$$q = \frac{1}{1 + (d_0/A)[1 - \exp\{-h\nu/kT\}}. \quad (3)$$

The principal deduction to be drawn from the above is that q is independent of the density s of the exciting light, in which respect it differs from the quantum output of the total radiation. The latter is a monotonic function of s, tending to unity as $s \rightarrow 0$ and to the magnitude of q when $s_1 \rightarrow \infty$.

For $d_0 = 0$, i.e. in the absence of radiationless transitions, we obtain the trivial result $q = 1$. The output q also equals unity when the temperature is so high (flame temperatures) or the transition frequency ν so low (radio frequency region) that $\exp\{-h\nu/kT\}$ virtually equals unity. In physical terms, this means that under such conditions the presence of external radiation does not disturb the energy distribution between the levels, and consequently the number of quenchings equals the number of excitations, i.e., no heat is lost (radiated).

Under the conditions commonly obtained in luminescence experiments the value of $\exp\{-h\nu/kT\}$ is approximately zero and, therefore, according to (3),

$$q = A/(A + d_0). \quad (4)$$

Translated by M. Rosen
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[1] B. I. Stepanov, Doklady Akad. Nauk SSSR **99**, 971 (1954)

[2] S. I. Vavilov, Introduction to the Russian translation of "*Fluorescence and Phosphorescence*" by P. Pringsheim.

Self-Neutralizing Light Meter with Adjustable Red Boundary

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THE photoelectric meter is the most sensitive instrument for measuring the luminous flux[1]; therefore, work on its perfection or the extension of its application presents practical interest. This article is devoted to experiments on the design of a photometer with controllable spectral characteristics. Such an instrument could combine the functions of a light receiver and spectrometer. The first experiment in this direction was carried out by Kudriavtseva[2].

In order to control the red boundary of spectral sensitivity of the photometer, an additional electrode, a screen, was installed near the photocathode of the meter. The retarding field, created between the screen and the photocathode permitted the selection of the photoelectrons, passing through the screen into a sensitive zone of the meter, according to their speeds. In order that such a separation of photoelectrons be effective, it is necessary that the electrons not lose the speeds obtained under the photoelectric effect on the path from the photocathode to the screen (in absence of the restraining field), i.e., that the distance between the screen and photocathode shall be of the order of the free path length of the electrons in the gas in the meter. For this purpose the distance from the screen to photocathode should be made very small, or about 50 μ, and the argon gas should be used to fill the meter; in argon the mean free path is a maximum for electrons with velocity 0.3 - 1.5 V[3]. As the neutralizing component of the mixture methylal was used in 10% strength; the pressure of the mixture in the meter was 80 mm of mercury.

The meter had a cylindrical shape. A thin wall tube, 15 mm in diameter, of non-corrosive steel served as the cathode. The slits (12×8 mm) were cut on the opposite sides of the tube. One slit was used for illumination, and another was covered by a screen, behind which the cylindrical aluminum photo-cathode was attached to the insulation support. The aluminum was of a type having a red boundary for the photoelectric effect of about 3500 Å (3.6 ev). The screen was made of 20 micron tungsten foil by means of anodic etching under a thin rolled copper screen, pressed to the foil surface. In such a manner a copy of the copper screen was impressed on the tungsten foil, the cells of which were 0.33×0.25 mm and the transparency about 60%.

The tungsten metal was selected for preparation of the screen on account of its high energy yield. It served the purpose of lowering the uncontrollable photoeffect from the screen surface under illumination by the light under investigation. A steel cathode tube was subjected to chlorinization for the same purpose.

The complete meter represented a separate apparatus suitable for long work[1]. The anode and cathode of the meter were connected in the usual manner in a standard measuring system. The voltage given between the photocathode and screen (connected with the cathode of the meter) was supplied from a potentiometer, fed by dry cells.

A quartz lamp served as the light source for an examination of the meter during experiments. For the separation of required spectral bands Shott's light filters Wg 1, 3, 6 and 7 were used, and therefore the spectral characteristics of the meter, given below, are only approximate.

The meter has an energy plateau of about 100v (near 1050 v), while the dark background amounts to 100 impulses per minute – (independently of the voltage between the photcathode and screen).

During the operation of the meter with initial illumination, the general background, interfering with the measurements, is composed of dark background and uncontrollable photoeffect from the screen and inner surface of the cathode. Therefore the region of the meter operation from the short wavelength side is determined by the red boundary of the photo-effect of the screen and cathode materials. On the long wavelength side it is determined by the red boundary of the photocathode. The light of a quartz lamp passing through the filter Wg 7 (boundary of the transparency 2600 Å or 4.9 ev) created a background apparently equal to the photocathode effect; consequently, the measurements of spectral characteristics of the meter were made mainly with the filters Wg 7 and the more "red" Wg 6 (with boundary of transparency at 2800 Å or 4.5 ev).

