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PROCEEDINGS OF THE
IVth INTERNATIONAL SEMINAR

MANUFACTURING OF SCIENTIFIC SPACE INSTRUMENTATION

USSR, Frunze, September 18–24, 1989

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INSTRUMENTS FOR STUDYING SPACE PLASMA AND COSMIC RAYS

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НАУЧНОЕ КОСМИЧЕСКОЕ ПРИБОРОСТРОЕНИЕ

ПРИБОРЫ ДЛЯ ИССЛЕДОВАНИЯ КОСМИЧЕСКОЙ ПЛАЗМЫ И КОСМИЧЕСКИХ ЛУЧЕЙ

СССР, Фрунзе, 18-24 сентября 1989

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Под редакцией В.М.Балебанова

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The IVth International seminar on scientific space instrumentation manufacturing was held in Frunze in September 1989. The Seminar was initiated by the Space Research Institute, USSR Academy of Sciences, and by the INTERCOSMOS Council, USSR Academy of Sciences.

More than 200 specialists from the USSR and other countries (including - for the first time - capitalist countries) participated in the Seminar.

These Proceedings include papers submitted to the Program Committee by the time the preparation of seminar materials for publication began.

IV Международный семинар по научному космическому приборостроению состоялся в сентябре 1989 г. в г. Фрунзе. Семинар был организован по инициативе Института космических исследований АН СССР и Совета "Интеркосмос" при АН СССР.

В работе семинара приняли участие более двухсот советских и зарубежных специалистов, в том числе впервые из капиталистических стран.

В настоящий сборник вошли доклады, представленные авторами в программный комитет к моменту начала подготовки материалов семинара к публикации.

METHODS AND FACILITIES FOR MEASURING THE PARAMETERS OF MICROCHANNEL SECONDARY MULTIPLIERS USED TO RECORD 'PACE PLASMA CHARGED PARTICLES

'.V.Apanasovich, Ye.V.Novikov, E.A.Platov, V.A.Chudovskii, A.E.Skvortsov, S.M.Sheronova, N.M.Shutte

The secondary electron multipliers (SEM) on microchannel plate basis (MCP) are widely used as sensitive detectors in the instruments intended for space studies [1-3]. It is essential that these instruments should be preliminarily tested to obtain reliable data on their main performance characteristics, to choose optimal operation modes, to predict whether long functioning of the detectors is reliable, and to develop technical requirements to the electronic instrumentation.

These problems can be solved with the help of an automated system for comprehensive studies of the MCP structures, which consists of a vacuum chamber with a sample shift device, a source of charged particles, a device for control intensity of charged particle fluxes, equipment for preliminary formation and conversion of the MCP output signals, and facilities for recording and analyzing the converted statistical amplitude and time characteristics of the MCP output pulses (see Fig.1).

The facilities for measuring statistical MCP output characteristics comprise two autonomous multipurpose systems [4,5]: 1) for amplitude and pulse duration analysis and 2), for analysis of time intervals between pulses. Coordinated interaction of these systems is provided by a common control computer (DVK-3).

