NOTES.

[Under the head of NOTES, it is intended in future to publish in the *Journal*, at the discretion of the Editor and Publication Committee, any brief and original communications that may be presented to the Society by our Fellows on the Construction of the Microscope, Microscopic Optics, subsidiary Microscopic Apparatus, and kindred subjects.—EDITOR.]

Notes on Colour-Illumination, with Special Reference to the Choice of Suitable Colours.

By Mr. JULIUS RHEINBERG.

(*Read 15th February*, 1899.)

"IN the exhibition of objects in multiple colour-illumination before you this evening, I have endeavoured to keep two ends in view. The first was to have as varied a selection of colour-discs as possible; the second, to show as varied a set of objects as possible. The latter seemed to me the more important, and you will find on the tables specimens of physiological and botanical subjects, crystals, fibres, fabrics, insect structures, diatoms, living rotifers, &c., shown by the three different systems.

"The last time I had the honour of bringing colour-illumination before your notice, only two methods were available; but since that time I have come across a third, which, to distinguish it from the high-power or diffraction method and the low-power or refraction method, may be conveniently termed the composition method; it is equally applicable to all powers, and there is no restriction to the cone of light used, as in the first-named methods. It consists of the employment of a disc in the condenser, having preferably a red centre and a green rim, which, when the quantity of green is correctly adjusted by means of the iris-diaphragm to the quantity of red of the central spot, together form white light, so that, without an object in the field, the latter appears practically white. When an object is in the field, though the background is white, the different parts of the object itself do not catch the red and green light in the right proportion to form white light, and the object itself appears coloured, edges and prominent parts coming out in the green colour of the oblique green light thrown upon them, whilst small perforations and other less prominent parts which do not catch the more oblique light to the same extent, appear in red.

"The reason a green disc with red centre is most suitable for this method of illuminating, is because the intensity of coloured rays entering the eye appears to vary with their obliquity. As the red part of the spectrum affects the eye so much more strongly than the other part, the red part of the disc needs to have given to it the special opportunity of affecting the eye in the strongest possible way; therefore the central portion of the disc must be assigned to this colour. *Vice versâ* I have not been able to obtain satisfactory results.

"I may here be permitted to say a few words as to the colours which I have found most suitable for discs for the other kinds of illumination.

"As regards the low-power method, it is essential for good results to keep the central portion of the disc of a colour not too luminous. On this account blue and green are preferable to red, and the most generally useful disc appears to be a malachite-green spot, an "Oxford" blue spot, and an olive-green. If a red ground is used, care must be taken to lessen its brilliancy by narrowing the band of the spectrum which it passes. This can be done by superposing a green; as almost all greens will, curiously enough, be found to transmit a certain range of rays in the red portion of the spectrum. It will be found in general to be a much more convenient way of getting at a good colour for central spots, to superpose different colours, and get at the result by subtraction as it were, than by adding two or three layers of the same colour. For the peripheral portion of those discs in which two colours are employed, red or orange will be found most useful, though almost any colour, no matter whether a pure or a mixed spectrum colour, will do, so long as it is sufficiently luminous relatively to the central spot.

"As regards the choice of discs, it will be found that opaque and thick sections are better seen when a disc is used having both rim and centre coloured; in fact there is a striking difference in the clearness of such objects as seen with a double coloured disc compared with their appearance when discs with centre coloured only are used. On the other hand, the latter kind of disc is usually preferable for diatoms and thin sections.

"Now, with regard to the preparation of discs for use above the objective in the high-power or diffraction method, the colours used for the central spot should not be too dark. It is essential for the most perfect performance of the disc that its central spot should allow a certain range of colours to pass through it common to the peripheral portion. By this means the untoward diffraction effects seen when the dioptric rays are stopped out with a black spot, are evaded and avoided. A light blue or a light green, which, as is well known, usually pass a wide range of the other colours of the spectrum, are to be most recommended for the central spot; a red should only be employed in the centre, when the peripheral portion of the disc is left uncoloured.

"With regard to the choice of discs for viewing particular objects, those with a red periphery, having the centre either coloured light blue or left uncoloured, are most suitable for relatively opaque and thick sections, whilst discs with a blue rim are best where it is a case of wanting to see the finest structure; the reason for this being, of course, that the blue rays diffracted from very fine structure may be just grasped by the objective, whilst the corresponding red ones may be just outside its cone.

"In some previous papers I have mentioned that discs for use above the objective might be made by cementing two cover-glasses together by Canada balsam, filmed surface inwards. Further trials have shown, however, that such discs are inferior in use to single cover-glasses covered with collodion, for anything higher than 1/3 in. objective, because the thickness of the double glass affects the correction of the lens too much, even when fitted with correction collar. With a thin single glass, the corrections are not appreciably disturbed, and can be compensated for entirely by the correction collar and tube-length.

"Reverting now to the employment of colour-discs in the condenser, I should like to show you my latest illuminator (fig. 29). You will observe it consists of a box, open at the ends, fitted under the condenser, in which there are a number of metal carriers, which can be pulled out or pushed in quite independently of one another by means of little handles. So that they may slide freely, each carrier is separated from the next by a sheet of celluloid. Each carrier has two circular apertures, the one being fitted with a colour-disc or other stop, the other one being left free. The kind of stop is indicated on the handle. The openings in the carriers are so arranged that when the apparatus is closed all the free openings coincide, so that illumination can be effected in the ordinary way. When any other illumination is required, it is only necessary to pull out the particular stop or combination of stops, each stop being in accurate position when pulled out as far as it will go. The special thing about the particular illuminator I have here, is that the edges of the carriers are turned over, so that the gelatin or other stop can be slid into them freely, and therefore easily centered.

