

The Measurement of Colour

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LII. *The Measurement of Colour.* By A. C. JOLLEY and A. J. BULL.

THIS Paper deals with a series of experiments made with a view to ascertaining the form of optical instrument most suitable for the measurement of colour. All forms of colour-mixing arrangements in which intermittent light is required were omitted from these experiments, because the authors have found that intermittent illumination produces a somewhat rapid fatigue of the eye and the readings soon become of little value.

The standard colours employed may be derived either from the spectrum of white light or from colours produced by selective absorption. The latter suffer from the disadvantage that abrupt endings to the chosen regions cannot be secured nor a uniformity of transmission over the selected region, so that such colours must be somewhat arbitrarily chosen.

Methods most likely to be useful are those based upon the Young-Helmholtz's hypothesis. The central fact of this hypothesis is that it is possible to imitate any colour by the admixture in suitable quantities of the lights of three narrow regions of the spectrum, provided these are suitably chosen, and we have found that the only three with which we could match all shades were, for the blue primary a narrow region from 0.463 to 0.466μ , for the green the region from 0.529 to 0.535μ , and for the red from 0.634 to 0.644μ . Instead of adding these coloured lights broader primaries may be subtracted from the white light by the selective absorption of suitably chosen dyes, but in this case the difficulty of expression becomes a serious one, owing to the impossibility of securing dyes which absorb one primary region and transmit the remainder on the white light in equal proportions. This is indicated by the absorption curves in Fig. 1, which are those of a set of dyes carefully selected for the purpose.

The authors found the following experimental arrangements answer well for the matching of colours. Fig. 2 shows a method of employing monochromatic primaries. The colour under test is placed half-way over a transmission grating, the coloured patch and a portion of the grating being surrounded with black velvet. The lamp L provides the illumination for

the colour-patch, whose image half fills the field of the lens R, when the observer's eye is at the slit S. At a distance of 6 or 8 metres three straight filament lamps are placed in such posi-

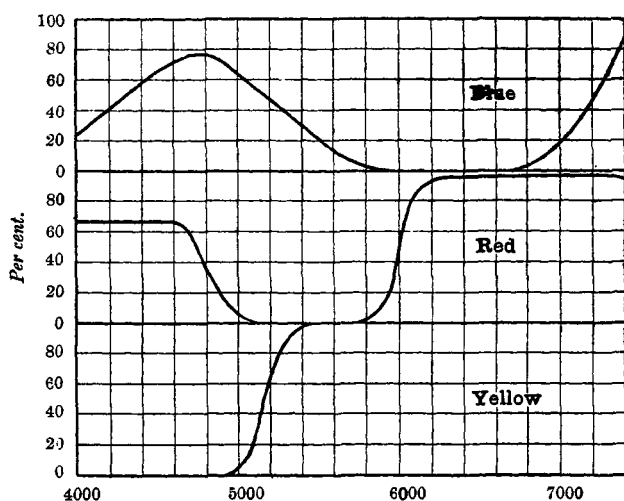


FIG. 1.

tions relative to the grating that each filament and the observing slit are conjugate for some particular wave-length.

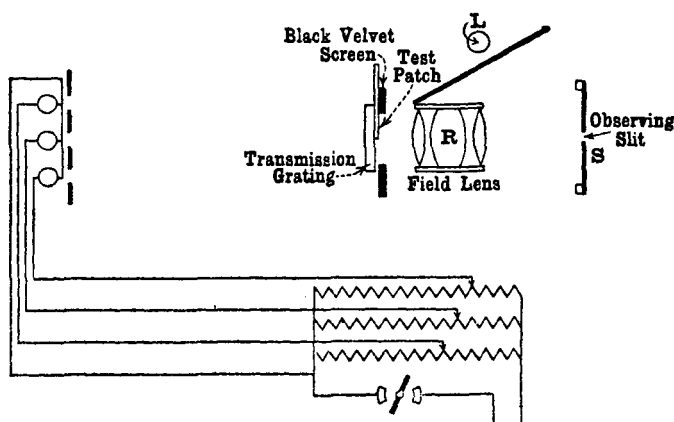


FIG. 2.

