A new method of self-calibration of the emissive power of an emissive diode is presented. The method involves determining the overall volume of the thermal and emissive power released in a semiconductor-type radiating structure in the non-steady-state mode. According to a preliminary analysis, the method possesses high metrological characteristics.

Through the use of instruments for measurement, storage, and reproduction of the radiometric unit, chief among which is the flux of the optical emission (i.e., emissive power), the field of radiometry may be divided into emissive versus receiving radiometry. In emissive radiometry, the unit which is to be reproduced is assigned to the emitting device (black body model, synchrotron, etc.). In receiving radiometry, the unit is assigned to the receiving device (hollow and cryogenic radiometer, self-calibrating photoelectric diode, etc.).

Emissive radiometry possesses important advantages by comparison with receiving radiometry. The emissive power of a radiator is an active measure; in the course of generating radiation, all the conditions needed to maintain the value of the emissive power which is to be reproduced are reproduced a priori. The response of the receiver to the radiation is a passive measure; it preserves the unit and depends not only on the emissive power of the radiator that is employed, but also on a host of other parameters (the geometry of the radiation, the instability and spectral composition of the radiation, the characteristics of the route and of the receiving surface, etc.).

In recent years, single-electron elements, such as semiconductor-type radiators and radiation detectors, have come to be more and more widely employed as radiometric devices. This circumstance may be attributed to such unanticipated properties of these types of devices as their stability, quantum efficiency, speed of response, smallness of size, and low cost. The method of photoelectric diode self-calibration [1] has been a major achievement in the field of radiometry. It was in this area that reproduction errors of less than 0.1% were obtained for the very first time. However, as it suffers from all of the drawbacks that are inherent to receiving radiometry, the method exhibits a rather high error in the transmission of the dimension of the unit to secondary measurement instruments. This circumstance is mainly due to difficulties in maintaining super-high-stability, low-divergent monochromatic radiation.

The self-calibration method using a semiconductor-type radiator, or emissive diode, lacks the drawbacks inherent to receiving radiometry. The essentials of the method are as follows. When forward-biased electric power $P_{el}^{\text{for}}$ is fed to an emissive diode, it turns into nonemissive thermal capacity $P_{t}^{\text{for}}$ and into emissive power $P_{\text{em}}$. When reverse-biased electric power $P_{el}^{\text{rev}}$ is fed to a radiator, it turns into thermal power $P_{t}^{\text{for}}$ without also producing any emissive power. If the forward-biased and reverse-biased thermal capacities released in the emissive diode are equated, $P_{t}^{\text{for}} = P_{t}^{\text{rev}}$, the emissive power is given as follows:

$$P_{\text{em}} = P_{el}^{\text{for}} - P_{el}^{\text{rev}}.$$  

Translated from Izmeritel'naya Tekhnika, No. 8, pp. 22-23, August, 1996.
The principal error of the method is associated with the error in equating the forward-biased and reverse-biased capacities and with maintaining conditions of equivalence between the thermal capacities released within the volume of the semiconductor structure.

In a steady-state, temporally continuous mode, forward-biased nonemissive power is released basically in the $p-n$ junctions, though a portion of the capacity is released in the series resistance of the contacts (around $0.05 P_{el}^{for}$) and a portion in the light-emitting portion of the crystal ($0.001 P_{el}^{for}$); some of the capacity also drains off through the current-conducting legs of the instrument. Reverse-biased nonemissive power is released in the region of a space charge adjacent to the $p-n$ junction.

Because we are able to take into account these nonequivalences in the evolution of heat and to equate the capacities through measurement of the temperature of the housing of the radiator (but not of the $p-n$ junction), we are able to maintain the error in the reproduction of the radiant capacity (emissive power) of a GaAs:Si emissive diode ($\lambda_{max} = 0.95 \mu m$) in the steady-state mode at the 0.5% level [2].

In the non-steady-state pulse mode, the heat which is released within the volume of a semiconductor-type radiator propagates along different layers possessing differing thermal conductivities and differing heat capacities as well as differing time constants [3]. If the mechanism underlying this form of heat transport is taken into account, it becomes possible to select the range of durations of the electric power pulses at which the forward-biased and reverse-biased nonemissive pulsed capacity released in a semiconductor-type radiator will be localized in the same internal space when there is no heat exchange with the environment. This will simultaneously maintain an equivalence between release of thermal capacity in the forward and reverse directions.

The temperature of $p-n$ junction and the heat which is released in it may be described on the basis of the values of the forward and reverse voltage across the $p-n$ junction in the case of a steady current. Following the action of pulses from a forward-biased capacity and a reverse-biased capacity, it is possible to maintain a high-precision equivalence between these capacities on the basis of measurements of the forward voltage.

On the basis of the foregoing principles, a method was developed and a self-calibration instrument designed based on use of an emissive diode operating in a nonsteady-state mode [4]. The method is illustrated in Fig. 1. A primary radiator is fed a sequence of rectangular, bipolar electrical pulses from a high-precision current generator (Fig. 1a). The value of $I_0$ is