Note on the stereophotochromoscope : a new optical instrument / by David Fraser Harris.

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stereophotochromoscope proper—in which the photographs are submittted to inspection.

For a reason to be given immediately, *three* stereoscopic *pairs* of photographs of the one coloured object are taken by a single exposure on one sensitive plate.

Thus there are six negatives in pairs (each pair being sometimes called a "stereogram"): positives of these are then made in the usual way by "developing" and "printing" upon glass; the set of transparencies being then known as a "chromogram"; for, as will presently be explained, these photographs are records of colour-effects.

As the paired photographs are not to be all examined in one plane in the photochromoscope, the three pieces of glass, each with its double transparency, are hinged together by a flexible material to permit of chromatic illumination in three different planes.

The essence of the Young-Helmholtz theory of colour-vision is that in the retina we must suppose *three* sets of end-organs, of such constitution that one set responds most energetically to light at the red-end of the spectrum, less so to greenish light, and least of all to violet; that the second set are most irritable in green light, less so in light at the extremities of the spectrum, while the third set is most susceptible in violet light, less so in greenish, least of all in reddish light. The sensation of white light is produced when all the three end-organs are excited in nearly equal degrees.

Now, it is known that it is not only pure spectrum-red rays that excite the fundamental sensation of "red" (consequent upon stimulation of what we have called the first set of retinal nerve-endings), but that the "red"-sensation is produced by all the spectrum-rays from red to green, though most powerfully by the orange; similarly, the "green"-sensation is produced not only by spectrum-green, but by the simultaneous action of orange, yellow, yellow-green, green and green-blue (all of which rays act with varying energy on the so-called "second set" of nerve-endings); and lastly, the violet-sensation is the result of the simultaneous action of the several rays, from the green-blue to the violet extremity of the spectrum. Thus, although it is true that the three "primary" colours are red, green, and violet, yet this must only be taken as a succinct statement of the Young-Helmholtz theory; for while spectrum-rays of one colour will serve to *represent* chromatically the corresponding fundamental colour-sensation, yet it is a physical fact that several widely-separated rays, *i.e.*, lights of very different colours, can excite in any one normal person one and the same fundamental sensation. We can, therefore, map out in the solar spectrum three curves, the height of each being a measure of the power of the different rays to excite their respective colour-sensations, and the area enclosed by each curve being a graphic representation of the entire group of rays, which, when simultaneously acting, yield a particular fundamental colour-sensation.

Thus any of the rays from red to yellow can excite, in varying degrees of intensity, the red-sensation, and all those rays acting together give the full fundamental sensation; but when we represent by a colour what this sensation is, we indicate it by light somewhere about the C line. And similarly for the other sensations. In fact, there is a difference between all the actual coloured rays, efficacious in producing a colour-sensation, and the chromatic representation of that fact of consciousness by a light of one definite colour.

The place of these rays in the spectrum, their relative sensation-producing power, and their relative amount of actinic influence, are physical facts; so that, following the data given by Maxwell, König, and Abney, one can, to use Mr Ives' own words, "by the photometric measurement of the density-curve of a spectrum negative" find the relative amount of reaction by the different spectrum rays. "It is therefore," he continues, "only necessary, in order to secure action by different rays in any definite proportions, to use such a combination of sensitive plate and colour-screen as will yield a spectrum negative having a density-curve corresponding to the graphic curve representing such proportionate action."[1]

Let us call the three paired photographs or stereograms A, B, and C; the negative of A was taken by interposing between the object and the sensitive plate a glass of such colour (yellow-orange) that only those rays capable of exciting the fundamental red-sensation acted on the plate, in the case of B the light which

[1] *Journal of Society of Arts*, May 27, 1892.

had passed through an aniline-yellow glass was such as affected only the fundamental green sensation; and C was illuminated, in its turn, by such rays as excited only the blue-violet-sensation, this being brought about by the use of a green glass selective screen.

We have really, therefore, not merely three stereograms or "positives" of stereoscopic photographs (which in themselves, viewed by daylight, show no colour, but are like ordinary positives from negatives taken in daylight), but we have three such records of the natural colours of the object, that in order to reproduce these to the eye, it is only necessary to superpose upon the retinæ the three triple images illuminated in the following way—that representing the effect of the fundamental "red"-sensation with pure red light (of wave-length as at line C), that representing the green-sensation with pure green light (wave-length E), and that representing the blue-violet-sensation with pure violet light (about wave-length G). This *blending* of the three images lit by the three "primary" coloured-lights, *i.e.*, the colours characteristic or representative of the three sensations, will excite exactly the same colour-sensations as did the polychromatic light coming directly to the eye from the object itself.