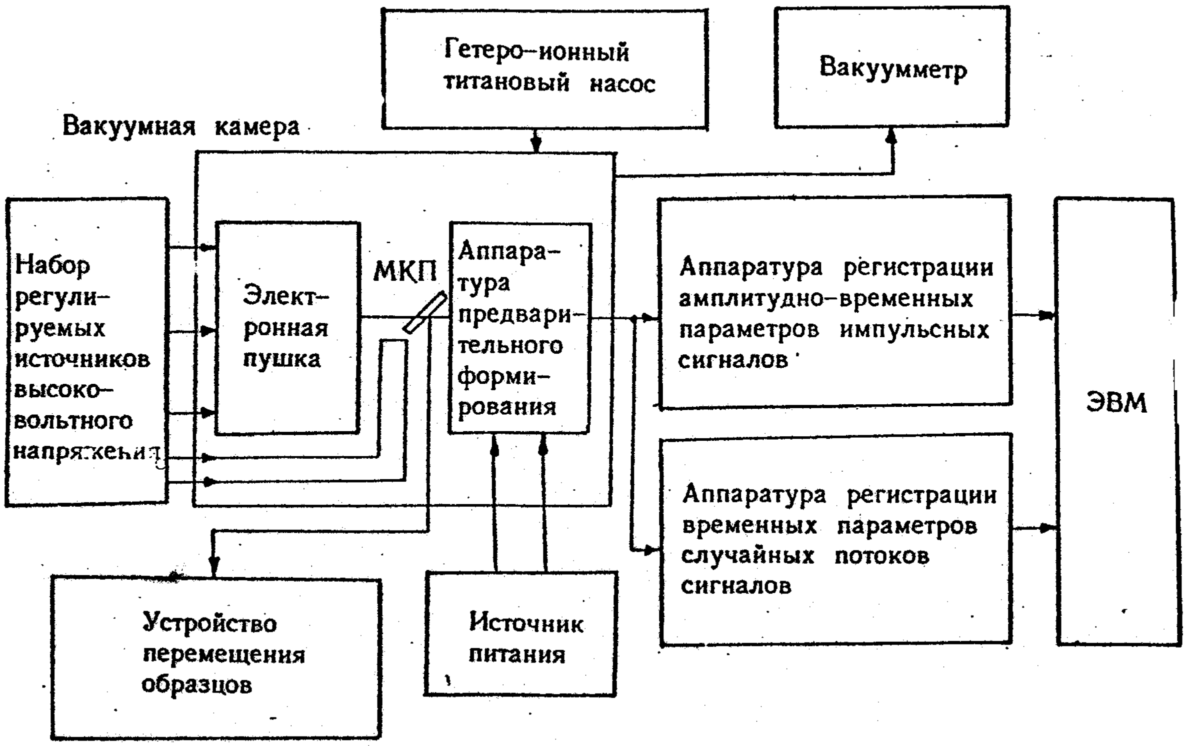

Fig.1

The first system allows recording and analyzing the amplitude and pulse duration statistical distributions at a given level of small-amplitude nanosecond-signals of the regular and random fluxes over eight channels. The dynamic range of signal amplitudes is 5mV-5V (40dB) and can be broadened to 50V (60dB) by changing the gain of the input signal amplifiers. The time range corresponds to 2 - 30ns. If the total intensity of a recorded signal does not exceed $5*10^5$ pulses/s over all eight channels the losses are about 0.3%.

At higher intensities the system operates in the "rarefaction" mode blocking at the input so that the total frequency did not exceed 0.5 MHz. The results of measurements can be formatted as distribution histograms of the main statistical characteristics (means, standard deviations, confidence limits, etc.) at the control computer outputs.

The structural diagram of the data-measurement system (ИИС) for recording and analyzing the output pulse amplitude characteristics is given in Fig.2.

