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VIII. *The Flicker Photometer and the Iris.*

By H. C. STEVENS \*.

IN a recent number of this Journal, the suggestion was made by an eminent authority † that the “physiological process” which affords the common basis by which coloured and uncoloured lights are measured by means of the flicker phenomenon, is the iris. The writer states that “The iris contracts when the eye is exposed to a bright red or to a bright green light. There must, therefore, be some relative brightness of the two lights which tends *equally* to close the iris, and this may afford the measure required. The flicker adjustment is complete when the iris has no tendency to alter under the alternating illumination.” And further, “It is clear, I think, that we have here a common element in variously coloured lights, such as might serve as the basis of coloured photometry.” It is undoubtedly true that the iris responds differently to lights of different intensities. Indeed, Haycraft ‡ has shown that the diameter of the pupil, as measured by instantaneous photograms, is a function of the intensity of the light falling upon the eye. The brightnesses of coloured lights determined by this method agree tolerably well with those obtained by the flicker photometer. It might well seem, therefore, that the iris were indeed the “physiological process” which serves as the common element in the measurement of intensities by the flicker photometer.

The hypothesis is susceptible of an experimental test such as to leave no doubt as to the rôle played by the iris in the flicker phenomenon. By the simple expedient of paralysing with atropin the *musculus sphincter pupillæ*, an iris is secured which is entirely immobile in the presence of lights of different intensities. Thus one is able by means of an *experimentum crucis* to eliminate from consideration the muscular action of the iris, according to the logical principle of the method of difference. If the flicker phenomenon persists in an eye with a paralysed iris, obviously some other physiological process must be sought as the cause of the phenomenon. Inasmuch as both irides react when light is thrown exclusively upon either eye, by virtue of the so-called consensual reaction of the irides, it is obvious that both eyes

\* Communicated by the Author.

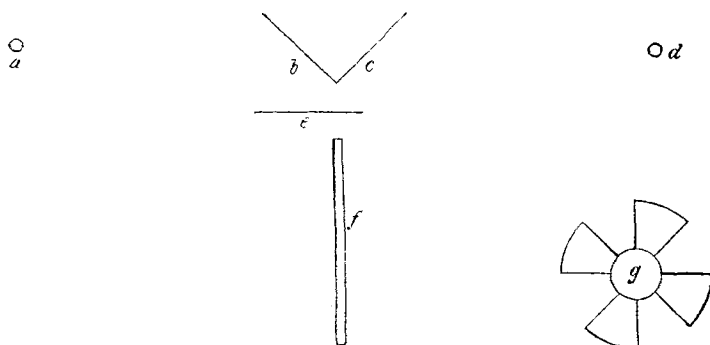
† Lord Rayleigh, ‘Coloured Photometry,’ vol. xxiv. no. 140, p. 301, Aug. 1912.

‡ Schaefer, ‘Text-book of Physiology,’ vol. ii. p. 1078.

must be atropinized in order to secure a condition which satisfies the logical requirements of the test.

The arrangements for producing flicker are shown in figure 1. The sources of light were two 16 candle-power

FIG. 1.



THE APPARATUS FOR PRODUCING FLICKER.

*a* and *d* are 16 c.-p. lamps on a 110 D. C. circuit.

*b* is dark blue coloured surface.

*c* is an orange coloured surface.

*e* is the card-board disk shown in *g*.

*f* is the tube through which the observations were made.

lamps, which are shown at *a* and *d* in the figure. The constancy of illumination of the lamps was controlled by a voltmeter in circuit with the lamps. The light from the lamps was reflected from the two oblique surfaces *b* and *c*. Surface *b* was coloured blue and surface *c* an orange. The sectored disk *g* was placed at *e*, where by its rotation it intercepted the light of the lamps which was reflected from surfaces *b* and *c*. The eye of the observer was placed at the end of the tube *f*, through which two flickering coloured surfaces, which divided the field of vision equally, appeared. Although the arrangement chosen for this experiment differed somewhat from those used in colour-photometry in that two flickering surfaces are shown in the field of vision, the arrangement was found very suitable for our experiment. By varying the speed of the motor, a series of flickers were produced which were arranged subjectively in a series from very coarse to fine, with the following designations: very coarse; coarse; medium; fine; and just visible. These designations proved to be very useful, since it was possible by means of them to compare the speed of rotation which caused a just noticeable flicker

or a coarse flicker for one observer with the speed of rotation of the disk, when a second observer described the flicker in the same terms as the first. The speed of the motor was regulated by means of a brake.