Thus, in the chromogram, A is a photographic record of all entirely red things and of such parts or points of any other things that reflected, scattered, or in any way transmitted red or allied light to the camera: the glass used as a selective colour-screen was not red (for red things looked at through a red glass are not red but whitish), but yellow-orange tinted glass, through which red things look most intensely red. Analogously for the other colours: B is a record of all things and all parts of things that in any way transmitted green or allied light to the camera, and C is such for the violet. A "primary" colour is one which cannot be made by combining any other coloured rays: red, green, and violet, or, in popular terms, vermilion, emerald-green, and ultramarine, are these colours, and with these we can form white light, and every possible colour, with all intermediate shades and tints of nature, not excepting the "saddest" of æsthetic hues. Thus every point of the object is represented somewhere in the chromogram, and the light it originally reflected is now provided to illuminate it: if it originally reflected only one kind of coloured ray—a primary—it can find that light again to tint it; if it reflected two or three kinds of rays, they are all there again for simultaneous treatment by it. The crucial test is in the case of colours not present as such in the spectrum, *e.g.*, the *purple* of plums or grapes: the photographs of these objects are combined into *one* image, as of solid plums or grapes, now lit simultaneously by both red and violet light—a fusion which produces the sensation of purple; and so on for all other shades and tints of colour. To quote Ives' words—"The three images of the chromogram represent the action of all incident light upon the respective fundamental colour-sensations, and the light by which each image is illuminated in the lantern or heliochromoscope represents the sensation itself." This is the gist of the whole matter: the "heliochromoscope" is the older name for the stereophotochromoscope, and by it a single image may be thrown on a screen instead of the double one into the eyes. Of course, when so projected on to a flat surface and viewed with the naked eye, as in a lantern demonstration to a large number of people, the illusion of solidity in the coloured picture is entirely lost, that being an effect due to optical contrivances produced by its very nature only in the brain of each individual looking into the instrument. While using the projection-lantern, the whitest of light—that of the electric arc if possible—must be employed, when the results are very satisfactory.

To those conversant with the practical details of photography, a criticism will at once suggest itself:—How can the three chromograms be taken simultaneously on the one plate, seeing that the time of exposure for red light is much longer than for any other colour? This is a difficulty which the inventor overcomes in two ways: he either reduces the intensity of the other two more active colours by interposing "ground" or smoked glass in the path of their rays, or he employs a larger diaphragm for the "red" light than for the "green" or "violet."

What strikes one on looking into the stereophotochromoscope is the brilliance or vividness of the colours of the object—an appearance partly due to the image being seen against a dark background, and partly to its being reduced, or less than "life"-

size: it is for this latter reason that the inverted image of a coloured object, sharply focussed on to the ground-glass plate of the camera, looks so clear and bright.

I have hitherto purposely omitted all reference to the purely optical contrivances in these two instruments. In the stereoscopic camera they are the outcome of extensive knowledge of chemistry, photography, and chromatics; in the other instrument, of as practical an acquaintance with both physical and geometrical optics. In the Photochromoscope, in order to cause coincidence upon the retina of the three coloured images, there are employed, besides the pure colour screens, objective-glasses and eye-pieces, seven mirrors—4 of silver, 3 transparent; each coloured ray undergoing at least three plane reflections before reaching the eye.

In a physiological laboratory this instrument will be of great value in demonstrating the physical data of the Young-Helmholtz theory of colour-vision; while it will be used by scientific physicians who desire to have a more accurate record than even an artist can give them of the colours and hues of lesions in skin diseases.

To the ethnologist, anthropologist, geographer, and scientific explorer it will also be of great service, while the value of any invention that would give a record of personal chromatic characteristics would be great in the Criminal Investigation Department.

A NOTE UPON THE VIBRATIONAL RATE OF THE MEMBRANES OF RECORDING TAMBOURS. By DAVID FRASER HARRIS, B.Sc. (Lond.), M.B., C.M., F.R.S.E.

(From the Physiological Laboratory, University of Glasgow.)

SEEING that certain observers believe that the inertia of the lever and india-rubber covering of recording tambours (*e.g.*, Marey's) is a source of error in tracings with these instruments, and seeing that these tambours have been widely used for graphic representations of movements of very different vibrational rates, I thought it well to attempt to estimate the period of oscillation of lever and membrane after mechanical agitation. I took an ordinary Marey's circular recording tambour (4·5 cm. diam.) covered with thin sheet india-rubber, stretched to medium extent, and carrying a light straw lever, 12 cm. in length, furnished with the usual short quill writing-style. The tambour was mounted on a heavy brass stand, and its quill touched the smoked paper of a drum rotating at the rate of 14 cm. per 5″. The drum having attained full speed, I struck the table (a large, heavy one, screwed to the floor) with a violent blow of the clenched fist, in order to set up free oscillations of lever and india-rubber, according to their own proper period dependent on their inertia. Only the amplitude of the oscillations, not their rate, was altered with varying degrees of energy of blow. The blows were given at intervals, on an average, of ·5″, the amplitude of the initial excursion of the lever varying from 4 mm. to 1·5 mm. according to the violence of the blow.