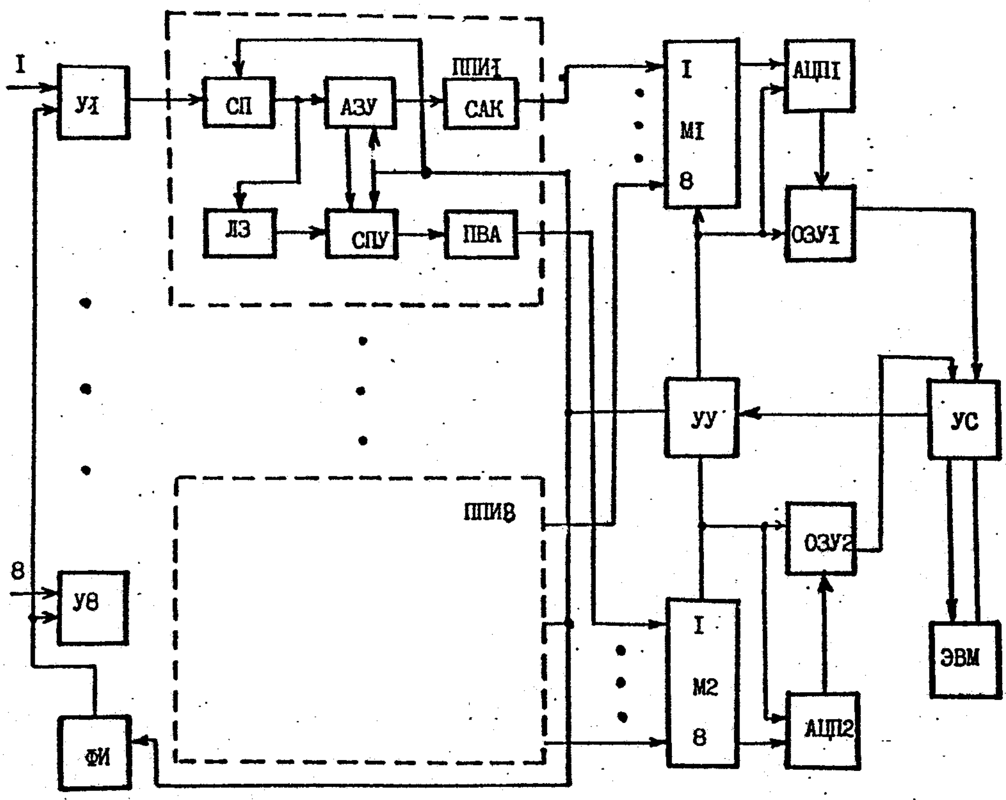

Fig.2

The ИИС includes the input signal amplifiers YI-Y8, pulse parameter converters ППИ1-ППИ8; analog multiplexers M1, M2, high-speed 8-bit analog-to-digital converters АЦП1, АЦП2 on the microcircuit 1107ПВ2; buffer main memory ОЗУ2 with 13-bit-word-capacity of 4K; standard amplitude pulse former (Ф1); control device YY and system-to-computer interface. The computer accumulates,makes processing and displays the results of measurements.

The ППИ1-ППИ8 are the main transforming devices of the ИИС,they feature a pulse gating circuit СП at the measurement circuit input; a diode-capacitive analog memory ОЗУ (for input signal amplitudes); a tracking threshold device СПУ with a coaxial delay line ЛЗ at the input, a time-to-amplitude converter ПВА, an analog correction circuit САК of the input amplitude value according to the results of signal duration measurement. The ИИС is equipped with a circuit of analog-to-digital stabilization of the converting channel parameters, which envisages algorithmic correction for the systematic components of measurement errors.

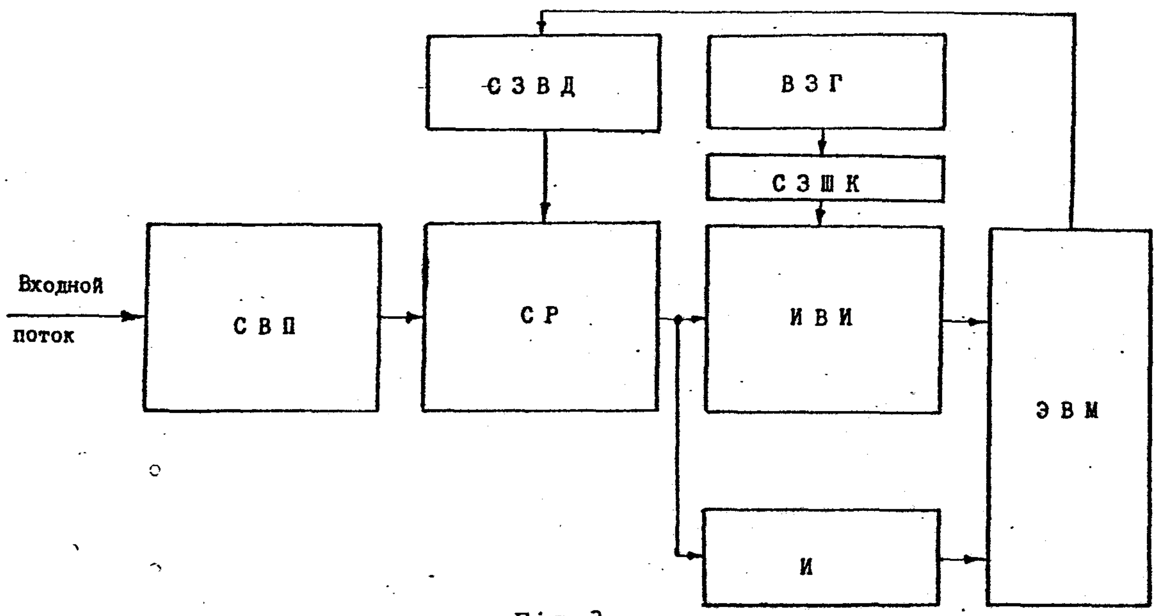

Fig.3

The ИИС experimental studies showed that the maximum error of amplitude measurements are +3.5%, of time measurements +5.5%, the temperature instabilities of total errors are 0.04% and 0.08%, respectively.

The system for recording the time (CPB) parameters of random signal fluxes is designed to measure the integral intensity of a flux and to statistically distribute the duration of time intervals between individual pulses [6]. The range of measurements is 20ns-0.1mcs, the sampling interval changes from 20ns to 10,24μs. The results of measurements are sent to the control computer.