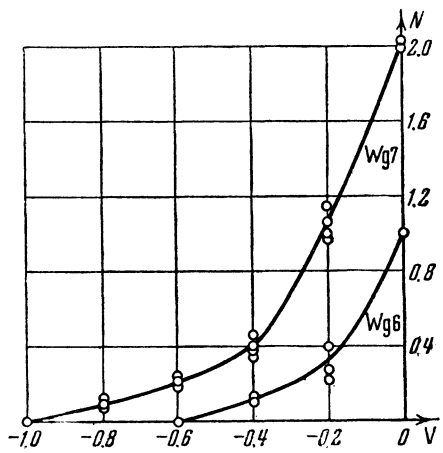

Fig. 1

On Figure 1 is shown the number of meter impulses, reduced by general background (in relative units) and the voltage added between the photocathode and screen affected by the light which passed through the filters Wg 7 (upper curve) and Wg 6 (lower curve). The experimental points were obtained during a few tests with the illumination varying from three to four times. Figure 1 also shows that the photoelectrons, excited by the light passing through the filter Wg 7, were slowed down by the retarding field of 1.0 v and by the light passing through the filter Wg 6 by a field of 0.6 v. The Figures, and also the boundary of transparency of the filters (see above), lead one to the conclusion that the amount of the energy yield from the photocathode (3.9 ev) exceeds the amount of the energy yield of the aluminum sample, used for preparation of the photocathode by 0.3 ev. This difference should be related to the difference of potentials at contacts (between aluminum photocathode and tungsten screen), which creates an additional retarding field of 0.3 v.

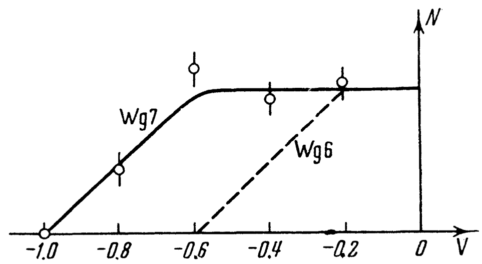

Fig. 2

From Figure 1 it is also seen that the retarding field changes the spectral characteristics of the meter. This is still better illustrated in Fig. 2, where the points of a solid line were obtained from the curve for Wg 7 (Figure 1) by means of recomputation with the approximate consideration of the spectral characteristics of the light filter Wg 7. The dotted line on Figure 2 was obtained in the same manner for the filter Wg 6. Gradual lowering of the spectral sensitivity of the meter seems to be explained by non-uniformity of the retarding field.

Figure 3 illustrates the construction of the orientating relation (solid line) of the red boundary of light sensitivity of the meter to the magnitude of the restraining field (without account of the potential difference at contacts). The light passing filter Wg 7 is conditionally related to the wave length 2650 Å and that passing Wg 6 to 2900 Å. (At this wavelength the transparency of the filters is about 20%.) The dotted straight lines were drawn through the pair of experimental points (ordinates corresponding to the impulse numbers without background) related to each retarding field and were extended to their intersection with the abscissa. The intersection points are used as the orientating values of the red boundary of the meter for the given value of retarding field for construction of the solid line. The ordinate of this curve is the value of retarding field (right scale). The point (3500 Å + 0.3 v) char-

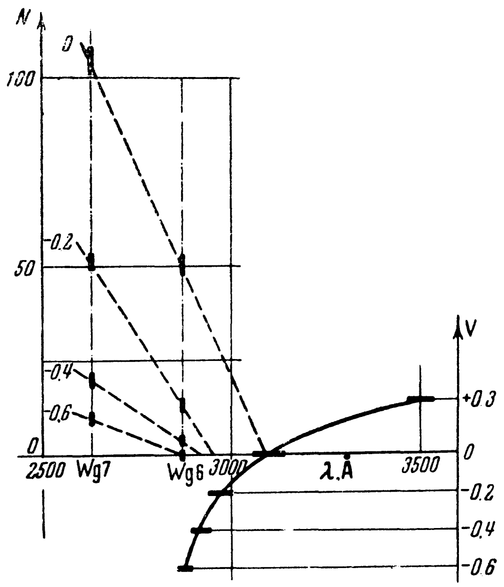

Fig. 3

acterizes the aluminum photocathode in the absence of the screen and the difference of potentials at contact appearing under this condition.

It is necessary to note that the sensitivity of the meter with the screen is substantially smaller (by more than an order of magnitude) than the sensitivity of the conventional photometer with open photocathode . The reason for this seems to be due to the dispersion of considerable amounts of the photoelectrons on the path from the photocathode to the screen.

According to available published data only one attempt was made to create a meter with a controllable screen[2] However the results of this work are uncertain, inasmuch as the observed effect of the screen action lay within the limits of precision of measurements. Moreover, this meter generally could not serve as a stable measuring instrument, because it was operated exclusively in a vacuum installation. The present work proves the experimental possibility of construction of a self-neutralizing light meter with regulated red boundary and possessing all the operating characteristics of the contemporary photometer[1].

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Translated by N. P. Setchkin
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[3] K. Ramsauer and R. Kollat, Usp. Fiz. Nauk 15, 128 (1935)

Translator's note: General principles of the light meter are also given by Radionov in J. Exper. Theoret. Phys. USSR 10, 294 (1940).