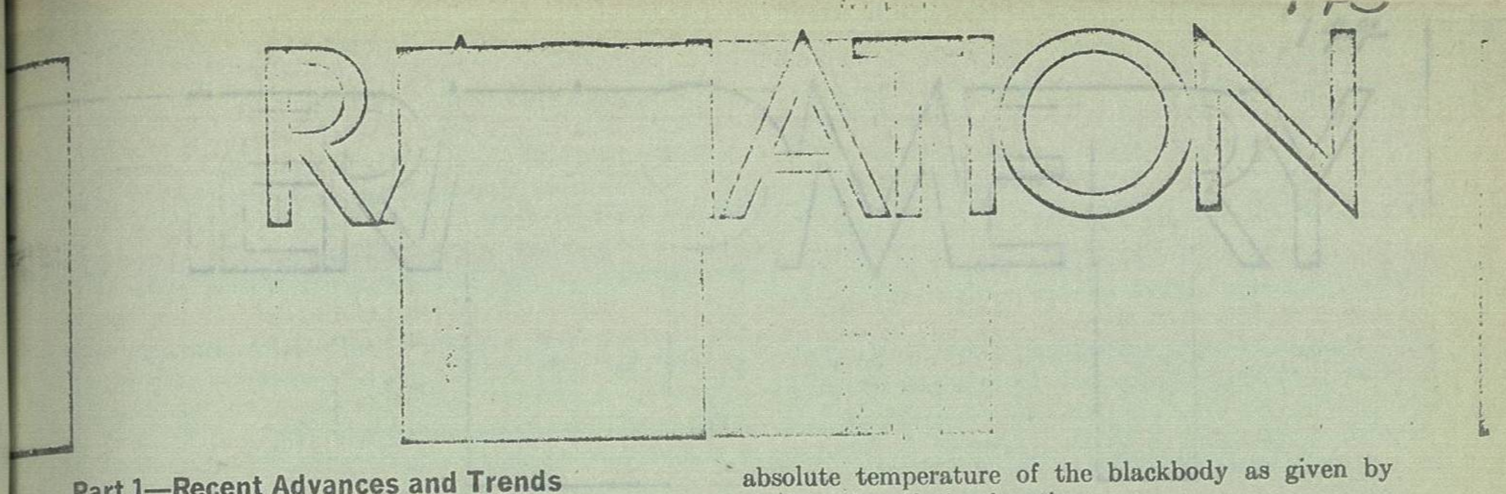

Part 1—Recent Advances and Trends

Here's a survey of changes in the field of radiation thermometry over the past decade. Considerable advantage has been derived from operating modern photodetectors in selected spectral regions, and extension of the low-temperature limit by use of infrared radiation. Highly accurate automatic versions of disappearing-filament optical pyrometers have been developed for high-temperature applications. Criteria for selecting wavelength and spectral bandwidth appropriate under various circumstances are given with special emphasis on effects of atmospheric spectral absorption and spectral emissivity.

GENE D. NUTTER[1]
University of Wisconsin, Madison, Wisc.

Radiation thermometry has long played a vital role in industrial and laboratory measurement of temperatures. It is unique among temperature-measurement methods in that direct physical contact with the object whose temperature is being measured is not required. At very high temperatures there is no alternative method, since contact thermometers degrade too rapidly to be useful, or they simply melt or vaporize. This noncontact characteristic is, however, a mixed blessing. The physical laws that govern the behavior of thermally emitted radiation are not always in concert with the desires of those who must use thermal radiation as a means of measuring temperature, and in general such methods require more knowledge on the part of the user than do the methods of contact thermometry.

Radiation Temperature Scale

Radiation thermometry is based on the concept of blackbody radiation, illustrated in Fig. 1, for which spectral radiance is an exactly known function of the absolute temperature of the blackbody as given by the Planck radiation function.

$$N_{b\lambda} = C_1\pi^{-1}\lambda^{-5}(e^{C_2/\lambda T} - 1)^{-1} \qquad (1)$$

where

N_λ = spectral radiance (radiant power per unit projected target area per unit solid angle per unit wavelength interval)
$N_{b\lambda}$ = spectral radiance of a blackbody
C_1 = the first radiation constant
C_2 = 0.01438 m·K, the second radiation constant
λ = wavelength of electromagnetic radiation
T = absolute temperature of the blackbody.

Equation (1) is used to define the International Practical Temperature Scale (IPTS) at temperatures above the freezing temperature of gold. Late in 1968, the IPTS was again updated [1][2] and is now designated IPTS-68. A significant change in terms of radiation thermometry was the new value assigned to the freezing temperature of gold (1064.43 C ± 0.2 C), about 1.4 C higher than the previous value. The value assigned to C_2 was changed from 0.01438 to 0.014388 m·K. If $C_2/\lambda T \gg 1$, Planck's radiation law may be replaced by the mathematically simpler approximate form known as Wien's law:

$$N_{b\lambda} = C_1\pi^{-1}\lambda^{-5}\, e^{-C_2/\lambda T} \qquad (2)$$

Although equation (1) is used to define the IPTS, the accuracy of equation (2) is adequate for most calculations in the analysis of radiation thermometry.

Since about the turn of the century, radiometry has been employed as a means of temperature measurement, and until the development and widespread application of modern photodetectors only two general classes of radiation thermometers have been available. These have been the "disappearing-filament optical pyrometer," or minor variations thereof, and the so-called "total-radiation pyrometer."

Disappearing-Filament Optical Pyrometer

The disappearing-filament optical pyrometer had reached a state of essentially complete development by about 1920 [2], with practically no significant change since then. It measures the nearly monochromatic radiance of a high-temperature source and indicates the temperature of a blackbody radiator having the same spectral radiance.

---

[1] Assistant Director, Instrumentation Systems Center.
Based on a paper contributed by the ASME Research Committee on Temperature Measurement. This survey was based on work supported by the Pyrometer Instrument Co., Inc., Northvale, N. J.

[2] Numbers in brackets designate References at end of article.