

ART. XXXVIII.—*Color Photography by Lippmann's Process*; by CHARLES B. THWING, Evanston, Ill.

IN a communication to the Académie des Sciences on the second of February last, M. G. Lippmann opened an entirely new line of experimentation on the problem of the photographic reproduction of the colors of nature. To Lippmann's account of his discovery is appended in *Comptes Rendus* a note by Mons. Edw. Becquerel to the effect that the process of Lippmann differs radically from the discovery made by himself in 1848, in that while Becquerel was able by photo-chemical means to produce a colored image of the spectrum which could not be exposed to light since the action of the usual fixing agents reduced the deposit to a mere film of metallic silver, Lippmann, on the other hand, had by a physical process obtained an image which retains its colors after treatment with hyposulphite of soda, and is, therefore, as permanent as an

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ordinary negative. The peculiarities of Lippmann's method consist, first, in the use of a plate which is transparent and free from grains; second, in the exposure of the plate with its film side resting against a reflecting surface of mercury. The interference of the reflected with the incident ray of light divides the film into a number of layers at the maxima which will correspond in their distance apart with the wave length of the incident light, and will, therefore, be able to reproduce by reflection the color which produced the layers.

Lippmann says that the plates are positive for reflected and negative for transmitted light (*négatif par transparence*). By negative he means showing the complementary color. In that one of Lippmann's negatives which I have seen and all those obtained by myself, the plates are opaque to transmitted light, showing only differences of density like an ordinary negative. The reverse side of the plate, however, shows the complementary colors, somewhat fainter than the original colors which appear on the film side of the plate.

If the plates were, in reality, negative by transmitted light, it might be possible to obtain by two steps instead of the one employed in ordinary photography, a number of copies from a single negative. The remaining method is to copy the reflected image, and, as the reflected colors are bright, this may not prove impossible. In my experiments certain modifications were introduced with a view of determining several points which are not brought out by the original experiment as reported by Lippmann. It is difficult to obtain a plate which shall be transparent and yet possess any sufficient degree of sensitiveness. The plates I have found most satisfactory hitherto are of collodion on a thin substratum of albumen.

Following is the formula employed:

(1) {	Cadmium bromide.....	25 g.
	Alcohol .....	280 c.c.
	Hydrochloric acid .....	5 c.c.
	Of (1) .....	5 c.c.
	Ether .....	40 c.c.
	Pyroxyline .....	2 g.

Sensitize by adding, drop by drop, a solution of silver nitrate, 1 g., in alcohol, 10 c.c., and pour without waiting for the emulsion to ripen.

The film obtained is a pale opalescent blue, almost perfectly transparent, and requires an exposure of twenty minutes or more in direct sunlight to produce images of the green and red. It should be remarked, however, that the image is not latent but appears nearly as strong without the use of a devel-

oper as when development is resorted to. Suitable developers will doubtless reduce the time of exposure.

The plates were exposed against mercury, not, however, to the spectrum, as with Lippmann, but to light transmitted by strips of variously colored glass, one object being to determine whether the ordinary colors of objects, consisting, as they do, of a mixture of rays of several different wave lengths, would be reproduced with the same fidelity as were the pure rays of the spectrum. The composition of the light transmitted by the strips of colored glass employed as determined by the spectroscope is shown in the following table :

Red : All the red with distinct traces of orange and green.

Orange: The entire spectrum reduced in intensity.

Green: A band extending from the middle of the blue to the middle of the red.

Blue: Blue, with bands throughout the green and red.

Purple: Green and red.

The results obtained, though by no means conclusive at all points, seem to indicate: First, that mixed colors may be reproduced with some fair degree of accuracy, though some curious modifications sometimes occur. Thus, a thickening of the film between exposure and final drying, will occasionally change all the colors in the direction of the red end of the spectrum. A shortening of the distance between the thin plates, and a consequent displacement toward the violet, on the other hand, may be produced by allowing the incident light to strike the reflecting surface of mercury, at an angle other than the normal, thus shortening the distance between the maxima which mark the layers of reflecting deposit in the sensitive film. Second, that an exposure sufficiently long to give a clear image of the red is quite certain to obliterate the blue by over-exposure. Third, that an over-exposure may completely reverse the colors, causing the original colors to appear on the reverse, and the complementary on the film side of the plate.