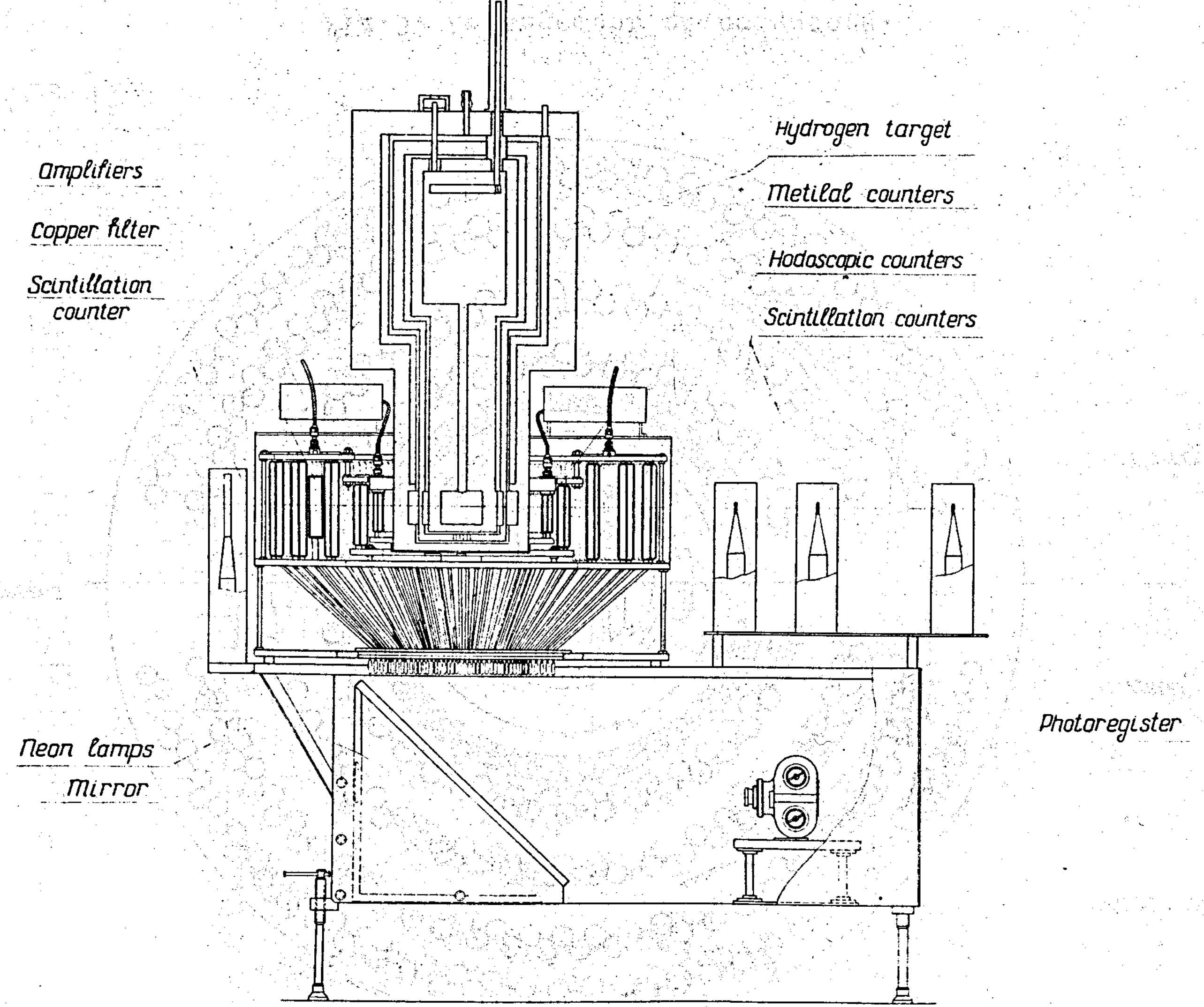

Fig.2. Vertical section of hodoscope.

