We are much indebted to Mr. Floyer for the great pains he has taken to collect, in Nubia, the necessary material for this investigation, and also to Sir W. T. Thiselton-Dyer for having grown the plant at Kew, from seed obtained from Egypt.

"On the Spectroscopic Examination of Colour produced by Simultaneous Contrast."

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Received June 12,—Read June 21, 1900.

In a previous communication I have described some methods of using the spectroscope to analyse sensations of successive contrast. In those experiments the eye, after having been fatigued by monochromatic—preferably spectral—light, is exposed to a second stimulus, consisting also of spectral light, exciting one or more colour-sensations which may or may not include that fatigued by the primary sensation. The question naturally arises, whether the spectroscopic method might not be applied to problems of simultaneous contrast.

With this view I made a number of experiments with the Marlborough spectroscope during the summer of 1897, of which the following may be mentioned. A piece of thin cover-glass was fixed in front of the eye-piece at an angle of 45° with the optic axis, so as to reflect into the field of view a small complete spectrum furnished by a $3\frac{1}{2}$-inch direct-vision spectroscope. In order that this might be visible against the bright field of the larger spectroscope, a glass disc, with an opaque spot of the required size painted on it, was inserted in the eye-piece close to the diaphragm.

With this arrangement it was easy to see the effect of contrast upon the smaller spectrum, but the lack of a comparison spectrum made the experiment far less striking than I had anticipated.

Recently a device has occurred to me by which this difficulty may be got over, namely, the production of simultaneous contrast by different colours in the two eyes.

This method is employed in the well-known experiment by Hering, to show that the apparent alteration of colours by contrast is not due to an error of judgment, but to some real effect produced in the eye itself.

An ordinary stereoscope is very convenient for this purpose, a square of red glass being inserted on one side of the central partition and a square of blue glass on the other. A small black wafer is then fixed at the centre of each glass, with a white wafer close to the left side of the one on the right-hand glass, and another on the right side of that

on the left-hand glass. The black wafers being the only spots common to both fields are easily fixed binocularly, and the white wafers, each seen with a different eye against a different colour, appear on either side of the combined black spots.

Under these circumstances, although the blue and red fields combine more or less to produce a purple sensation, each white spot retains the contrast colour due to that constituent of the coloured background which alone affects the eye in which its image is formed.

It was only necessary to find some method of substituting for the white spots two small spectra in order to demonstrate the cause of the greenish-blue appearance of the white spot on the red glass, and of the orange hue of the white spot on the blue glass. To do this, I place over each eye-lens one of Thorp's replicas of Rowland's gratings having 15,000 lines to the inch. Two slits are held in a frame in front of the aperture by which light is usually admitted when using the stereoscope for opaque photographs. The spectra of the first order of these slits appear in the middle of the two glasses. In order to prevent direct admixture of the colours of each spectrum with those of the opposite backgrounds, two opaque squares of black material are cemented to each of the coloured glasses, so shaped as to appear of the exact size and position of the spectra. On looking through the stereoscope, two spectra are seen side by side on a field, the colour of which continually oscillates from red through purplish-grey to blue. That connected with the red glass shows little or no red, but a splendid green and an equally splendid violet; while that belonging to the blue glass has the red well developed, the green pale and dingy, and the blue almost absent. The effect of varying the nature of the blue screen is very instructive. With cobalt glass the red is not very bright, owing probably to the transmission of some red rays by the cobalt glass, but the addition of a film stained with Prussian blue, by which these rays are absorbed, greatly improves the red. On the other hand, a pale yellow film which cuts off the violet causes the violet of the spectrum on the blue ground to stand out brightly, while a purple film brings out the green, which, owing to the green light transmitted by ordinary cobalt glass, is generally a good deal enfeebled. In each case the contrast of the two spectra seen by different eyes is so well marked that the experiment seems likely to be of service in teaching. It should not, however, be forgotten that the conditions are not quite so simple as in the ordinary production of artificial colour-blindness, and that the results are also somewhat more complex.

Hering's contention, that contrast phenomena originate in the eye rather than in the mind, is substantiated, but the complementary colour to red is shown to consist not of one simple colour-sensation but of two at least, namely, green and violet, and in my own case of blue also. Against a magenta background the complementary colour

is seen to be spectral green. But in this case the physical stimulus is complex. On adding to the magenta a yellow glass, to cut out the violet, or using candle light, the violet reappears in the complementary spectrum, while if a blue glass is added instead, the violet vanishes, and red stands out brightly in the spectrum. It may be thus shown that the colour which has green for its complementary is not spectroscopically simple, and since the spectral elements of it have each a different and independent effect upon the spectrum of the complementary colour, I conclude that the green sensation has no special connection with the red, or indeed with any single colour sensation.

It would, of course, be easy to arrange the apparatus so as to use pure spectral colours for the backgrounds, but the phenomena are sufficiently distinct for ordinary purposes with coloured glasses.

A portion of the apparatus used has been paid for out of the sum of £10 allotted to me by the Royal Society from the Government Grant.

"An Experimental Investigation into the Flow of Marble." By FRANK D. ADAMS, M.Sc., Ph.D., Professor of Geology in McGill University, Montreal, and JOHN T. NICOLSON, D.Sc., M.Inst.C.E., Head of the Engineering Department, Municipal Technical School, Manchester. Communicated by Professor H. L. CALLENDAR, F.R.S. Received June 12,—Read June 21, 1900.

(Abstract.)

That rocks, under the conditions to which they are subjected in certain parts of the earth's crust, become bent and twisted in the most complicated manner is a fact which was recognised by the earliest geologists, and it needs but a glance at any of the accurate sections of contorted regions of the earth's crust which have been prepared in more recent years to show that there is often a transfer or "flow" of material from one place to another in the folds. The manner in which this contortion, with its concomitant "flowing," has taken place is, however, a matter concerning which there has been much discussion, and a wide divergence of opinion. Some authorities have considered it to be a purely mechanical process, while others have looked upon solution and redeposition as playing a necessary *rôle* in all such movements. The problem is one on which it would appear that much light might be thrown by experimental investigation. If movements can be induced in rocks under known conditions, with the reproduction of the structures found in deformed rocks in nature, much might be learned concerning not only the character of the movements, but also con-