PYROMETERS FOR MEASURING LOW TEMPERATURES

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The development of devices for contactless measurements of low temperatures (from 35 to several hundred degrees of Celsius) of small surface sections of objects removed to a considered distance from the measuring instrument entails several specific problems which require a special approach to the selection of the instrument's components and methods of measurement. It also becomes necessary to take into consideration small radiation levels whose maximum lies in the long-wavelength part of the spectrum.

The existing means provide the possibility of developing highly sensitive pyrometers whose readings are virtually independent of atmospheric attenuation, instability of the receiver's voltage characteristic and of variations in the gain of electronic amplifiers used in the circuit. The effect of the tested body's radiation factor on the measurement results is also reduced in these pyrometers.

Below we describe a pyrometer developed for measuring temperatures in the range from 40 to 400°C of objects located at a considerable distance (for instance up to 20 m and more) from the pyrometer. Moreover, the diameter of the surface whose temperature is measured at a distance of 10 m is of the order of several centimeters.

A block diagram of the pyrometer is shown in Fig. 1. Radiations from the measured object 1 are transmitted through the objective 2 and one or two filters 6 to the infrared radiations transducer 8. The filters have different spectral characteristics for transmitting infrared radiations. They are fixed to the obturator 5, which is rotated by the electric motor 7. The signal of the photoelectric sensing element is transmitted through the electronic amplifier 9 and processed by the converting device 10, so that the readings of the recording instrument 11 become proportional to the logarithm of the ratio of signals transmitted through the filters 6. The incandescent lamp 13, the lens 14, and the photoelectric element 15 are used for producing clock pulses which control the operation of the converting device 10.

The pyrometer assembly also contains the plane mirror 3, the eyepiece 4, and the scale indicator 12.

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From the measured Fig. 3, \( t_{\text{out}}, \) mA

\[ 0 \quad 1000 \quad 2000 \]

\[ 100 \quad 200 \quad 300 \quad 400 \quad 500 \]

Fig. 4

![Diagram](image)

From the measured Fig. 3.

\[ t_{\text{out}}, \) mA

<table>
<thead>
<tr>
<th>( T )</th>
<th>( P_{3.3-4.1} )</th>
<th>( P_{4.3-5.9} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>294 K</td>
<td>( 8.6 \times 10^{-11} ) W</td>
<td>( 2.2 \times 10^{-9} ) W</td>
</tr>
<tr>
<td>300 K</td>
<td>( 1.14 \times 10^{-10} ) W</td>
<td></td>
</tr>
<tr>
<td>320 K</td>
<td>( 2.64 \times 10^{-10} ) W</td>
<td></td>
</tr>
<tr>
<td>490 K</td>
<td>( 4.95 \times 10^{-9} ) W</td>
<td></td>
</tr>
<tr>
<td>340 K</td>
<td>( 5.47 \times 10^{-10} ) W</td>
<td></td>
</tr>
<tr>
<td>( P_{4.3-5.9} )</td>
<td>( 8.4 \times 10^{-9} ) W</td>
<td></td>
</tr>
</tbody>
</table>

\[ T = \text{temperature} \quad \text{in} \quad \text{K} \]

\[ \lambda = \text{wavelength} \quad \text{in} \quad \mu \text{m} \]

The infrared radiations transducer 8 consists of an indium antimonide photovaristor cooled with liquid nitrogen. The spectral sensitivity curves of the photovaristor are shown in Fig. 2. It will be seen from the photovaristor's spectral characteristic (curve a) that it is sensitive to infrared radiation up to \( \lambda = 5.8 \mu \text{m} \) and has a maximum sensitivity at \( \lambda = 5.3 \mu \text{m} \). This photovaristor has a high spectral sensitivity covering a wide spectrum of infrared radiations (almost up to 6 \( \mu \text{m} \)) with a sufficiently high voltage sensitivity, a low noise level, and small geometrical dimensions of the photovaristor, which makes it suitable for measuring relatively low temperatures over small sections of the measured object's surface.

The effect of the infrared radiations' attenuation by the atmosphere was taken into account in developing the pyrometer. By taking into consideration the spectral sensitivity of the photovaristor and the fact that at temperatures approaching room temperature the spectral radiation maximum of the object lies in the range of 10 \( \mu \text{m} \), the following atmospheric attenuation bands of 2.9-4.2 \( \mu \text{m} \) and 4.3-6.0 \( \mu \text{m} \) were selected as working ranges. In accordance with this the transmission characteristics of the filters used in this pyrometer were provided with the shapes shown by the curves b and c in Fig. 2. From the knowledge of the optical parameters and the spectral characteristics of the filter and transducer, it is possible to evaluate the radiation transmitted from the measured object to the transducer. If the measured object consists of a complete radiator, we obtain:

\[ T = 294 \text{ K}; \quad P_{3.3-4.1} = 8.6 \times 10^{-11} \text{ W}; \quad P_{4.3-5.9} = 2.2 \times 10^{-9} \text{ W}; \quad T = 300 \text{ K}; \quad P_{3.3-4.1} = 1.14 \times 10^{-10} \text{ W}; \]

\[ T = 320 \text{ K}; \quad P_{3.3-4.1} = 2.64 \times 10^{-10} \text{ W}; \quad P_{4.3-5.9} = 4.95 \times 10^{-9} \text{ W}; \]

\[ T = 340 \text{ K}; \quad P_{3.3-4.1} = 5.47 \times 10^{-10} \text{ W}; \quad P_{4.3-5.9} = 8.4 \times 10^{-9} \text{ W}. \]