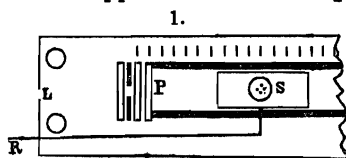


ART. IX.—*Description of a Photometer ; by Prof. O. N. Rood.*

DOVE, a short time ago, proposed a photometer, consisting essentially of a compound microscope provided with a microscopic photograph, the latter being used as a "screen," and illuminated from both sides, in such a way that when the compensation had been reached, the photograph was rendered invisible.<sup>1</sup> In the construction of the instrument at present described, I have availed myself of this general mode of comparison, discarding however the microscope and photograph, and supplying their place in a more simple, and, for many purposes, in an at least equally efficient manner.

The instrument consists of a board from 50 to 100 inches in length and 12 inches wide; a slide at S supports a small lamp or standard candle; the slide can be moved towards or away from the screen P by a light rod R; the screen, reckoning from L, is composed of four parts, disposed thus: 1st, a glass plate is coated with a collodion sensitized with iodid of potassium and of the variety called adherent; this is immersed in a solution of nitrate of silver, just as though it was to be used for the reception of the camera image; it is then exposed to broad daylight for two minutes, and developed by sulphate of iron, washed and dried. By this operation a dense and absolutely opaque deposit of silver is produced in the substance of the collodion. The collodion film is then removed from one spot  $\frac{1}{4}$  an inch square; this can be done neatly and completely by the use of a needle, great care being taken to leave the edges of the little square sharp and clean. The observations are made by means of this spot, and it of course is to be located in the axis of the instrument. On account of the uniformity of the appearance of this plate by



<sup>1</sup> *Pogg. Annalen*, Band cxiv, page 145.

reflected light, and the sudden, sharp transition from the thin opaque edges of the film to the clear glass, the screen is, I suppose, better adapted for use than any which has yet been proposed. The collodion side of the glass plate is turned towards L.

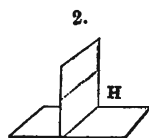
2d. Next in order comes a piece of blackened card board of the same size with plate No. 1: this is provided with an aperture corresponding with, and somewhat larger than, the exposed portion of the collodion plate.

3d. Then follow two thin finely ground glass plates of the same size with No. 1, the ground surfaces facing towards L. A single plate of ground glass can be used, but with two plates the illumination of the square spot is much more uniform and even; in other words, by the use of two plates all idea of the ground glass texture is removed, and nothing is seen but a square patch of light.

Two small lamps or standard candles are placed about as indicated at L. The construction of the lamps is the same with those used by Potter, (*Physical Optics*, page 112,) in his photometric experiments, consisting, viz: of shallow cups filled with oil, which support little metallic bridges, formed of thin plates of metal perforated with four holes, through two of which small wicks are drawn, the others supplying air. When properly arranged these lamps will give a pretty uniform light for thirty minutes together; but though by no means furnishing a truly constant illumination, yet the variation is almost always gradual and steady, a point of great importance, for this being the case, it is easy to make the observations in such a manner as nearly to exclude errors from this source, as will presently be shown.

The movable lamp is provided with a vernier, and a scale divided into inches and tenths extends from that ground glass surface next to the collodion plate along the entire length of the board. At L is a shade to protect the eyes while observing; this has an aperture one inch square placed in the axis of the instrument. The photometer, when arranged as above described, is peculiarly adapted to measure the amount of light transmitted by plates of colorless or colored substances, as well as the amount of light reflected from polished or unpolished plane surfaces at various angles of incidence. For these uses it was expressly contrived, but at the same time it is plain that by modification it can be adapted to other purposes.

*Mode of using the instrument.*—The three lamps, after being lighted, are allowed to burn for twenty or thirty minutes, till their light has become steady, then the centre of the flame of the slide lamp is made to coincide with the vernier by using the arrangement seen in fig. 2; this is constructed of wood and all its angles are right angles. The vernier being placed at H, the eye is brought opposite the dotted line



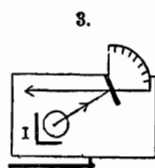
in such a way that the surface of the upright is reduced apparently to a line, when the lamp is moved on the slide till this line bisects the flame. The slide is then placed about as distant from the screen as may be desired and, compensation approximately effected, by moving the pair of lamps at L away from or towards the collodion surface. If these are brought too near the screen, the square spot will appear dark on a light ground; if too far off, light on a dark ground. The final compensation is made by moving the slide lamp S; this takes place when the spot becomes invisible. In the first experiments, instead of a pair, a single lamp was used, and owing to this the spot never became entirely invisible; one half was always faintly lighter than the adjacent ground, the other half darker; this was owing to the slight difference in the distances of the sides of the square from the lamp, and may be adduced as a proof of the delicacy of the photometer. The observer then reads off on the scale the distance of the slide lamp from the ground glass surface next to the collodion plate, the white page of the note book reflecting sufficient light for the purpose. Supposing it is desired, for example, to measure the amount of light transmitted by a plate of polished glass at a perpendicular incidence, the plate is placed at P, when it will be found necessary to bring the slide lamp nearer in order to effect compensation. The amount of light transmitted is then at once calculated by the law that "the intensities which measure the values of the illuminating powers are *directly* as the squares of the distances from the screen."

