THE PRESENT CONDITION OF COLOR PHOTOGRAPHY[1]

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The past five years have been noteworthy in the history of photography as marking the appearance of processes of color photography which have, in the fullest sense, been practicable and have been used extensively by the professional and the amateur photographer. While there is yet to be seen the simply produced print on paper which, to the popular mind, can alone deserve the name of color photograph, still pictures are now tolerably common which need neither an instrument to render them visible, nor delicately arranged conditions of viewing. It must be said, however, that in correctness of color rendering, no advance has been made on the three-color reproductions shown by F. E. Ives twenty years ago in the Kromskop, nor over some of the most perfect examples of the Lippmann process of almost the same age. Recent developments have all been toward simpler or popularly more acceptable means of achieving the same result.

It will be most feasible to discuss progress in color photography after making a classification of the various methods into direct and indirect methods (the latter again may be arranged under various sub-heads, as is done below). Considering, now, direct methods of color photography, there is but one illustration—the Lippmann or interference process. Because of extreme delicacy of manipulation, and because it is subject to disturbing influences, it has been used successfully by very few. Some work, however, has been done with it comparatively recently. H. Lehmann, Cajal and H. E. Ives have made studies of modes of preparation of the sensitive film, of the action of the different developers, and by means of sections of the film, of the action of various types of light.

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These have, in the main, confirmed the beautiful scientific theory which underlies this method. The last named investigator, by using certain slow, clean-working developers, and by bleaching with mercuric oxide, has produced films containing hundreds of reflecting surfaces and possessing a resolving power sufficient to reproduce spectral colors with great purity. Lehmann has developed a special color screen for taking interference pictures, in which are three maxima of transmission whereby whites are produced by a set of laminae instead of by a diffuse deposit, which latter frequently possesses a single maximum of reflection, corresponding to the center of the sensitive region of the plate, or to green. Some substitutes have been proposed for the mercury mirror originated by Lippman, but no attempts to simplify the process in this way have encouraged many to use it. The interference process seems in fact fated to remain only a beautiful scientific demonstration.

Indirect processes of color photography are those in which the color is not produced in the picture by the action of light, but is added either by instrumental means or by colored media, such as dyes. These processes naturally fall into two classes: one, represented by the prismatic dispersion process, in which the actual spectral composition of the original color is copied; the other, those making use of the physiological characteristics of the eye, whereby colors may be reproduced subjectively by the objective mixture of others. The first processes are at present confined to several schemes originated by Lanchester and others, whereby the image of the object photographed is spread out into a large number of narrow adjacent spectra, by the combination of a prism with an opaque line grating. The positive from the negative thus obtained is then viewed through an instrument similar to the camera. The images of the narrow spectra act as templates, transmitting more or less of the spectral colors to the eye at different points on the image. Thus an exact reproduction of the acting light is obtained, and the colors are reproduced in such a manner that they appear correct to all observers no matter what their peculiarities of color vision. The necessity for using a viewing instrument and of accurately adjusting the linear spectral images to their spectra are, of course, disadvantageous from the practical or commercial standpoint.

With these brief notices of direct color photography, and indirect by spectral analysis and synthesis, we come to those processes which have produced, by far, the most promising and practical results, namely, the color mixture processes, which practically reduce to various forms of the three-color process. The theory of three-color photography, first put into scientific form by Maxwell, and later developed by F. E. Ives, may be outlined as follows: By experiment on color mixture, it has been found that all colors of the spectrum may be reproduced as to hue (but not absolutely as to saturation) by mixtures of three spectral colors—a red, a green and a blue. According to the experimental work of Koenig, and the theory known as the Young-Helmholtz theory, the facts of color mixture may be represented by the assumption of three so-called primary color sensations, red, green and blue, none of which are present in full purity in the spectrum. It is, however, possible to select from the spectrum the three colors in which each of the three sensations are present with least admixture of the two others, or it is possible to select three colors which in their mixture introduce least degradation of purity, that is, least admixture of white (either on the whole or in colors considered most important). Having selected three primaries conforming to the latter requirement, it is possible to obtain color mixture curves, giving the mixing proportions of these selected primaries which shall reproduce the spectral colors. If, now, three negatives are made, in each of which the distribution of photographic action through the spectrum is as given by one of the mixture curves, then these three negatives, or the positives from these, when suitably viewed by the three primary colors, and combined, will reproduce to the eye the original object. It is thus seen that the theoretical requirement is for negatives taken through screens in which all the spectral colors are transmitted in certain proportions which represent the color and luminosity values, and for the viewing of the resultant positive by three colors which are only narrow isolated portions of the spectrum. Any departure from this latter condition means the use of primaries which, in their mixtures, either introduce more than the minimum possible amount of white, or else restrict the hue range.

