ON THE METHODS OF MEASURING MEAN HORIZONTAL CANDLE-POWER.

C. P. MATTHEWS.

THE photometrist has at his command two methods of obtaining the mean horizontal intensity of a glow lamp. The first, and that in general use, consists in finding the mean radius of the candle-power distribution curve, as taken point by point; the second consists in whirling the lamp about a vertical axis of symmetry at a speed such as to eliminate flickering, and in making photometer settings with respect to the mean illumination as perceived on the photometer disk. This latter method, it appears, was first suggested by Professor C. R. Cross.¹

Considerations based on Helmholtz's law² for the action of intermittent light upon the retina would indicate that the two methods should give the same result. The writer has held the opinion, however, that it would be well to put the psychological point involved to actual test under the unique conditions met in a spinning glow-lamp, particularly so since the Committee on Light Standards of the American Institute of Electrical Engineers has recently recommended the general adoption of the whirling method. In this opinion he has been joined by several authorities on physiological optics, with whom he has communicated.

Measurements made with Mr. C. H. Sharp about a year ago indicated that any existing difference was at any rate small, and that much care would be needed to bring it out. With a view of making the matter definitive the writer has recently taken new data, with all possible care, the results of which are given below.

But before passing to these results, it may be well to add that there are, aside from any possible difference of the character mentioned, ulterior effects which might put the results obtained by the two methods at variance. Thus Professor Thomas³ has pointed out the existence of a "phantom filament." The light reflected from the bulb of a glow-lamp produces marked, sudden variations in candle-power as the lamp is slowly turned on its vertical axis. When the mean horizontal candle-power is obtained from readings taken at 30-degree intervals, these variations are likely to be excluded; but when the lamp is rapidly rotating they necessarily contribute to the mean as perceived by the eye. Furthermore, there is always in lamps with slender filaments a certain amount of filament distortion due to the speed of rotation. This distortion is marked in lamps

¹ Franklin Institute Congress in 1884.

² *Physiologische Optik*, 2d ed., p. 483.

³ *Proceedings of the Electrical Congress, Chicago, 1893.*

having filaments of the double-loop type. The planes of the loops tend to separate as the speed of rotation increases. If the filament is anchored the motion is confined to the top of the loops. In any case there is likely to be an initial lack of symmetry in the filament which, if the speed be sufficiently increased, will cause it to bend until it touches and ruptures the bulb. Now, since the fundamental law of photometry is not one of simple distances, any bending, even though symmetrical, must change the effective center of the light source. This effect, although of trivial importance when a long bar is used, must yet be regarded as real.

The incandescent lamp as manufactured to-day gives a horizontal distribution that is nearly circular and hence is ill adapted to test the point at issue. An irregular distribution was obtained for the following measurements by pasting pieces of black paper on the bulb of the lamp. As some distortion occurred at high speeds, the top of the lamp was entirely screened by a hood of black paper, so as to effectually cover the points at which the bending was noticeable. Finally the lamp was whirled at different speeds, from a minimum which caused a barely perceptible flicker to a maximum beyond which it was not considered safe to go. No variation in intensity with speed was found.

The distribution curve shown in Fig. 1 was then taken, the readings being made at 10-degree intervals. The mean bar readings and the corresponding light ratios, multiplied by 10, appear in the sub-joined table. A 360-part bar was used and a standard of approximately 10 candle-power, purposely adjusted to give about the same intensity and color as the lamp under test.

Degrees.	Mean reading.	Light- ratio $\times 10$.	Degrees.	Mean reading.	Light- ratio $\times 10$.
0	183.1	10.71	190	182.2	10.50
10	185.7	11.34	200	182.2	10.50
20	184.8	11.13	210	178.1	9.58
30	173.8	8.70	220	174.3	8.80
40	160.5	6.48	230	204.5	5.78
50	159.4	6.32	240	162.35	6.74
60	169.9	7.99	250	153.55	5.52
70	160	6.4	260	153.75	5.55
80	165.6	7.26	270	172.1	8.39
90	188.1	11.97	280	180.9	10.02
100	187.8	11.88	290	182.5	10.56
110	187.7	11.86	300	181.6	10.36
120	187.15	11.73	310	181.85	10.40
130	187.55	11.83	320	182.5	10.56
140	184.4	11.03	330	185.9	11.40
150	185.9	11.4	340	183.55	10.82
160	183.45	10.79	350	182.2	10.50
170	181.75	10.38	360	183.5	10.80
180	180.7	10.16			

Fig. 1.

To facilitate integration the readings were also plotted in rectangular coördinates. The planimeter shows from this latter curve a mean horizontal candle-power of 9.655. The mean of all readings on the whirling lamp is 9.649. The difference, amounting to .006 or about .06 per cent. is entirely within the limits of photometric error.

The obvious conclusion is, then, that the two methods lead to the same result *when there is no color difference*.

Ferry found that the error

resulting from the use of the sector disk was not a function of the luminosity ratio of the sources compared but was dependent on their

¹ PHYSICAL REVIEW, Vol. I., p. 338.

color. It would be natural to expect the occurrence of similar phenomena in the present instance. The writer hopes to report on this later.

Messrs. J. Walter Esterline and R. W. Treat rendered most valuable aid in taking the foregoing measurements.

ELECTRICAL LABORATORY, PURDUE UNIVERSITY,
July, 1897.