As diffraction effects interfered with the use of a very narrow slit a short range of wave-lengths, comprising some 50 tenths-metres was usually employed. The voltage at the terminals

of each lamp was made variable by connecting it across a potentiometer resistance placed under the observer's hand. In this way the intensity of each luminant was completely under control. The wave-lengths of the transmitted primaries were determined by means of a Hilger wave-length spectroscope placed at the observing slit. With this arrangement it was found that all pigment colours could be accurately matched, but that different eyes, sometimes the two eyes of the same individual, required different amounts of the primaries. So that, although the matchings were perfect, the arrangement did not lend itself to the specification of a given hue. It was found that with broader bands the proportions of the primaries were the same for different eyes, and Fig. 3 shows the plan of an arrangement for using these broader bands. It consists of a reversed spectroscope. The light from a white diffusing sur-

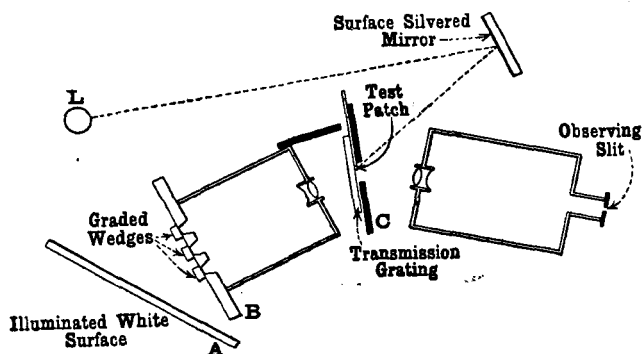


FIG 3.

face, A, which is lit by the lamp L, passes through three broad slits in the screen B. The grating C was half covered by the patch of colour under observation and was illuminated by light reflected from L by a surface-silvered mirror. The variation of the amounts of the primary lights was effected by sliding across the apertures in B three long-graded wedges of lamp-black in gelatine. This arrangement, although not as perfect as the previous one, was sufficiently good to show that the matches obtained were correct for eyes differing considerably in their colour sensitiveness, and, therefore, indicated that instruments employing broad-banded primaries are more likely to yield comparative results than those employing narrow ones.

Red, green and blue primaries produced by selective absorp-

tion were also tried, although these suffer from the defects that, except in the case of the red, it is not possible to obtain colour filters which transmit a large proportion of a given region ter-

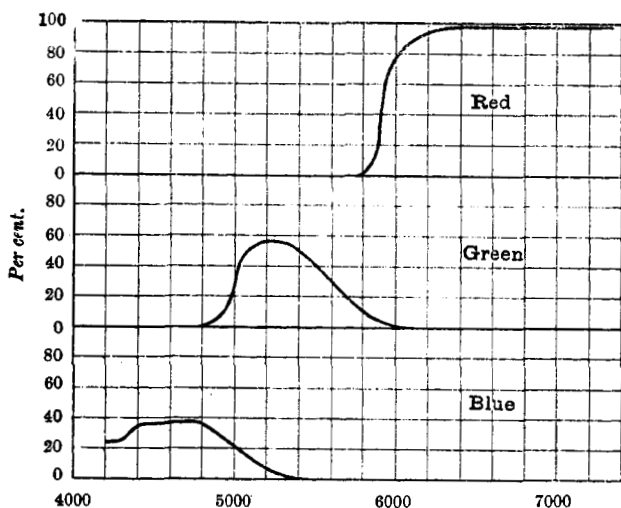


FIG. 4.

minated by abrupt absorptions, as shown by the transmission curves in Fig. 4. The lights passing through these colour filters were superposed by the arrangement indicated in Fig. 5.

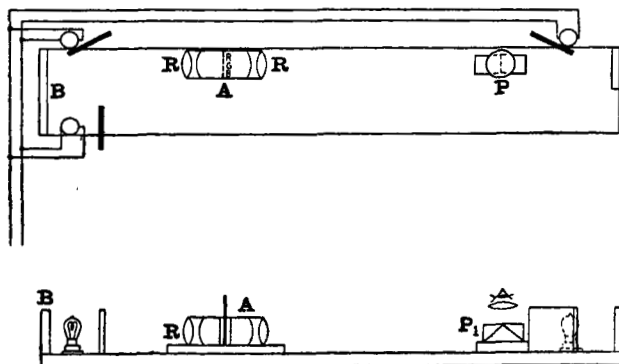


FIG. 5.

The two components of a large rectilinear lens were mounted in a framework and three variable apertures in the screen A covered by selected red, green and blue broad-banded filters.

A photometer, P, devised by Dr. C. V. Drysdale, and consisting of two right-angled prisms mounted with their edges in contact, was placed in such a position that the lens focuses the illuminated surface B on the photometer, therefore, one-half of the photometer is filled with light transmitted by the apertures in A, while the other receives light from the test patch which is illuminated by a lamp connected in parallel with those illuminating B. The matches were made by varying the apertures in A. This is the simplest arrangement tried, and the colours could be specified in terms of the apertures.