The practically exact attainment of the conditions just outlined was actually reached in three-color projection, and in instrumental synthesis in the Ives–Kromskop twenty years ago, and no more perfect results have since been achieved. Recent progress in three-color photography has been along the lines of simplification of procedure, often, however, made possible by some compromise with the theoretical requirements.

The most prominent three-color processes now are those known as "screen plate," of which the Lumière Autochrome, Dufay and Warner-Powrie are examples. Their common characteristics, from which the name is derived, are, first, a mosaic screen of the three taking color screens, second, the negative emulsion superposed on this screen, and, third, the necessary practice of reversing the negative, in order to secure a positive, which, lying as it does in intimate contact with the mosaic screens, owes its color to the light transmitted by the complex color screen. The color photograph is a transparency, and from the manner of its production is unique and incapable of simple copying. The same mosaic of color screens is used for viewing as for taking. This entails a compromise: the constituent colors are made less pure than they should be for viewing purposes, more pure than they should be for taking. That this compromise causes a loss in fidelity of color rendering is unquestionable. Photographs of certain pure colors, such as a spectral yellow, which reproduces as red, show this only too plainly. Still, as most colors in nature are far from pure, and as the eye is marvelously adaptable to changes of color scale and saturation, this compromise is much less apparent in the results than might be expected. Beautiful color photographs, chiefly taken by the Lumière process, are now rather frequently to be seen.

The various screen plate processes differ in their mechanical details. In the Autochrome plate the components of the screen are dyed starch grains, mixed in proper proportion to produce a gray and then strewn on the plate. In most of the other processes various lines or other geometric patterns predominate, some made by ruling processes, others—notably the Warner-Powrie—made by gelatine bichromate printing and subsequent dyeing. An advantage of the linear elements in the Warner-Powrie Screen is that the negative may be used for making structureless positives by a process of parallax printing. The irregular structure of the Autochrome plate keeps more than a portion of the transmitted light from being available for contact printing on another plate, or on a bleach-out paper.

Another development of the three-color idea which has produced interesting results, and which may be expected to produce more in the future, is that of complementary color printing, either as transparencies or as prints on paper. The theory underlying this method of working is the same as before, but the different mode of approaching the problem calls for a different set of colors. Instead of adding colors to produce white, the print processes start with white and build up by successive absorption until they reach black. The colors required are minus colors; that is, the nearest approach possible to the color obtained by subtracting each of the three constituents of a three-color white, colors which shall also, when taken together, produce black. These are minus red, or peacock blue, minus green, or pink, and minus blue, or yellow. The first pictures of this sort were obtained by printing the three negatives on bichromated gelatine. After development the three prints were stained with appropriate dyes and superposed, making excellent transparencies. Recent forms of this process are due to F. E. Ives. One process originated by him has for its essential characteristic the use of bichromated fish glue for the printing surface, whereby very shallow reliefs can be obtained. A later process uses gelatine bromide plates into which a quantity of yellow dye is incorporated, which again serves the purpose of keeping the relief shallow, so that the soaking up of dye-stuff can be accurately controlled.

Two processes carry three-color printing to the form of prints on paper. These are the Koenig Pinatype process and the Sanger Shepherd imbibition process. These both make prints in gelatine, which are transferred by squeegeeing to a gelatine-faced or blotter-like paper.

Another printing process of great interest is the bleach-out process, known as Uto. The central idea of this is the use of a paper coated with a mixture of three dyes of minus color which, together, produce black. Each dye has the property of being faded by its complementary color of light. Consequently, when exposed to a colored image all colors from black to white (complete fading) are attainable. The technical difficulties in the way of this clever idea are many, but a paper has actually been produced upon which prints from color transparencies have been made. At present, however, this process is not a serious rival to the screen plate.

Various cameras for the production of three-color negatives continue to be devised, but their details involve no strikingly new departures other than what may be termed mechanical ones. The use of the screen plate has led attention away from special cameras, but the possible development of improved three-color print processes may direct the ingenuity of inventors back to the problem of securing three negatives from one point of view in some simple and compact camera.