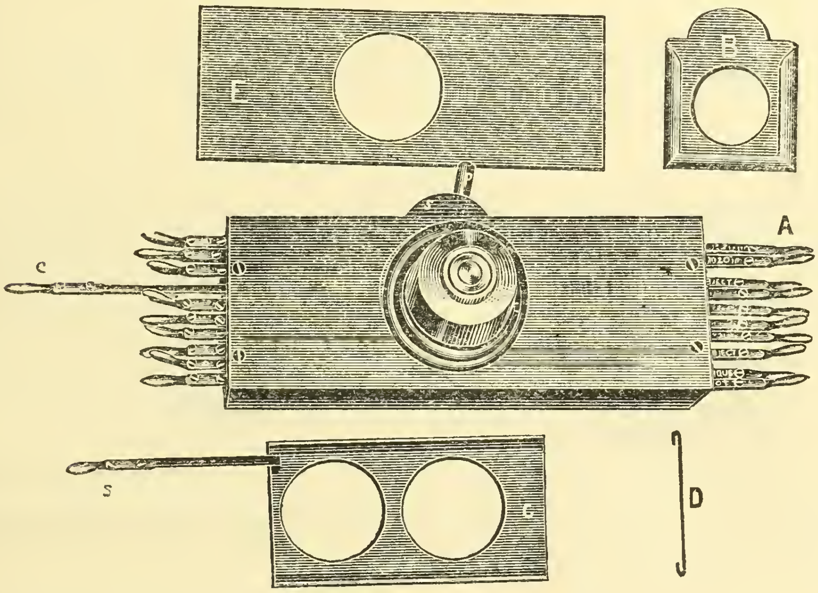
"Though the illuminator is bulky in the hand, it packs away under the stage of the Microscope, so as to be out of the way, and in use it is very convenient for rapidly comparing the effects of different stops.

"A good *large* source of light is the best when low-power or the composition method of illumination is resorted to. This may be obtained by using the bull's-eye in the usual way, or by placing a piece of ground glass immediately in front of the luminant, and dispensing with the bull's-eye. Personally I always use a Welsbach light, with a piece of ground glass just in front. In this way the source of light, besides having considerable extent, is a truly plane surface, and this I think is a great advantage over any source of light of irregular shape such as a lamp flame. Indeed, if I may say so, I believe insufficient attention has been given to using a plane surface of light in general microscopic work; which is curious enough, considering the attention given to the aplanatism of condensers. Surely the one demands the other.

"I have, in conclusion, only to add that we are indebted to Messrs. W. Watson and Sons and R. and J. Beck, Ltd., for the loan of the Microscopes displayed this evening, whilst a number of the slides are from the collection of the Society.

"To most of the cards at the sides of the Microscopes, a colour-disc is attached, exactly the same as the one employed in the instrument; and by holding the cards against the light, the colours can be examined."

Fig. 29.



A, Colour illuminator, with Abbe 1·4 N.A. condenser, seen from top, showing one carrier, *c*, pulled out; *p*, pointer of iris diaphragm; *s*, projecting part of a special carrier B, which can be pulled out altogether, and any kind of stop inserted as required.
C, One of the metal carriers, top view; *s*, screws for affixing little metal plate or coloured piece of gelatin, indicating kind of stop.
D, Cross section of metal carrier.
E, One of the sheets of celluloid separating the carriers.

Stops on left-hand side.

1. Matt ground celluloid spot.
2. Black central spot.
3. Blue ,, ,,
4. Red ,, ,,
5. Green ,, ,,
6. Red spot, green periphery (composition method illumination).
7. Large red spot, green periphery, (composition method illumination).
8. Black and white quarters.
9. Clear annulus in black stop.
10. Malachite green screen.

Stops on right-hand side.

1. Black annulus, 5–15 mm. diameter.
2. ,, ,, 10–20 mm. ,,
3. Blue periphery, clear centre.
4. Red ,, ,, ,,
5. Green ,, ,, ,,
6. Yellow ,, ,, ,,
7. Red and green halves, clear centre.
8. Blue and red quarters ,, ,,
9. Adjustable oblique light stop.
10. Adjustable slot.

N.B.—For low-power colour illumination the top lens of condenser must be removed.

Table of Comparison of the Three Methods of Colour-Illumination.

Method.	Colour-differentiation dependent	Available with	Chiefly suitable for	Cone of light from condenser used.	Colour-disc placed	Cone of light transmitted by central differentially coloured part of the colour-disc.
1st, referred to as high-power or diffraction method.	Chiefly on diffraction.	All powers.	Medium and high powers.	Narrow compared to objective cone.	Above or between lenses of objective.	Narrow compared to objective cone.
2nd, referred to as low-power or refraction method.	Chiefly on refraction and reflection.	Low powers.	Low powers.	Much wider than objective cone.	In sub-stage condenser.	Equal or slightly exceeding objective cone.
3rd, referred to as composition method.	Chiefly on position and form of the different parts of the object, without diffraction playing any determining part. In exceptional cases, however, wholly due to diffraction.	All powers.	Medium and high powers.	Any cone at will, greater than that passed by central spot of colour-disc, and not exceeding objective cone.	In sub-stage condenser.	According to circumstances; any cone less than objective cone.

A list of the objects exhibited under multiple-coloured illumination will be found on p. 245.