Gabriel Lippmann – Nobel Lecture (December 14, 1908)

Colour photography

The problem of direct colour photography has been facing us since the turn of the last century. Edmond Becquerel, as is known, gave a first solution though only an imperfect one. Becquerel showed that the colours of the image of the dark room print on a layer of violet silver chloride. Zenker explained Becquerel's finding by a phenomenon of interference. Experiment shows that this explanation is not true and that Zenker's theory does not hold good for silver chloride. Becquerel's prints remained, however, what they were: not fixed, and fading in light. Then Otto Wiener fixed by photography a shot of interference fringes that are found in the neighbourhood of a silver mirror. That physicist did not, however, envisage obtaining colours by an interference method. I will not lay any further stress on the background of experiments and ideas which preceded the method on which I am to have the honour of addressing you, and which furnishes the coloured image of objects.

The method is very simple. A plate is covered with a sensitive transparent layer that is even and grainless. This is placed in a holder containing mercury. During the take, the mercury touches the sensitive layer and forms a mirror. After exposure, the plate is developed by ordinary processes. After drying the colours appear, visible by reflection and now fixed.

This result is due to a phenomenon of interference which occurs within the sensitive layer. During exposure, interference takes place between the incident rays and those reflected by the mirror, with the formation of interference fringes half a wavelength distant from each other. The fringes imprint photographically through the whole thickness of the film and form a casting for the light rays. When the shot is afterwards subjected to white light, colour appears because of selective reflection. The plate at each point only sends back to the eye the simple colour imprinted. The other colours are destroyed by interference. The eye thus perceives at each point the constituent colour of the image. This is no more than a phenomenon of selective reflection as in the case of the soap bubble or mother-of-pearl. The print in itself is formed of colourless matter like that of mother-of-pearl or soap film.

This explanation can be checked by an experiment we are going to carry out in front of you. Here first is a print of the spectrum projected on to the screen. As you see, the colours are bright. We wet the plate and project it on to the screen again. There is no colour there. The gelatine has swollen and the intervals between the images of the interference fringes (Zenker's laminae) have become two or three times too large. Wait one minute while the water dries off. We see the colours re-appear in accordance with and at the speed of the drying process. They re-appear according to an order which can be predicted. Red, which corresponds to the greatest wavelengths, reappears first, followed by orange, green, blue, and violet.

The reproduction of the simple colours of the spectrum was the easiest to carry out. The photography of composite colours that exterior objects present posed a harder problem. At first sight it might have been held impossible. In effect, in the case of simple light, the interference maxima are equidistant planes separated by intervals equal to half a wavelength. In the case of composite colour, an infinity of systems must be obtained for maxima infinitely slight and with an infinity of interval values separating them - that is to say, the whole thickness of the sensitive layer is occupied in continuous manner by these maxima. The spaces that exist in the instance of simple light and which allow to assimilate the photographic plate with a series of fine laminae have disappeared. It was thus necessary to reshape the theory of the phenomenon in wider terms. First it must be noted that the amplitude resulting from the interference varies according to a function that is continuous even in the case of simple light. The general case is derived by an analysis based on one of Fourier's chapters. It can thus be demonstrated that photography of composite colours is possible.

Once all theoretic reserve was gone, the technical difficulties appertaining to the isochromatism of the films remained to be overcome. I got quite good results from protein plates. Later, Valenta in Vienna and the Lumières at Lyons found means of coating the plates in grainless gelatine, sufficiently isochromatic and very much better than the protein plate. Dr. Neuhauss in Berlin carried isochromatism to perfection. Thanks to the work of Messrs. Miethe, Krone, H. Lehmann, and others whom I will not detain you by mentioning, the technique of colour photography has been perfected. Allow me to show you projections of results obtained.

(Series of slides - still-life paintings, vases with flowers, views of Fontainebleau, Lake Annecy, Biarritz, Zermatt, Venice, and child portrait from life.)

The photographs that you are seeing needed approximately one minute of exposure to sunlight. The series of photographic operations, developing, washing, final drying, takes about quarter of an hour. Most of these pictures, taken while travelling, were developed on the mantelpiece of a hotel room, which proves that the method is easy enough to carry out.

It nevertheless still remains to be perfected in some points. The length of exposure (one minute in sunlight) is still too long for the portrait. It was fifteen minutes when I first began my work. Progress may continue. Life is short and progress is slow.