The period or vibrational-rate appeared by this method to be, on an average, 56 per 1″; the tracings showing 10 vibrations per 5 mm. of paper with striking uniformity in a large number of trials.

[Speed was 14 cm. per 5″

$\therefore$ per 1″ $\frac{14}{5}$ cm.;

now in 5 mm. there were 10 oscillations

$\therefore$ in 1 cm. . . 20 „

$$\therefore \text{ in } \frac{14}{5} \text{ cm.} \quad . \quad . \quad \frac{20 \times 14}{5} \text{ oscillations,}$$

or 56 per second.]

The oscillation usually gave a visible tracing for only ·25″, the amplitude rapidly dying away after 3 or 4 oscillations. In other words, the inertia of the india-rubber membrane of a 4·5 cm. diam. Marey's tambour expresses itself in an oscillation having a rate of between 50 and 60 per second, being in this case elicited by mechanical agitation of considerable energy.

I venture to think, therefore, that this alleged source of mechanical error can constitute an element of fallacy only in tracings of such movements as have a period somewhere between 50 and 60 per second.

Provided that a time-tracing be simultaneously taken, the rate of the main series and of superimposed wavelets could always be estimated. Without doubt each tambour has a different period from every other, dependent upon the extent, the thickness, and the tension of its membrane, and upon the weight and length of its lever.

Thus, in any investigation making use of such instruments, and especially when, in interpreting the curves, stress will be laid upon any small waves (rapid vibrations), or upon small waves superimposed upon larger (slower) ones, it would be necessary to determine, in some such fashion as the above, the "proper period" of the apparatus. According to my observations, the instrumental oscillations, even when set up by considerable violence, tend to cease (or become so small as to give no tracing) in the comparatively short time of ·25″. Professor Haycraft seems to have elicited vibrations of a cardiograph by surprisingly gentle pressures—light taps of the finger upon the membrane. From the above observations I would scarcely have expected such slight agitation to have set up the "proper period" oscillations described by Haycraft with such care.[1] The upper tracing he gives on p. 457 closely resembles several I obtained, and had it happened to be accompanied by a simultaneous time-tracing this note would be superfluous.

[1] "The Movements of the Heart within the Chest and the Cardiogram," *Jour. of Physiol.*, vol. xii., 1891.

NOTE ON THE REDUCING-POWER OF THE TISSUES.

By David Fraser Harris, M.B.

It is a fundamental conception in modern physiology that the tissues have an avidity for oxygen,—that internal or *tissue*-respiration is *the* process whereby oxygen is abstracted from the blood.

This was lately demonstrated to myself accidentally when injecting an animal for histological purposes with the Berlin-blue and gelatine mixture.

The instant the animal's heart ceased beating, it was bled from the apex of the right ventricle, and simultaneously the Berlin-blue injection through the aorta proceeded with. After the body had cooled and the organs were cut open, I was disappointed with the appearance of several of them, liver and kidneys especially,—thinking them uninjected, so pale did they appear. Parts seemed not coloured at all, others of the palest green; while in some of the large divisions of the portal vein in the liver, the gelatine mass seemed absolutely colourless. Every part of the lung was of the deepest blue.

Glancing at the little bits of liver and kidney ten minutes afterwards, I noticed they were distinctly deeper coloured; three minutes afterwards the deepening was undoubted; next morning (they had lain overnight in 10 per cent. formol), one would have said that parts were now well injected which the day before were colourless and apparently filled with gelatine only.

This was an undoubted case of de-oxidation by the living tissues, for the injection had been made so rapidly that both kidney and liver were practically 'alive,' and their avidity for oxygen uncompromised. Berlin-blue or Prussian-blue (a 2 per cent. solution) is ferric ferrocyanide—a *blue* salt; on de-oxidation it was reduced to a *ferrous* salt of light green colour; further de-oxidised (as in the liver) it was *bleached* to a colourless salt, or the chromogen of Prussian-blue.

On oxidation by exposure to air a comparatively slow recovery of colour ensued.

In these results there is nothing new,—they are only an unlooked-for variation of Ehrlich's experiments with methylene-blue, which also is bleached by de-oxidation.

In the lungs no de-oxidation occurred, because whatever small amount of oxygen the pulmonary tissue needed could be got from the air in the air-vesicles more readily than from its chemical combination in a salt of iron.