The CPB (structural diagram is given in Fig.3) consists of a time reference circuit СВП, a pulse selector-distributor CP, a time range setting circuit СЗВД, a time master oscillator ВЗГ, a sampling interval setting circuit СЗШН, a time interval meter ИВИ of direct pulse counting type and ratemeter И.

According to the methodology of experiments and processing of their results, the software of the systems of the MCP-output signals provides the estimates of gains, time and amplitude resolutions of detectors studied and their dead time, as well as measurement of the dependences of these parameters on the operation time and conditions.

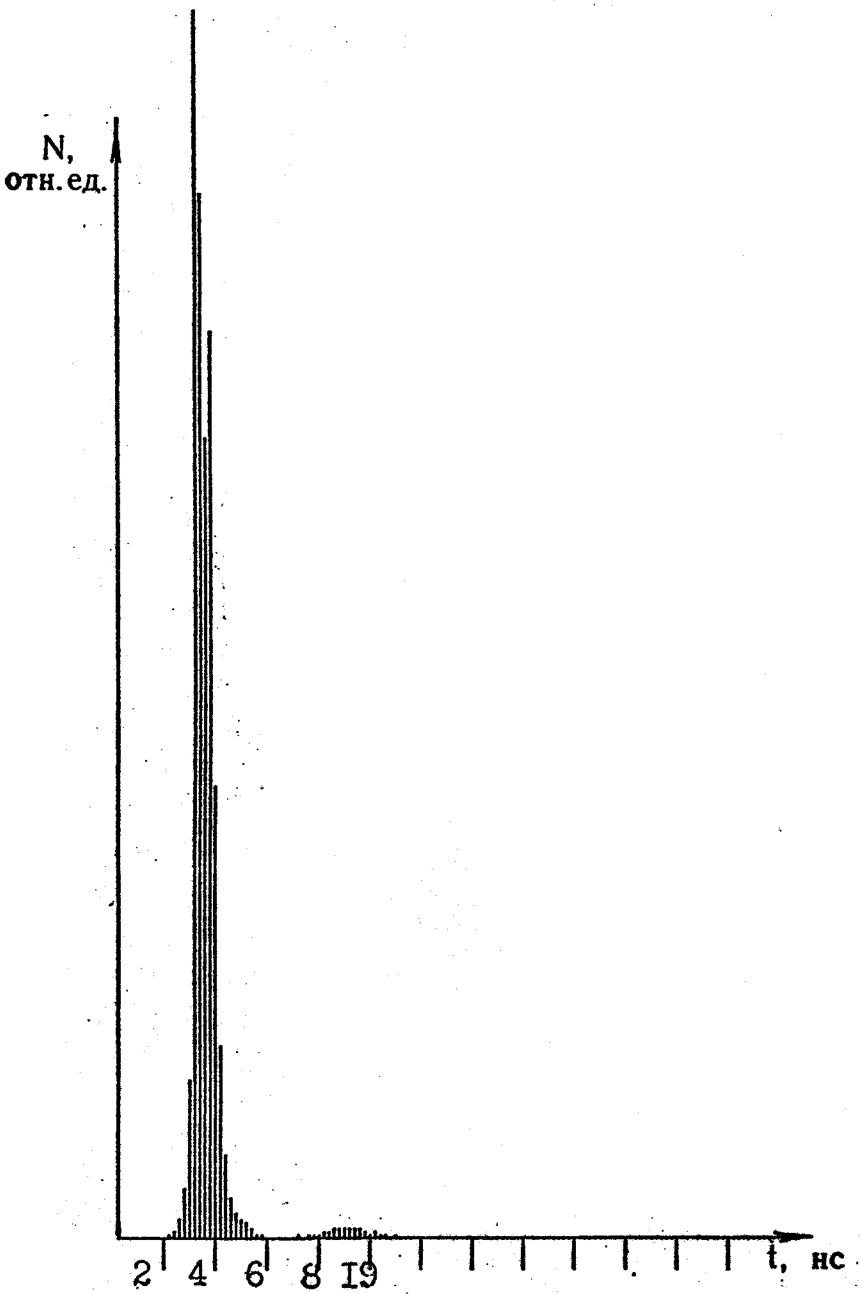

Fig.4

Figs.4-7 illustrate the results of measuring the distribution of pulse amplitudes from the MCP output and those of their duration. It is seen that with the increase in the intensity of input signals, the intensity of output signals (counting rate) increases concurrently with the decreasing amplitudes of these signals. Pulse duration ranges vary from 2 ns to 5 ns.