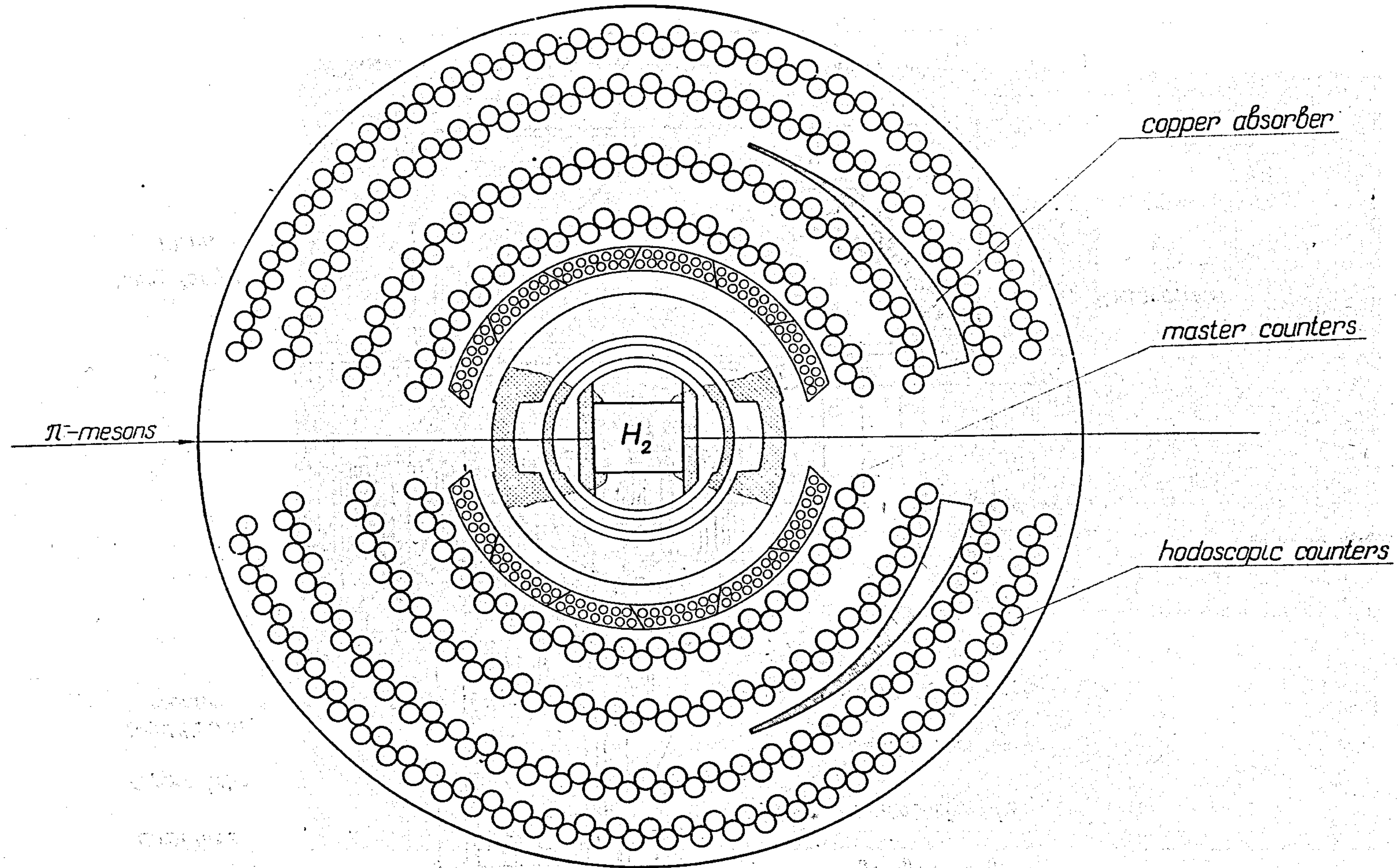

Fig.3. Arrangement of hodoscope.

