The use of semiconductors in ionizing radiation dosimeters is an urgent problem at the present time. Interest in such semiconductor detectors is determined by a number of factors. The dosimeters most widely used nowadays are those with ionization chambers. The strength of the ionization current arising in chambers of this type with the dose rates usually applied in radiotherapy (tens and hundreds of roentgens per minute) is of the order of $10^{-10}$ to $10^{-12}$ A. Such small currents can be measured directly only by means of electrometers, which require the utmost care in operation and are not always suitable for practical dosimeters. The use of ordinary measuring instruments (microammeters) for this purpose would require amplification of the direct current to not less than $10^{-9}$ A. However, dc amplifiers with an amplification factor of $10^3 - 10^4$ are highly unstable in work or are extremely cumbersome, and this limits their use in practice. Methods of measurement by means of pulse-frequency converters of small currents also are relatively complex.

Semiconductor detectors absorb more radiation than an ionization chamber and, for the same dose rate, the current generated by the radiation in a semiconductor detector may be several orders greater than the ionization current in an ordinary ionization chamber of equal volume. The need for using an electrometer or current amplifier is thus obviated. Furthermore, dosimeters with ionization chambers measure the ionization of the air resulting from the action of the radiation, and they consequently determine the exposure dose, whereas some semiconductor detectors, because of the similarity between their $Z_{ef}$ value and that, for example, of bone can be used in principle for the direct measurement of the absorbed energy.

Although dosimeters with semiconductor detectors have many advantages over dosimeters with ionization chambers, they are not yet manufactured commercially, apart from the Siemens (W. Germany) "Gammameter," which is in quantity production and is designed to measure dose rates of $\gamma$-radiation, and does not completely satisfy the requirements of dosimetry in clinical practice.

Several difficulties have arisen in the course of the development of mass-produced dosimeters with semiconductor detectors, the more important of which are their inconstant sensitivity and the fact that the readings are highly dependent on the qualitative composition of the radiation; in some cases they also possess relatively high inertia.

For these reasons, and because of the recent considerable broadening of technological work on the development and production of new types of semiconductor elements, the investigation of the dosimetric characteristics of semiconductor elements of various commercial types in order to select detectors satisfying the demands of clinical practice is of the greatest interest.
Dose rate, relative units

~7.4 rad/min • m

Fig. 2. Relationship between short circuit current and dose rate of bremsstrahlung for phototransducers of gallium arsenide located immediately below the compensating filter. 1) Transducer No. AG-9; 2) No. AG-5.

Fig. 3. Sensitivity of certain silicon transducers to bremsstrahlung (for the same dose rate). The identification number of the tested transducers is given in the columns.

This applies in particular to the study of photoelectric semiconductor transducers. They have the simplest possible measuring circuit when used as detectors of ionizing radiation dosimeters; elements of this type are in quantity production, they are widely used for non-radiological purposes, and if the results of their trials are successful, they may therefore be used in mass-produced dosimeters.

Earlier investigations of Soviet mass-produced semiconductor phototransducers based on silicon and gallium arsenide [1-3], alone and in conjunction with scintillation materials, exposed to the action of x-rays showed that with respect to several of the principal dosimetric characteristics radiation detectors based on these transducers satisfy the requirements of clinical dosimetry. This justified the study of the behavior of these semiconductor detectors under the action of the other ionizing radiations used in radiotherapy and, in particular, high-energy radiations (bremsstrahlung and electron beams). No reference to work carried out for the investigation of the dosimetric characteristics of semiconductor photovoltaic elements and of combinations of these with scintillators under the action of high-energy radiations could be found in the literature.

This paper gives the results of a study of phototransducers and of combinations of phototransducers with scintillators exposed to the action of the bremsstrahlung of a betatron working at 25 MeV.

The object of the study was to determine the possibility of using semiconductor detectors for the standard dosimeter of a medical betatron working at 25 MeV. To carry out this study the following basic characteristics of detectors in bremsstrahlung had to be determined: sensitivity, relationship between the readings of the detectors and the dose rates of radiation, the effect of the detectors on the homogeneity of the field of irradiation, the inertia of the readings, the temperature stability, and the radiation stability. However, the temperature stability of phototransducers of this type when subjected to the action of ionizing radiation has already been investigated [4], and the problem of radiation stability lies outside the scope of the present paper and will be examined separately.

The source of bremsstrahlung was a type B-4 betatron working at 25 MeV. Mass-produced semiconductor photoelectric transducers (solar cells) based on silicon (type FKD-5, dimensions 20 × 10 × 1 mm, with a base of p-type, and working surface of 1.6 cm²) and gallium arsenide (dimensions 10 × 10 × 1 mm, with a base of n-type, working surface 0.7-0.8 cm²) were used. The DIM-60 dosimeter with a normal chamber (possessing a certificate of verification) and a "Cactus" dosimeter with an ionization chamber with a volume of 100 ml and a type RM-1M dosimeter with a normal chamber were used as standard dosimeters.

The dose rate of the bremsstrahlung was determined by a "Baldwin" dosimeter with a thimble chamber, located at the depth of the ionization maximum in a water phantom measuring 300 × 300 × 400 mm with walls of organic glass (thickness of wall of the entrance window 1 mm). The maximal dose rate of the bremsstrahlung was 7.4 rad/min • m.