Since the data on the random electron flux parameters at the MCP output, needed to reliably match the sensitive element with the recording electronics, and to better understand the results of measurements, can be obtained from cumbersome experimental

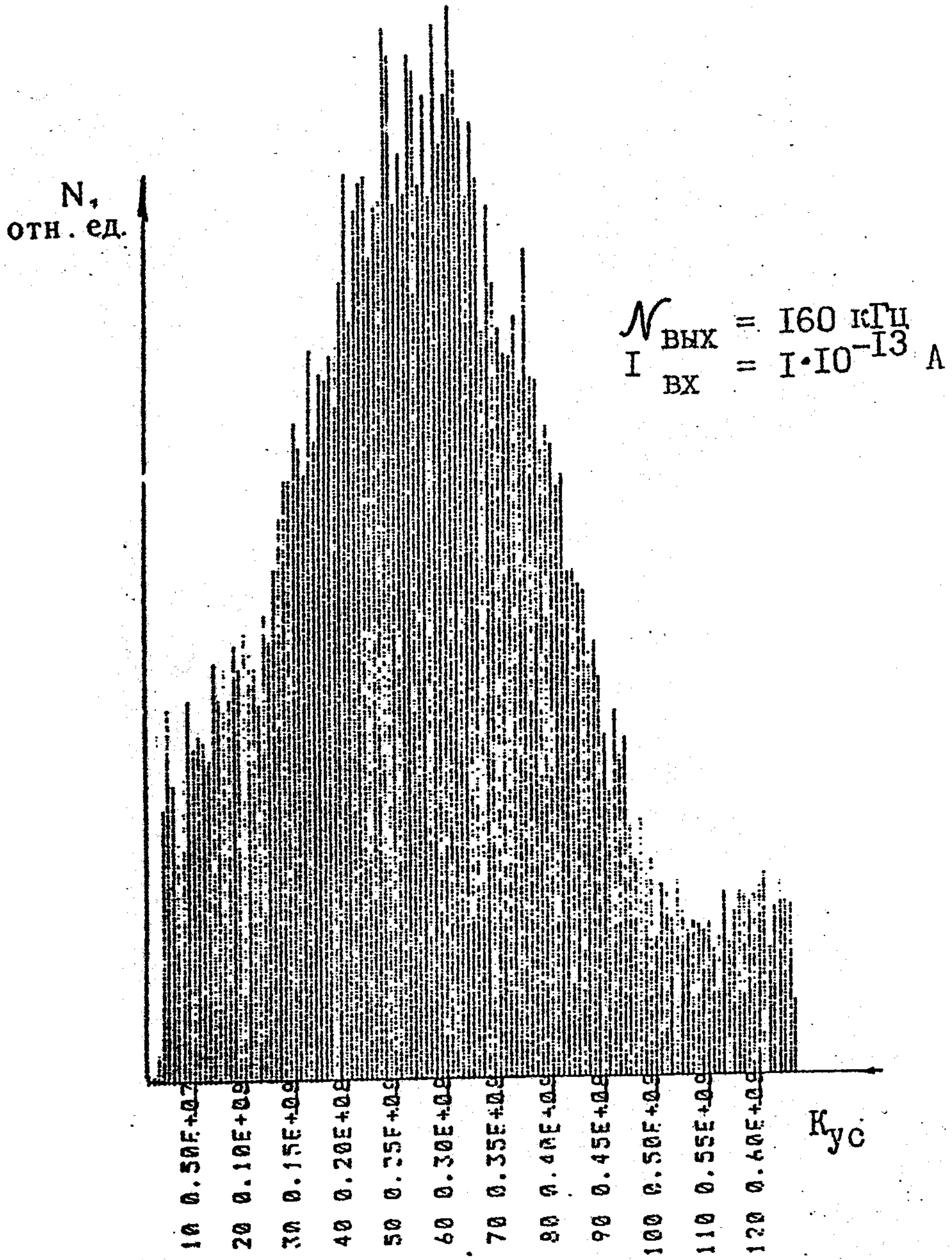

Fig.5

studies, an MCP functioning simulation model was developed and implemented, that makes it possible to reproduce the processes occurring in one channel of MCP after an electron reaches it.