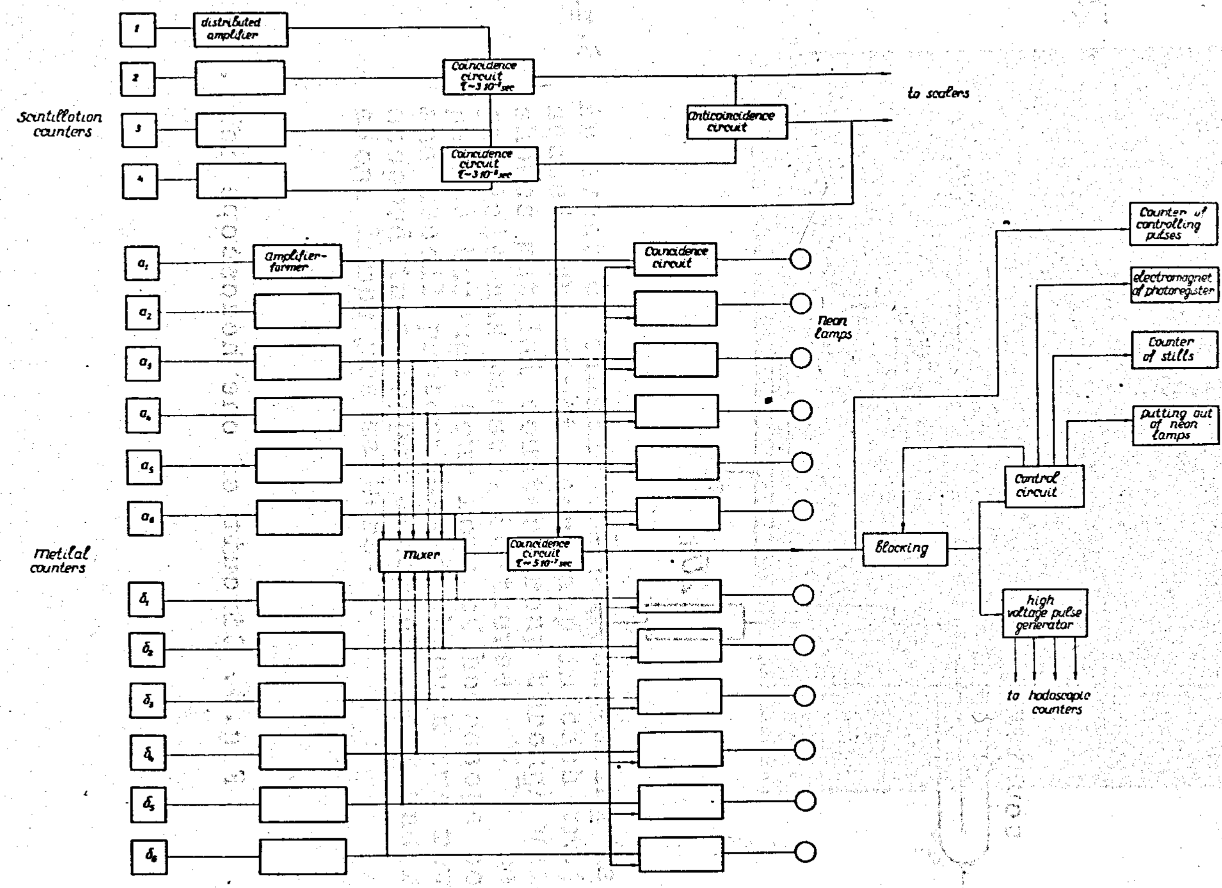

Fig.4. Block-diagram of electronic apparatus.

