The mean-square error of the measured results in relation to a variation of the angle of deviation of the setting area from the vertical position was \(1 \cdot 10^{-5} \text{ m/sec}^2\) with an unexcluded systematic error of \(1 \cdot 10^{-5} \text{ m/sec}^2\). The error in the measurement of the length of arm led to an error in the results of measurement of \(0.37 \cdot 10^{-5}\) (mean-square deviation) and \(1.1 \cdot 10^{-5}\) (unexcluded systematic error). In addition to the investigators described above, other component errors in representing acceleration were studied and estimated: such as that due to thermal expansion of the arm (mean-square deviation \(1.1 \cdot 10^{-5}\)), that due to centrifugal elongation of the arm (mean-square deviation \(2.9 \cdot 10^{-5}\)), that due to displacement of the spindle in the rotor bush (mean-square deviation \(0.37 \cdot 10^{-5}\)). The total error was also determined (a mean-square deviation of not more than \(2 \cdot 10^{-5}\) with an unexcluded systematic error of \(8.0 \cdot 10^{-5}\)).

Comparison of the State primary standard with similar equipment created abroad shows that it is in no way inferior to world standards in accuracy of representing units of acceleration, while in some parameters it is actually superior.

STATE PRIMARY STANDARD OF THE UNITS OF ELECTRON
AND ENERGY FLUXES FOR ELECTRONS WITH ENERGIES
FROM 0.8 to 8.0 \(\mu\)J (FROM 5 TO 50 MeV)

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Advances in the field of nuclear physics have led to the creation of new sources of electron radiation, i.e., accelerator devices of various types. Today, electron accelerators are being used widely in medicine, radiation chemistry, and defectoscopy. Because of this, problems of monitoring and measurement of the parameters of electron beams, electron flux dosimetry and also the metrological assurance of operation in this field acquire urgent importance. For this purpose, electron radiation detectors are used (about 50 different types), constructed on the basis of ionization, calorimetric chemical, electrophysical, and other methods. Also, international recommendations for the standardization of methods and means of measuring the basic parameters of electron beams are being worked out and improved [1].

Gosstandart SSR has approved the State primary Standard of the units of electron flux and electron flux energy, devised in the I. V. Mendeleev All-Union Scientific-Research Institute of Metrology (VNIIM), intended for the reproduction and preservation of these units and the transfer of their dimensions to functional means of measurement, and for ensuring the unity of measurements in this field.

The standard comprises: a device for extracting accelerated electrons from the vacuum chamber of the accelerator; a transportation and focusing system for the electron beam; a Faraday calorimeter cylinder; a magnetoinductive transducer; an electrostatic signal electrode, and a recording and signal equipment.

The unit of electron flux (electrons/sec) in the primary standard is reproduced by an electrophysical method using two detectors (a magnetoinductive transducer and an electrostatic signal electrode) and by a charge collection method using a Faraday cylinder.

The unit of electron energy flux (W) is reproduced by a calorimetric method using the Faraday calorimeter cylinder.

The standard permits estimation of the electron flux density, the electron energy flux density, the absorbed energy in aluminum and graphite and the mean energy of the electron spectrum, and also the pulse shape of the electron bunch.

Translated from Izmeritel'naya Tekhnika, Vol. 19, No. 6, pp. 5-6, June, 1976.
A betatron type B-50/60 electron accelerator serves as the source of accelerated electrons and is equipped with an electron beam extraction system. The extraction system for the accelerated electrons comprises the accelerator chamber, a pulsed magnetic extractor, a pulsed current generator, synchronization system, and a power pack.

Noncontact detectors are used in the standard—a magnetoinductive transducer and an electrostatic signal electrode, which have a minimal effect on the electron beam and which eliminate errors due to incomplete absorption of primary electrons and the formation of charged particle showers.

The Faraday calorimeter cylinder is a combined detector, designed for simultaneous measurements of the electron energy and flux, averaged with respect to time, and also the electron flux and absorbed energy in aluminum and graphite. For the purpose of a more complete absorption of electron emission with energy up to 50 MeV, the detector is made in the form of a massive composite Al–Pb cylinder, in the inlet window of which can be inserted the electron energy flux calorimeter or an absorbed dose calorimeter.

The principal means of measuring the electron flux (magnetoinductive transducer and electrostatic signal electrode) and the energy flux (Faraday calorimeter cylinder), supplemented by a detector for the position of the electron beam relative to the geometric axis of the ion conductor and a monitor–observer, are made structurally in the form of a single device, equipped with short electromagnetic and quadrupolar lenses. Data collection is provided in the equipment from the instruments and received by a digital printout equipment via a channel of an EUM-23 digital voltmeter–transcriber.

As a result of an investigation of the standard, the random errors of reproduction were determined for the unit of electron energy flux and the unit of electron flux, and also the sources were determined and the limiting value estimated for the uneliminated systematic errors of reproduction of these units.

The principal metrological characteristics of the standard assembly are given in Table 1.

Simultaneously with the creation of the State primary Standard, the "GSI State primary standard has been devised and an All-Union calibration scheme for means of measuring the electron flux and the electron energy flux at energies from 0.8 to 8.0 pJ (from 5 to 50 MeV)."

The All-Union calibration scheme (see Fig. 1) has been designed on the basis of built-up Soviet experience on the transfer of the size of these units, the systemic approach to the metrological guarantee of measurements of the parameters of electron beams and scientific research in this measurement field.