This model describes electron arrival at the MCP input, formation of secondary electrons, motion of secondary electrons in the accelerating field, formation of an output signal, etc. The model makes it possible to obtain the output signal shape, the amplitude, energetic and angular distributions of electron fluxes, which characterize the detector output signal. The main parameters which can be changed in modeling are voltage on the

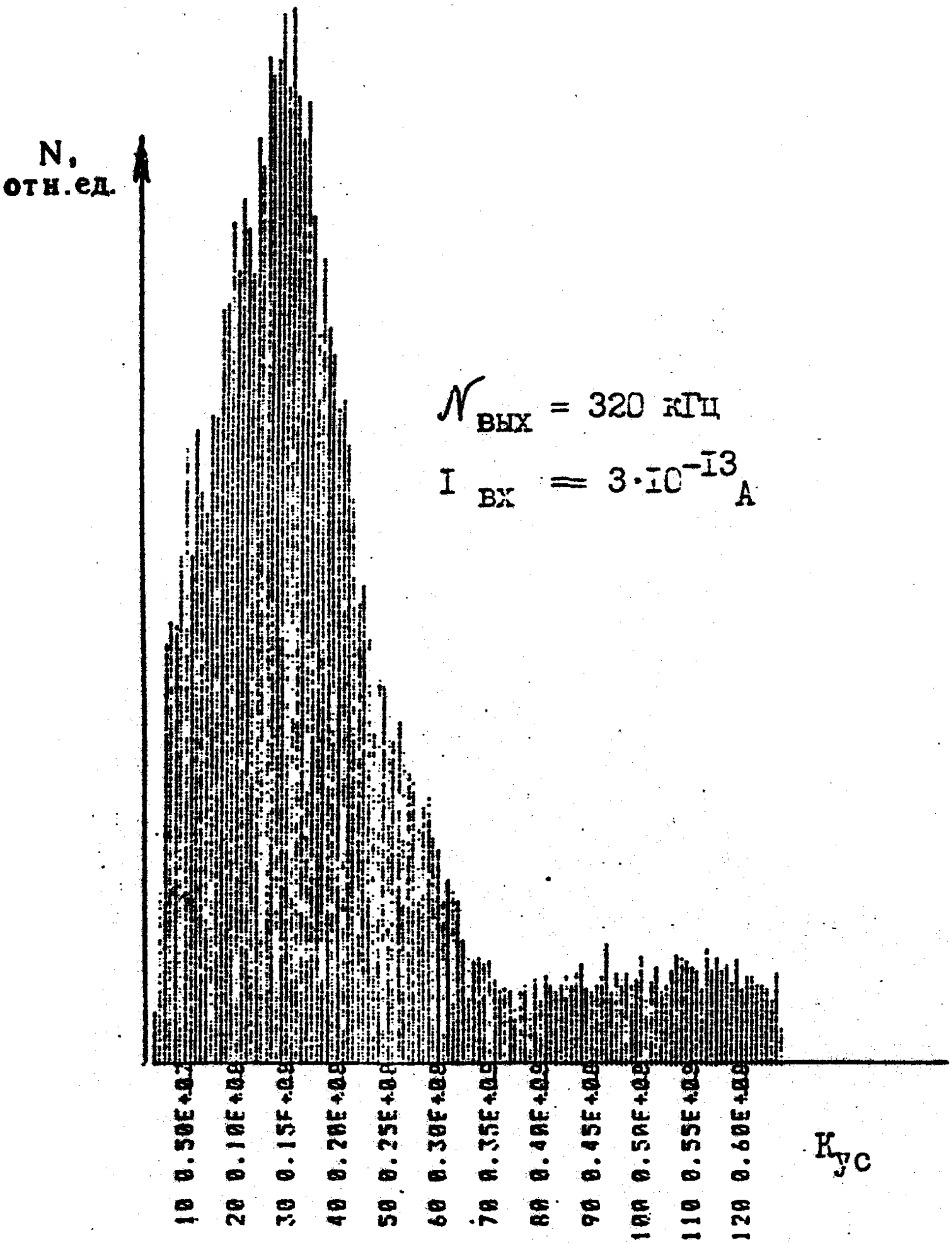

Fig.6

plate, channel size, energy and angle of incidence of an incoming electron, secondary emission character; gain, distribution laws for knocked-out electrons, their energy and angle of escape.

The model was used to carry out statistical experiments on studying the effect of MCP parameters on the output signal characteristics. A comparison of the measurement results and model presentations showed that they agree well both in the character and dynamics of amplitude distributions of the output signals, and in their angular distributions.