On January 18, 1913, an experiment was performed in which the irides of both eyes of the author and those of C. D. Livingstone were paralysed with a solution \* of homatropine sulphate. When the pupil ceased to change in size with changing intensities of light, the observers observed the flickering fields through the tube of the apparatus with each eye separately and determined the rate of the motor which caused the flicker to disappear. In order to make sure that the reaction of the pupil to light was totally abolished so as not even to remain residually, the pupils of both eyes of both observers were tested, with the aid of a bi-convex lens which magnifies about two times, by S. Karrer, whose eyes were normal. No visible reaction remained in the eyes of either observer when tested before and after the experiment. Under these conditions, the appearance of the flicker was not changed in any observable particular from the appearance of the flicker to the normal eyes. All degrees of flicker remained as before the atropine was placed in the eyes, and it is to be noted also that the disagreeable quality of the coarse flicker persisted undiminished. To make certain that both observers were observing the same phenomenon, the rate of rotation of the disk which was necessary just to obliterate the flicker was determined for

TABLE I.

	H. C. S.	C. D. L.
Left eye.	9.8 rvs. per second or 39.2 flashes per second.	9.9 rvs. per second. 39.6 flashes per second.
Right eye.	10.4 rvs. per second or 41.6 flashes per second.	10.9 rvs. per second. 43.6 flashes per second.

each eye and for each observer. The results are shown in Table I. Both the number of revolutions of the disk per second and the number of flashes of light are given in the table.

\* The prescription for the preparation is here given. As will be seen, the strength of the solution is somewhat less than 1 per cent.

Homatropinæ sulphatis i. gr. Aquæ Destillatæ ii. 3.

The agreement between the two eyes of each observer and between the two observers is as close as was to be expected from the method employed.

It should be pointed out that atropine, or its derivative homatropine, acts exclusively upon the myoneural junction of the nerve fibres which supply the sphincter muscle. The dilator muscle fibres, which have a nervous control totally different from that of the sphincter muscle fibres, are not affected by the atropine. The objection to the experiment just described, might be raised that the *musculus dilator pupillæ* might still respond to the light stimulus and so serve as the physiological process upon which flicker sensation depends. *A priori*, it is hardly conceivable that the dilator fibres could effect any change by themselves alone. The size of the normal pupil depends at any time upon the opposed action of the dilator and sphincter muscle fibres. When either muscle of the pair is paralysed, its opponent acts exclusively, with the result that a very large or very small pupil appears. But once the very large (mydriatic) pupil or its opposite condition the very small (myotic) pupil is achieved, there can be no change in the size of the pupil so long as the paralysis exists. The pupil is inactive in the presence of changing light intensities. The objection, therefore, is groundless.

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IX. *On the Energy required to Ionize an Atom.* By R. T. BEATTY, M.A., D.Sc., Emmanuel College, Clerk Maxwell Student of the University, Cambridge\*.

**T**HE energy required to ionize an atom, that is, to detach an electron from an atom, is a quantity of importance in checking theories of atomic constitution. Let us suppose that we specify the constitution of an atom by assigning to it a central positive charge  $ne$ , surrounded by  $n$  electrons distributed in rings of known radii round the central charge. Then we can calculate the energy required to remove one of the electrons from the system.

It is now widely believed that the atom contains a central positive charge surrounded by a number of electrons equal to about half the atomic weight. Some of these electrons are supposed to be attached tightly to the central charge and to possess a vibration frequency much greater than that associated with light-waves. A few electrons are supposed

\* Communicated by the Author.