My mode of work, in all cases, has been to alternate the observations, reading off first the distance of the free flame; 2d, that found with the plate of glass under experiment; 3d, free flame; 4th, plate of glass, &c.; and as the variations in the brightness of the lamps are generally slow and steady, by this mode, the error from this source is very greatly reduced.

Dove considers this form of photometer the only one which is capable of comparing the intensity of two masses of light having different colors; the degree of accuracy attainable in this direction can be judged of by the experiments detailed below. As the square spot will in such cases be differently colored from the ground, it always remains plainly visible, but there is a moment when the edges of this spot, to a great extent, disappear, and it seems to blend softly into the white ground. This I assume to take place when the illuminations are exactly balanced, and have accordingly employed it as the test in my experiments on colored media. Though the determinations with colored light are on the whole pretty satisfactory, still they by no means reach the accuracy easily attained when the two masses of light are similar in tint. With regard to the following observations, it may be remarked, that those made with col-

ored light show fully the degree of accuracy that can be attained in this direction with the photometer, the experiments, as far as they extend, being made with much care, though in such a way that each reading is entirely independent of the preceding, and has exercised no influence on that which follows.

To measure the amount of light reflected from a polished surface, I have used a plan not unlike that employed by Potter;<sup>2</sup> the slide, in the place of the lamp, carries the polished plate in an upright position and supported in such a way that it can be rotated on its axis and adjusted properly. Its axis corresponds with the centre of a divided quadrant by which the incidence of the ray can be measured. I is a shade to prevent the light from reaching the screen. The vernier is made to correspond with the perpendicular axis of the mirror, and of course the distance of the lamp's flame from the mirror's axis is always to be added to the reading obtained. By removing the shade I, and placing it so as to protect the mirror from light, the direct light of the lamp falls on the screen. As the lamp stands then a little obliquely, the slight error thus introduced must be allowed for, or, what is better, the lamp and mirror may be placed on either side of, and at equal distances from, the axis of the photometer.



Prof. Silliman, Jr., pointed out to me some weeks ago, that small errors might be introduced by reflection from the walls of the room. This is guarded against by the use of several blackened shades properly disposed about the instrument, or by experimenting in a room with blackened walls, as is usual in determining the photometric power of illuminating gas.

Determination of the amount of light transmitted by a plate of colorless, polished crown glass  $\frac{1}{2}$ th of an inch thick:

Flame free.	With plate.
20.7 inches.	19.95 inches.
20.85 "	19.9 "
20.8 "	19.9 "

Amount of light transmitted, 91.09 per cent.

Determination of the amount of light transmitted by a plate of colorless glass, finely ground on one side,  $\frac{1}{2}$ th inch thick:

Flame free.	With ground glass.
20.2 inches.	13.1 inches.
20.35 "	12.8 "
	13.1 "
	13.05 "

Amount of light transmitted, 41.13 per cent.

<sup>2</sup> Physical Optics, p. 112.

Determination of the amount of light transmitted by one plate of polished orange colored glass,  $\frac{1}{8}$ th inch thick :

No. 1.		No. 2.		No. 3.	
Flame free.	Orange glass.	Flame free.	Orange glass.	Flame free.	Orange glass.
23·05	15·50	22·10	15·50	22·2	15·40
22·60	15·80	22·20	15·75	22·2	15·65
22·60	15·40	22·40	15·40	21·15	15·10
22·64	15·30	22·60	15·60	21·8	15·00
22·15	15·65	21·90	15·50	21·2	14·3
22·35	15·50				
Amount of light transmitted, 47·45		48·74		48·42 per cent.	

Determination of the amount of light transmitted by a plate of deeply colored red glass,  $\frac{1}{8}$ th of an inch thick :

Flame free.	Red glass.	Flame free.	Red glass.	Flame free.	Red glass.
21·5	7·3	21·10	6·7	20·9	6·5
21·	6·3	21·15	6·6	20·2	6·7
22·	7·2	21·40	6·9		7·0
22·	6·7		6·8		6·2
	6·7		6·6		
Light transmitted, 10·03		10·05		10·36 per cent.	

Peace Dale, R. I., May 7th, 1863.