The First All-Union seminar on the theme "High-Frequency Relativistic Electronics" was organized, in accordance with a resolution of the Physical Electronics and Plasma Physics Scientific Councils of the Academy of Sciences of the USSR, by the Institute of Applied Physics of the Academy of Sciences of the USSR (IAP), the P. N. Lebedev Physics Institute of the Academy of Sciences of the USSR (LPI), and the Institute of Heavy-Current Electronics of the Siberian Branch of the Academy of Sciences of the USSR (IHCE). The seminar was held in Gorki from September 26 to 28, 1978.

Around 200 representatives from 36 scientific organizations participated in the work of the seminar, during which 43 reports and communications were presented and discussed. In his opening address the president of the organizing committee, Academician A. V. Gaponov-Grekhov (IAP), discussed promising trends and noted a series of important physical and technical problems standing before high-frequency relativistic electronics:

- the theoretical investigation of the physical mechanisms of induced coherent radiation from relativistic electron beams;
- the development of high-efficiency devices, especially those for which the theoretical efficiency is close to 100%;
- the improvement of systems for producing heavy-current beams;
- increasing the duration of the current pulse;
- development of devices operating under conditions of a periodic pulse train;
- increasing the working (optimum) currents of devices by constructing space-developed systems — at the present time the limiting current of accelerators is many times greater than the current necessary for microwave devices working on low modes;
- increasing the frequency of the radiation — of special interest in this connection are systems based on the stimulated scattering of waves by electron beams.

It was with the contemporary state of research on these problems that the work of the seminar was mainly concerned.

**Formation and Transportation of Heavy-Current Electron Beams**

As is well known, the level of development of electron-optics systems determines, to a large extent, the possibilities of high-frequency electronics. Accordingly, much attention was given at the seminar to questions of obtaining and transporting relativistic electron beams with optimum parameters.

Explosive electron emission in the diodes of heavy-current electron accelerators was reviewed by G. A. Mosyats (IHCE), who analyzed the laws of formation of centers of explosive emission in the passage of current from the cathode, cited the results of an experimental study of beam-plasma dynamics, and showed that the presence in the plasma of neutrals and the products of the cracking of hydrocarbons can determine the velocity of motion of the plasma across the magnetic field.

The present state of the art of heavy-current electron accelerators was discussed in the paper read by Yu. P. Usov [Scientific-Research Institute of Nuclear Physics affiliated with the Tomsk Polytechnic Institute (SRINPTPI)]. The reader cited the results of a study of electron guns of nanosecond and microsecond durations.
and described methods of controlling the parameters of relativistic beams. Several communications on accelerators forming electron beams of various durations (from 100 nsec to 100 μsec) were presented by co-workers of the D. V. Efremov Scientific-Research Institute.

Most attention at the seminar was given to diodes with magnetic insulation, since electron-optics systems of this sort result in an electron beam of high quality and are also promising as regards increasing the pulse duration and shortening the wavelength. The theory of magnetic guns with magnetic insulation was presented in a joint report by co-workers from the Computing Center of the Siberian Branch of the Academy of Sciences of the USSR and the Institute of Applied Physics (M. A. Gorskova, V. P. Il’in, V. E. Nechaev, et al.). The results of an experimental study of guns of this sort were described in communications by co-workers from the Institute of Heavy-Current Electronics and the Institute of Applied Physics (S. P. Bugaev, A. A. Kim, V. I. Koshelev of IHCE; N. I. Zaitsev, G. S. Korablev, B. P. Shemyakin of IAP). A number of communications on theoretical questions concerning the stability of relativistic electron beams were read by co-workers from the SRINPTPI, MIEM, and the IAP.

Mechanisms of Induced Radiation of Relativistic Electron Fluxes

The contemporary level of theoretical and experimental studies on the development of efficient high-frequency relativistic electron devices was analyzed in a review by M. I. Petelin (IAP). To date theoretical studies have already been made of the simplest variants of electronic microwave generators and amplifiers based on all known mechanisms of induced radiation of relativistic electron fluxes. All devices maintain, in principle, a high efficiency for arbitrarily large electron energies. However, as the voltage is increased, changes occur (and in some cases the changes are radical) in the similarity laws in accordance with which the optimum parameters of the devices have to be chosen. Greatest interest centers on devices based on the distributed interaction of the electrons with the high-frequency field. Increasing the beam voltage facilitates the application of surface- and space-developed electrodynamic systems, which are useful in mastering heavy currents in single-mode operating conditions. The reviewer concluded his review with experimental results.

The reports presented at the seminar discussed theoretical and experimental studies of devices based on almost all mechanisms of induced electron-beam radiation.

Devices Based on Induced Cerenkov and Transition Radiation

As asymptotic theory enabling the results of calculations on weakly relativistic O-type devices to be carried over to arbitrary electron energies was proposed by N. F. Kovalev (IAP). D. I. Trubetskov and A. P. Chetverikov [Scientific-Research Institute of Mathematical Physics affiliated to Saratov State University (SRIMPSSU)] considered transient processes and mode competition in a relativistic travelling-wave monotron.

A. N. Didenko (SRINPTPI) described the development, along with other relativistic microwave devices (carcinotron, cyclotron resonance maser), of a high-efficiency magnetron with a record power level of ~2 GW at an efficiency of ~40% operating at ~12 cm wavelength.

Under the supervision of G. I. Budker, co-workers of the Institute of Nuclear Physics of the Siberian Branch of the Academy of Sciences of the USSR (INPSB) have constructed a high-efficiency generator based on the transition radiation of a flux of relativistic electrons (the gyrocon). Co-workers of the INPSB (I. A. Shekhtman et al.) presented a series of communications on the development of high-power high-efficiency (greater than 70%) gyrocons generating in the long-wavelength part of the microwave spectrum and intended for the acceleration of beams of electrons and positrons under cw (P = 0.5 MW, λ = 1.65 m) and pulsed (P = 40 MW, λ = 0.7 m) operating conditions.

There was great interest in a joint communication by co-workers of the Lebedev Physics Institute, the Institute of Heavy-Current Electronics, and the Institute of Applied Physics (V. I. Belousov, B. V. Budkin, A. V. Gaponov-Grekhov, et al.) on the development of the first relativistic microwave device operating under conditions of a periodic pulse train.* The 3-cm-wavelength carcinotron had an output power of ~100 MW at an efficiency of ~10% and a pulse repetition frequency of 50 Hz.

*The first high-efficiency relativistic generator of coherent electromagnetic radiation, a carcinotron with an efficiency of around 15%, was developed in the USSR (Lebedev Physics Institute and Institute of Applied Physics of the Academy of Sciences of the USSR, joint experiment, 1973). Subsequently, a similar device was developed in the USA (Cornell University, 1975).