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The new physiology of vision—Chapter XLII. Further observations with the neodymium filter

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The highly important role played in human vision by the yellow sector of the spectrum emerged very clearly from the studies described in the earlier chapters. Striking demonstrations of this are furnished by the effect of the interposition before the observer's eye of a piece of glass coloured by neodymium oxide which is of just sufficient thickness to exhibit a practically complete cut-off of the spectral region between 570 and 600 mμ, while in other regions the absorption is relatively much weaker. Preliminary observations made with such a filter have already been described earlier. But it appeared desirable to carry out a more detailed study with its aid and to present the results.

Characteristics of the filter: The specimen of neodymium glass used in the present studies was of rectangular shape $3 \times 2\,\mathrm{cm}^2$ and had a thickness of 5 mm. When held against a white card illuminated by direct sunlight, it appears of a light purplish colour and produces a surprisingly large reduction in intensity of the light transmitted through it. This feature is even more strikingly exhibited when extremely brilliant objects are viewed through it. For example, the dome of an observatory covered over by aluminium paint when lit by direct sunlight appeared almost insupportably brilliant when viewed by the naked eye. But when the eye is protected by the neodymium filter, one can look at the dome and continue looking at it without any discomfort. It is evident from these observations that the part of the spectrum between 570 and 600 mμ makes a large contribution to the visual brightness of any object, and that this contribution becomes proportionately much larger when the luminosity of the object goes up to high levels.

Besides the intense absorption in the yellow sector of the spectrum, there are three other regions of absorption; a fairly conspicuous band with well-defined edges in the green sector between 520 and 545 mμ, a second and feebler band between 510 and 518 mμ and finally, a weak absorption in the blue sector between 470 and 490 mμ. The conspicuously bright regions in the spectrum of the transmitted light are in the greenish-yellow between 545 and 570 mμ and in the red from 600 mμ to the long-wave end of the spectrum. As a substantial part of the yellow sector comes through the filter unabsorbed, it is not surprising that the colour exhibited by the filter in transmitted light is only a light purple. Indeed, the filter might be easily mistaken as being of a neutral tint.

The spectroscopic behaviour of the filter provides an insight into the remarkable effects observed when differently coloured objects are viewed through it. For example, the face of a person having a fair complexion as seen through the filter exhibits a startling blood-shot appearance, evidently as the result of the extinction of the yellow in the light diffused by the human skin. Likewise, when the blue sky is seen through the filter, it appears a deeper blue. Vegetation of a light greenish-yellow colour appears a deeper and darker green. In various books and brochures, one finds illustrations representing the colours in a pure spectrum as seen by the eye. The colours seen in such illustrations are, of course, not actually those of a spectrum, but only imitations thereof. Hence, when viewed through the neodymium filter, they present an altered appearance. As is to be expected, the yellows show a marked diminution in intensity, but no great change in hue. Other colours show changes both in hue and in brightness. Orange, for example, loses brightness and changes to red.

Coloured silks: In an earlier chapter, the relationship between the spectral character of the light diffused by dyed silk and the colour exhibited by the material was studied and discussed for a variety of cases. A technique even simpler than spectroscopic examination is to view the silks through colour filters of different sorts and to note the changes in brightness and hue resulting from the introduction of the filter. We are here specially interested in the effects produced by the neodymium filter. But it is instructive to compare these with the effects produced by other colour filters of commoner types, e.g., red, orange, yellow, green, greenish-blue or blue filters. Some thirty different samples of silk were available for the tests. It is convenient for examining them to place them in a row with an ordered colour sequence. This enables them to be viewed simultaneously and compared with each other.

Of the thirty samples, twenty exhibit highly saturated colours which could be arranged in a pseudo-spectral sequence ranging from dark red to a deep violet, while the ten other specimens were very lightly dyed or else exhibit special colours and could not therefore be placed in such a sequence. These two types will be dealt with separately in what follows. The filters of glass through which the dyed silks were viewed also exhibited saturated colours which formed a pseudo-spectral sequence, viz., red, orange, yellow, green, greenish-blue and blue. The appearance of the silks forming a spectral sequence of colour changed in a significant but not unexpected manner when viewed through this series of filters.

As seen through the red filter, the six silks which range in colour from red to yellow exhibit a brilliancy increasing in that order, in other words, the yellow silk appears the most brilliant. All the other fourteen silks ranging from a light green to a deep violet appear quite dull or dark as seen through the red filter.

Seen through the orange-coloured filter, the yellow silks are still the brightest, while a greenish-yellow silk shows an appreciable brilliancy. The green silks all appear rather dull and dark. The blue-green silks appear of a dull green colour, while all the blue silks appear dull and dark.

Seen through the yellow filter, there is a remarkable increase in the relative brightness of all the green and greenish-blue silks, the latter now appearing of a brilliant green colour. The blue and violet silks remain dark.

As seen through a green filter, there is a notable diminution in the brightness of all the silks ranging from red to yellow in colour. The silks ranging from green to greenish-blue now appear fairly bright, the blue-green silks appearing green in colour. But the silks of a deep blue bright colour remain dull and dark.

Seen through a bluish-green filter, all the silks ranging from red to yellow appear quite dull. The remaining fifteen silks are fairly bright, the blue-greens and blues particularly so.

Seen through a blue filter, all the silks ranging from red to a light green appear very dull or dark. The remaining silks appear fairly bright, the light blue silks being the brightest.

In considering the visual effect produced by the neodymium filter, we have, of course, to take note of the loss of about 10% in luminosity due to reflection at the two faces of the filter. The effects of the two absorption bands in the green and of the absorption in the blue have also to be considered. These absorptions diminish the contributions to luminosity made respectively by the green and the blue regions in the spectrum. Even taking account of all these features, however, the effect due to the elimination of the part of the spectrum in the wavelength range from 570 to 600 mμ is so conspicuous that it can be recognized in most cases. The change in the visible colour produced by this absorption is specially evident in the case of the scarlet, orange, orange-yellow, yellow, and light green silks. The diminution in brightness produced by it is particularly conspicuous in the case of the orange-yellow, yellow, yellowish-green and green silks.

Rose-coloured silks: Three samples of dyed silk exhibiting a rose-red colour and differing in the depth of that colour were available; one of them was a dark rose-red, the second was of a brighter hue and the third a brilliant pink. Very remarkable changes both in brightness and in hue manifested themselves when these specimens were viewed successively through the six colour filters of the series, the three samples differing notably amongst themselves. The observations show in a more spectacular fashion what spectroscopic study reveals as the origin of the rose-red or pink colours, viz., the presence of the red and blue sectors in considerable strength and a nearly complete absorption of the green and yellow sectors. Observed through the neodymium filter, the samples manifest changes both in colour and in brilliancy. But these are not of a particularly striking nature.

Metallic colours: There are many cases in which superficial colour is manifested by reason of the variation of the opacity of the material to light over the range of the visible spectrum. The colours exhibited by the polished surfaces of metals and metallic alloys may be cited as examples. The yellow colour of gold and the red colour of copper are the best known illustrations amongst the pure metals, while brass, bronze and many other examples of metallic alloys could be mentioned. In all these cases, both the lustre and the colour of the polished surfaces exhibit striking changes when viewed through the neodymium filter. Gold appears duller and of an orange-yellow hue, while copper assumes a deeper red colour than is normally the case.