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The new physiology of vision—Chapter XXVIII. Observations with a neodymium filter

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Glass disks coloured by neodymium oxide make useful filters with which it is possible to cut out the yellow light of a mercury lamp (5770–5790 Å), while allowing the green light of the lamp (5461 Å) to be freely transmitted. Some specimens of such glass being available, it appeared worthwhile to examine the effect of placing a filter made of it before the observer's eye when viewing luminous objects. The changes in their appearance noticed in various cases are of such a striking nature that it appears desirable to place the observations on record.

Three plates were available, each about 4 mm thick. Viewing the sky through a spectroscope with one such plate placed before the slit of the instrument, an intense and sharply defined absorption covering the wavelength range from 570 to 600 mμ is visible. In other words, the filter cuts out the yellow light from the spectrum. Feeble absorption bands are noticed in the green part of the spectrum between 500 and 530 mμ. There is also a noticeable weakening of the blue part of the spectrum between 460 and 480 mμ. These other absorptions become very prominent when all the three plates are put together. But when only one plate is employed, they could be considered to be of negligible importance in comparison with the complete exclusion of the yellow from the spectrum by the principal absorption band.

Luminosity and colour: The reduction in absolute luminosity produced by the introduction of the filter becomes strikingly evident when we view an intensely luminous field, as for example, a part of the sky not far away from the sun. This region which appears insupportably bright to the eye without the filter could be tolerated when the filter is put in. Clouds in the vicinity of the sun which dazzle the eye when looked at directly could be viewed and their texture critically examined through the filter. The large contribution to luminosity made by the part of the spectrum between 570 and 600 mμ is thus made evident.

The effect of removing the yellow from the spectrum is even more striking in respect of the colours of various objects viewed through the filter. These effects are indeed of a rather paradoxical nature. The blue sky seems bluer when viewed through the filter. Green vegetation appears greener when seen through the filter than when viewed directly. Objects which normally exhibit red hues appear of a deeper and more saturated red colour. The explanation of these changes is not far to seek. A large contribution to the observed luminosity of the objects under view is made by the part of the spectrum between 570 and 600 mμ. When this is excluded by the filter, the luminosity of the object is reduced. At the same time the diluting effect of the yellow light on the colour of the perceived light is also abolished. The intrinsic colour of the object is thereby made more evident.

Many examples could be mentioned of the remarkable way in which the colours of familiar objects are altered by viewing them through the filter. Common sand and gravel laid on roads usually appear of a brownish-yellow colour by reason of their iron content. Viewed through the filter, they change to a brick-red hue. Fresh leaves which are of a greenish-yellow colour turn into a full green and appear like mature leaves, while mature green leaves turn into a darker green. Flowers are a particularly interesting study. Pelargoniums, for example, exhibit striking changes. Those which are of a pale rose-red hue appear quite red. Orange pelargoniums turn to a scarlet and scarlet pelargoniums to a bright red. Examples of such changes can be multiplied indefinitely. Perhaps the most startling effects are those exhibited by human complexions which when viewed through the filter appear suffused with blood. Striking changes also appear in the colours of the sky at the time of sunset, yellow hues turning to an orange red.

Colours of interference: Very interesting effects are observed when thin films exhibiting patterns of interference colour due to variable thickness are viewed through a neodymium filter. These effects are of different kinds, being respectively those noticed in areas where colours are ordinarily observable, those arising in the areas immediately surrounding them where little or no colour is ordinarily visible, and finally, those noticeable in more remote regions where the path differences are larger.

The first class of effects may be observed with Newton's rings or other arrangement exhibiting the colours of thin films of air. There is a notable reduction in the luminosity of the entire pattern and this is accompanied by striking changes in the distribution of luminosity as well as in the colours which are observed. The variations in luminosity as we proceed outwards from the centre of the pattern are less striking, though the first dark ring remains as a conspicuous feature. The spectral yellow along the circles of maximum luminosity disappears, while the colours seen in the adjoining regions gain in vividness. The cycles of the colour are replaced by green and red bands of strongly contrasted colour which are sharply demarcated from each other. Beyond the fifth ring of colour, numerous additional dark and bright rings spring into view. Some ten or twelve of these rings can be counted, five or six being perfectly achromatic, while those beyond which are less conspicuous appear edged with colour.

A convenient arrangement for observing the effects described above is to use two ordinary plates of glass each 10 cm^2 in area and about half a mm thick. After being carefully cleaned, the plates may be placed in contact so that only a thin film of air separates their surfaces. With a little gentle pressure, this air-film can be squeezed out from some areas which then exhibit interference colours. Viewing such an air-film through the filter, the various phenomena referred to above can be readily observed, and in addition, the entire area between the plates will be found to be covered with interference bands in areas where they would not be seen unless monochromatic light sources are employed.

We now proceed to comment on the explanation of the effects described above. It is well-known that by using a colour filter which cuts out most of the spectrum except a limited region, the number of interferences which can be seen and counted can be greatly increased. A red filter which cuts out all wavelengths less than 600 mμ may be cited as an example. An orange filter which cuts out all wavelengths less than 550 mμ produces similar effects but is not so satisfactory. The distinctive feature of the case with which we are now concerned is that the filter removes the limited region between 570 and 600 mμ but allows the rest of the spectrum to pass through. That it also results in an increase of the visible number of orders of interference is significant but is not altogether surprising. The effectiveness of the filter in this case is due to the fact that the spectral regions adjoining the absorption band are both quite luminous, viz., the green sector and the red sector respectively. Hence, they can both give rise to readily observable interference patterns. The superposition of these patterns is evidently responsible for the effects observed in the various regions and the differences between them.