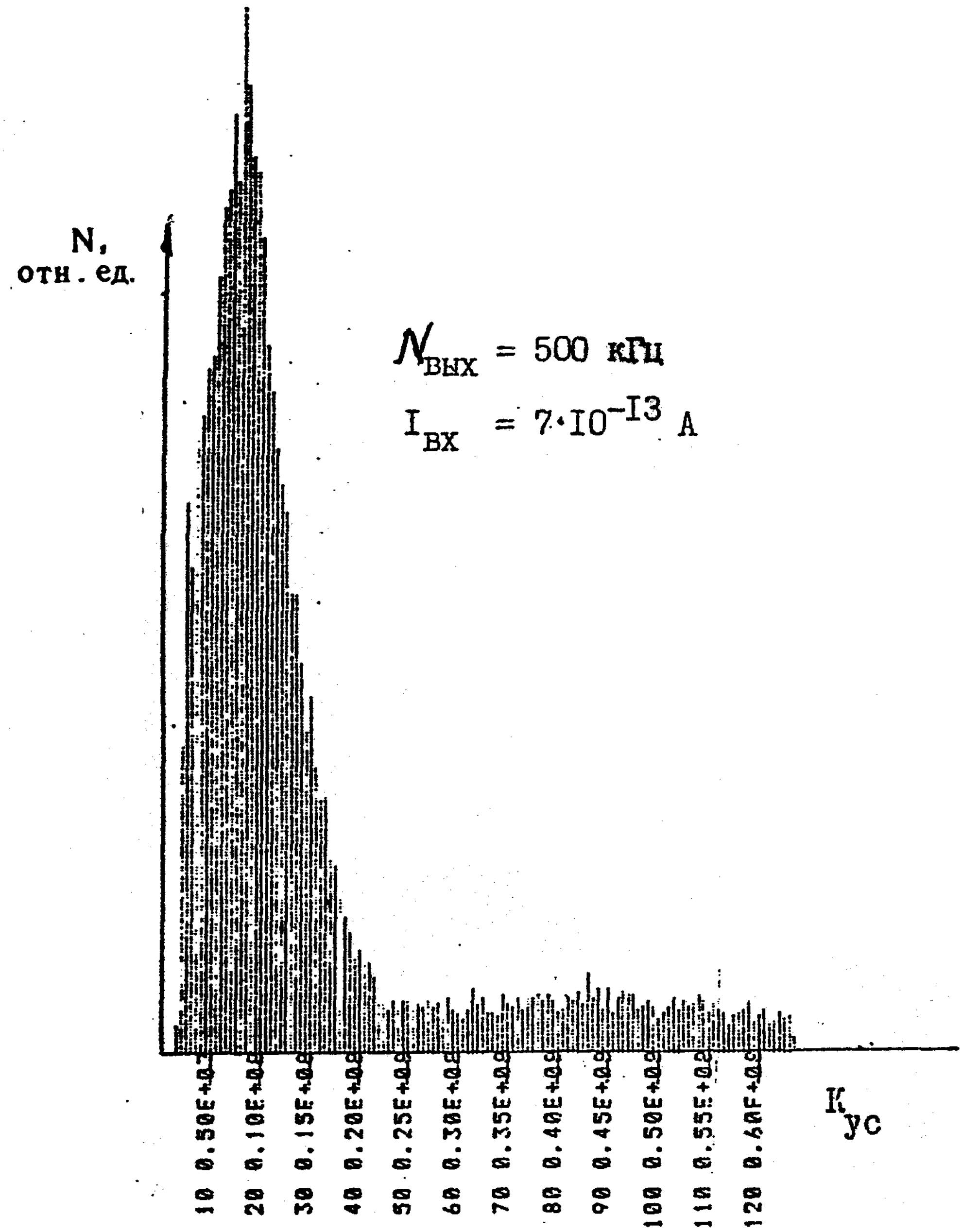

Fig.

According to the model studies the amplitude and angular distributions of electrons are enlarged as the MCP voltage grows; the maximum of angular distribution shifts towards large angles. Here the energy distribution of electrons also changes. It is characterized by an increase in dispersion with a steady maximum of density distribution near 20eV.

Figures 8 and 9 illustrate the calculated energy and angular distributions for three values of MCP-voltage with the 1mm length of the channel and 25mm in diameter.

