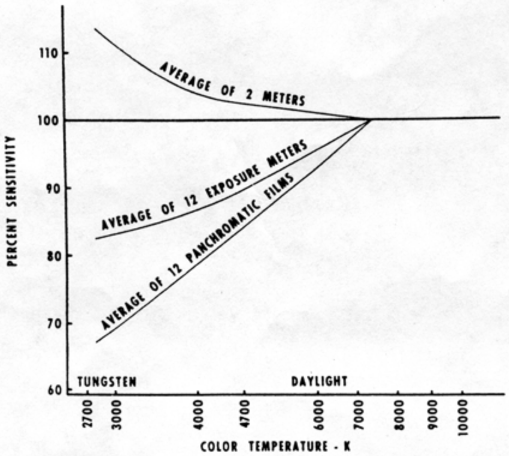

Fig. 2. Change in average spectral sensitivity with color temperature of 12 panchromatic films and 14 exposure meters.

markings has diminished. However, the industry is indebted to Deckel for naming a quantitative unit of camera exposure which had hitherto been nameless.

When Subcommittee PH2.18, under the chairmanship of J. L. Tupper, established[4] the exposure intervals corresponding to speed numbers and speed values, the divisions were at the boundaries and not the centers of the intervals. The relations are shown graphically in Fig. 1 for a typical portion of the range. The center points of the speed intervals on the two scales are spaced approximately a twelfth-root-of-two step apart. They can never correspond exactly because the arithmetic scale has three subdivisions and the log scale has only two. However, the conversion is sufficiently accurate for the intended use of the film products in question.

Calibration at 4700°K

With changes in color temperature, the sensitivity of selenium cells of American manufacture changes

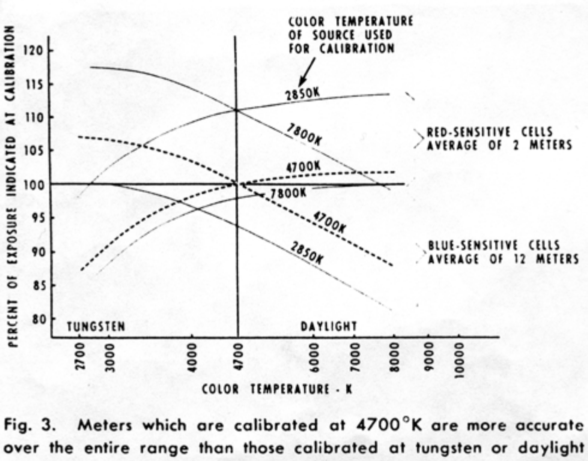

Fig. 3. Meters which are calibrated at 4700°K are more accurate over the entire range than those calibrated at tungsten or daylight color temperatures.

in the same direction, although somewhat less in magnitude, as panchromatic negative materials. Hence, meter makers have urged film manufacturers to eliminate tungsten film ratings for several years. K. S. Weaver of the Kodak Research Laboratories made extensive tests on a dozen of each of fourteen makes of meters to determine the feasibility of this elimination. His tests showed that two of the fourteen changed sensitivity with color temperature in the opposite direction from the majority. This confirmed other observations that some meters, which manifested perfect calibration in the laboratory (at 2700°K), differed markedly when used in daylight. The results are illustrated in Fig. 2. A. L. Sorem showed (Fig. 3) that the errors could be equally divided between daylight and tungsten if all meters were calibrated at 4700°K rather than 2700°K. This calibration is now included in the standard. It will assure closer agreement between meters in daylight and eliminate the need for tungsten film speeds for most panchromatic negative materials.

The only luminous standard[8] available for purchase is the tungsten "standard lamp." A variety of sizes and shapes may be procured from the National Bureau of Standards or from a few recognized standardizing laboratories. For use on a bar photometer such lamps are ordinarily rated in horizontal candlepower in the marked direction at the stated voltage or current and the given color temperature. Lamps for use in the Ulbricht sphere are rated in terms of total lumens. The accuracy of these ratings has been found to be within ± 2%, which is sufficient for most photometry. Some laboratories purchase several lamps at a time and preserve the one having the average candlepower as their reference standard. These standard lamps are used as a source for producing known illuminance, usually expressed in footcandles or metercandles. Different laboratories have agreed rather closely on the magnitude of the units of illuminance.

Measurements of brightness or luminance are more difficult, and disagreements between laboratories by as much as 50% have been encountered. In the past, it was not possible to buy a standard of brightness suitable for calibrating exposure meters. (In recent years the National Bureau of Standards did make available a small piece of opal glass calibrated for luminous directional transmittance[1] at tungsten color temperatures.)

Photometric measurements in photography are complicated because of the differing spectral sensitivities of the eye, the exposure meters, and the films. Scientists have agreed on the spectral sensitivity of the Standard Observer, and all photometric measurements are based on the corresponding luminous efficiency of radiant energy.[9] For instance, the 100% sensitivity level in Fig. 2 is the sensitivity of the eye to

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8. Allen Stimson Chap. 12., *Applied Electrical Measurements*, I. F. Kinnard, ed., John Wiley & Sons, New York, 1956, p. 387.
9. American Standard Method of Spectrophotometric Measurement of Color, Z58.7.1.