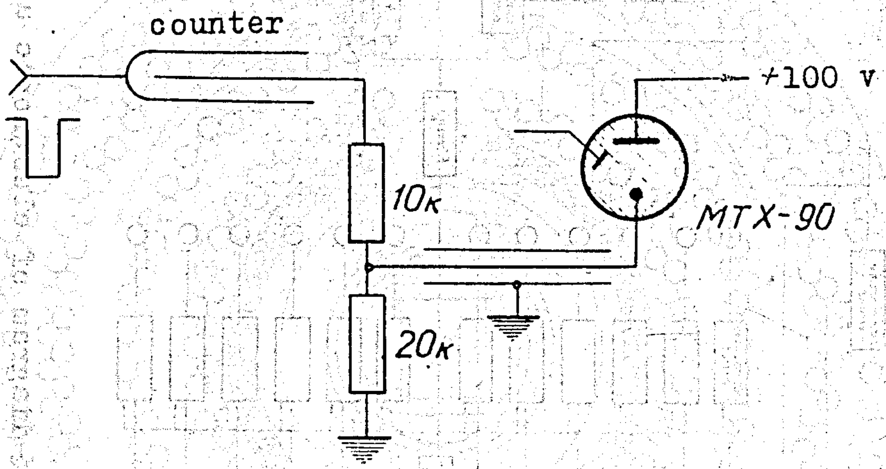

Fig.5. Circuit of one hodoscope cell.

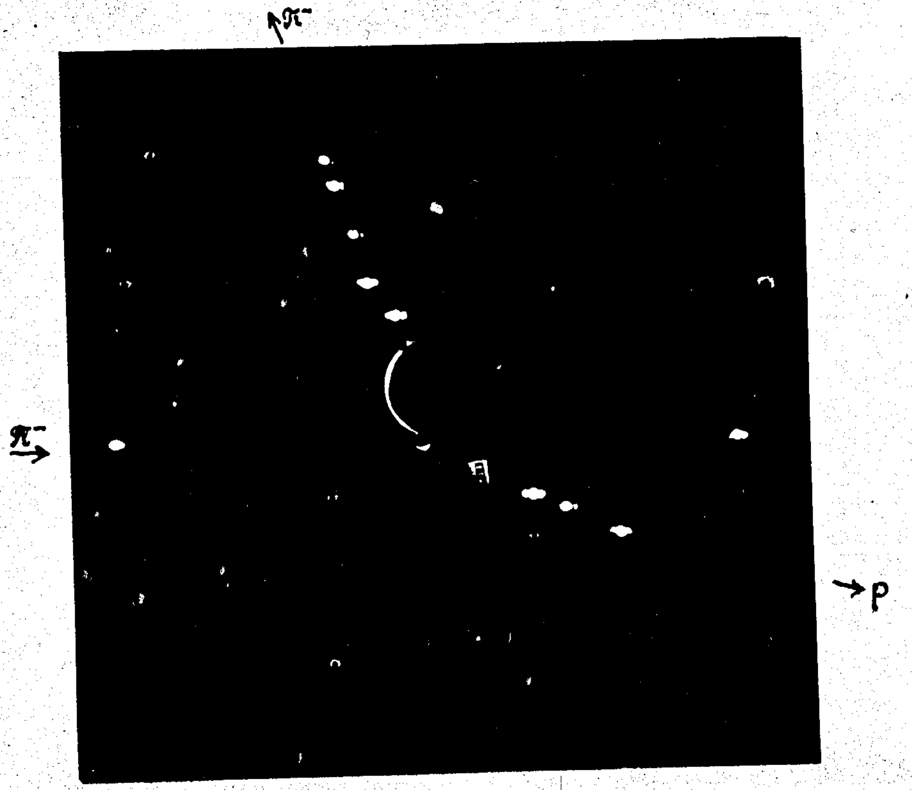

Fig.6. An event of elastic $\pi^- p$ scattering is represented. The first neon lamp in each trajectory showes metilal counter group through which a particle has passed. Scattered π^- meson passed through four rows of hodoscope counters and recoil proton passed through two rows and stopped in a copper absorber. Left and right alone lamps are markers.