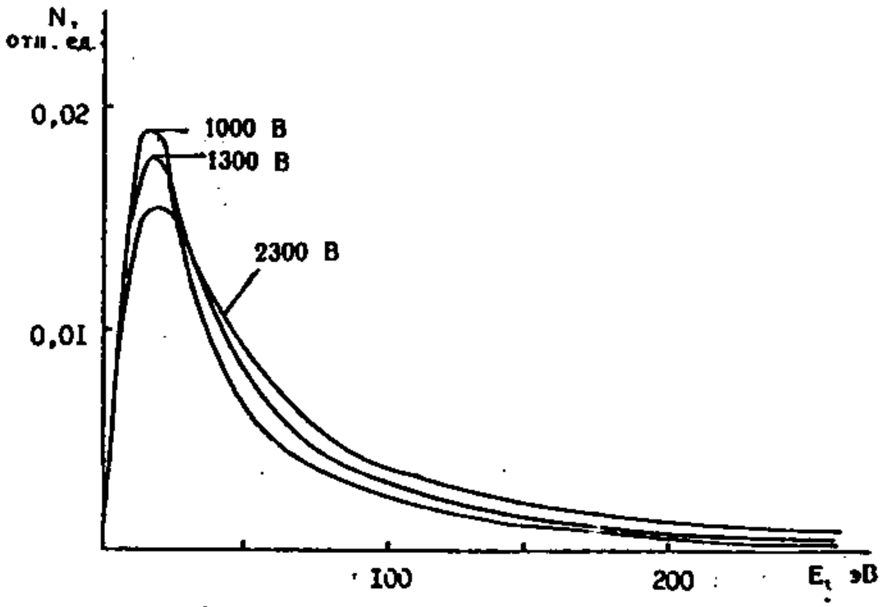

Fig.8

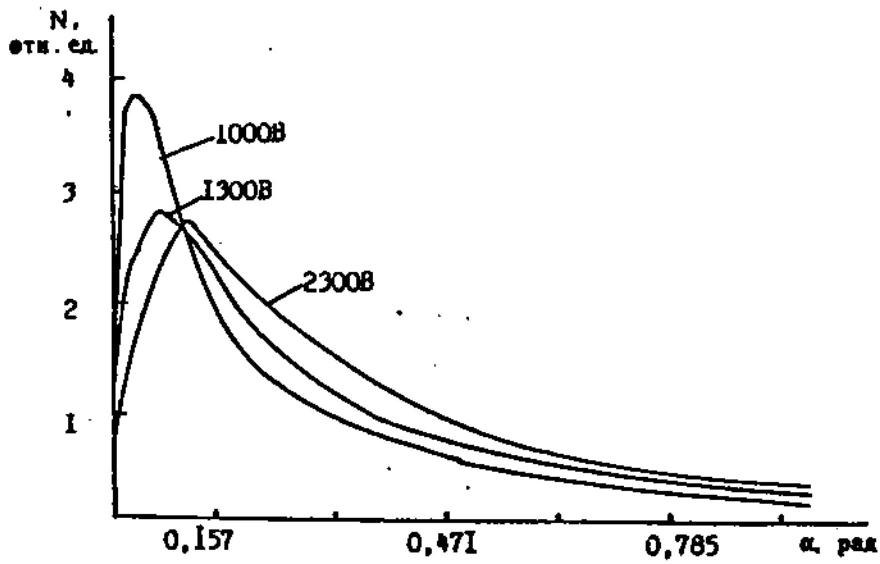

Fig.9

The results of modeling (Fig.8) show that the energy maximum of running away electrons ranges from 20 to 30eV that is in good agreement with the experimental data given in [7]. The change in angular distribution can be explained by the fact that with increasing MCP-voltage the number of electrons, running away from the region immediately adjacent to the channel end, grows.

So a set of methodological investigations and instruments has been developed that allows reliable recording and studying the

MCP signal output characteristics. The experimental data in combination with the model studies gives a better idea of the physical aspects of MCP operation and make it possible to accurately discriminate the effect of the MCP itself and of the measurement system on the output signal, i.e. to make measurements and analysis much more reliable.

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МЕТОДЫ И СРЕДСТВА ИЗМЕРЕНИЯ ПАРАМЕТРОВ МИКРОКАНАЛЬНЫХ ВЭУ, ИСПОЛЬЗУЕМЫХ ДЛЯ РЕГИСТРАЦИИ ЗАРЯЖЕННЫХ ЧАСТИЦ КОСМИЧЕСКОЙ ПЛАЗМЫ

В.А.Чудовский, Е.В.Новиков, В.В.Апанасович
Белорусский государственный университет

Н.М.Шютте, С.М.Шеронова, А.Э.Скворцов
Институт космических исследований АН СССР

Э.А.Платов
Завод "Гран", СССР

Широкое использование вторичных электронных умножителей (ВЭУ) на основе микроканальных пластин (МКП) в качестве чувствительных детекторов в различной аппаратуре космического на-