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The new physiology of vision—Chapter XXX. The photo-mechanical reproduction of colour

SIR C V RAMAN

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We return to the subject of the reproduction of colour dealt with in the preceding chapter for a closer examination of the results achieved by the process most frequently employed for that purpose. As has already been there indicated, this operates on the same principle as that used for producing illustrations in black and white and known as the half-tone process. But instead of one half-tone block, the reproduction of colour is based on the use of four such blocks, the impressions of which are transferred to paper using four differently coloured inks, viz., black, yellow, magenta (also known as process red) and cyan (also known as process blue). The four blocks are individually prepared from four separate negatives obtained by photographing the objects under study through four different and appropriately chosen colour filters. It is of great importance to notice that the ruled screens used in making these photographs are set at different angles, viz., for example, at 45° for the black printer, at 75° for the magenta printer, at 90° for the yellow printer and at 105° for the cyan printer. As the result of these arrangements, the rows of dots of varying sizes which are transferred to the paper by the four printing blocks are orientated differently, as can be seen on examining the final printing through a magnifying lens.

A remarkable consequence of the arrangements described above is that the colours perceived by an observer are the impressions produced on his vision by a mosaic of differently coloured dots grouped around each other in a geometric pattern. These mosaics are visible in the finished picture on examination through a magnifying lens. That a great range of colours are thus successfully pictured is a fact of experience which evidently calls for further study and elucidation.

The reproduction of pictures in colour is a common feature in many publications of a popular nature. It is therefore easy for anyone to have access to a great mass of material illustrating scenes and objects of the most varied nature. A detailed study of such pictures through a magnifier makes it possible to arrive at definite conclusions regarding the manner in which the colours observed are related to the mosaic patterns appearing in the reproductions. Such a study demonstrates that the view commonly expressed regarding the reproduction of colour by the half-tone process, viz, that it is based on the subtractive principle of colour superposition, is completely false.

Comparative study of numerous cases makes it evident that the sensation excited by a mosaic of colour dots is determined by the proportion of the areas in it occupied respectively by the four coloured inks used in the printing and by the unoccupied area, if any, of the white surface of the paper. This conclusion emerges from a study covering the most varied examples of objects portrayed as well as of the colours displayed.

The colour most often represented in pictures is the blue of the sky. Depending on the circumstances, the colour thus depicted varies from a very light to a very deep blue, such variations often appearing in one and the same picture and not infrequently in areas adjacent to each other. In the areas depicting a blue sky, yellow dots do not appear at all and it is also unusual to find any dots of black ink. The colours that we do find in the mosaics representing a blue sky are cyan, magenta and white. In the more lightly coloured areas, the proportions of white to cyan is very considerable and of the magenta to cyan is generally small. In the bluer skies, the proportion of white to cyan diminishes and may even become negligible. On the other hand, the areas occupied by magenta are proportionately larger, and numerous cases are to be found in which we have only cyan and magenta, the areas occupied by these being comparable with each other.

Cyan ink printed on white paper exhibits both the blue and the green sectors in the spectrum of the light diffused by it, the yellow and red sectors being weakened and indeed nearly suppressed. On the other hand, magenta suppresses the green and the yellow and exhibits only both the blue and the red sectors in the diffused light. It is not surprising in these circumstances that since yellow is absent, blue is the dominant colour in the sensation excited by a mosaic in which cyan and magenta are both present; both green and red being much weakened are masked by the blue and are not perceived.

Of particular interest in this connection are the pictures of specimens of *lapis lazuli* found in Afghanistan which will be found reproduced on page 434 of the *Geographical Magazine* for October 1965. Sixteen specimens are shown grouped together, their hues ranging from a light blue to a dark blue approaching violet in colour. The greenish-blue dots of cyan ink can be recognised in the reproductions of all the specimens, even in those which seem to the eye to be dark blue in colour. The spots of magenta ink are also visible, but they are not very conspicuous. It is evident that the black printer has played a highly important role in the representation of the specimens which exhibit darker hues. Indeed, these pictures suggest that a greatly diminished brightness of the mosaics is itself the reason why the blues are perceived as being of darker hues approximating to violet in colour.

The dominant colour of vegetation is green and it figures very prominently in pictures of gardens and parks. The shade of colour varies from a light green in the case of freshly-grown grass to a deep green in the mature leaves of well-grown trees. Cyan and yellow are the prominent features in the areas of mosaic which appear green in the pictures. The greater the proportion of yellow to the cyan, the lighter is the green colour which is perceived. These results are intelligible, since

cyan ink exhibits both blue and green strongly while weakening the yellow and the red. On the other hand, yellow ink extinguishes the blue while the rest of the spectrum is perceived including especially the yellow. In the resulting sensation, therefore, the green is dominant. The more completely the yellow and red are suppressed by the cyan, the deeper would be the green exhibited by the mosaic.

Pictures in colour of well-known personages are very popular. The chief interest in such pictures is, of course, the individual himself, including especially the contours of his face, his complexion, the colour of the eyes and other important details. These features differ widely from individual to individual. Certain general characteristics may, however, be recognised. In a great many cases, magenta and yellow are the principal colours noticeable in the mosaics appearing in the reproduction of the faces. The more suntanned the complexion is, the greater is the proportion of the magenta to the yellow. In the darker areas, the yellow is replaced by black, and a sprinkling of cyan is also noticeable. Indeed, the examination of portraits reproduced in colour furnishes a highly instructive demonstration of the role played by the mosaics of colour spots in determining what we perceive in the pictures.

Brightly coloured dresses form an attractive feature in pictures of assemblies or public gatherings. Examination of such pictures is a convenient procedure for ascertaining how the proportion of the inks present in the mosaics determines the perceived colour. Taking, for instance, the brilliantly coloured tartans exhibiting stripes of colour which are a familiar feature in pictures of Scottish assemblies, one can trace the colour composition of each individual stripe as reproduced in the half-tone picture. In the orange-coloured stripes, the mosaic consists of rows of yellow and magenta crossing each other, these occupying approximately equal areas. In the red stripes, we have also a mosaic of magenta and yellow, but the magenta is then preponderant. In the green stripes, we have mosaics of cyan, yellow and black, and in the blue stripes, mosaics of cyan, magenta and white.

The reproduction of floral colours by the half-tone process is a subject in itself. Flowers being the principal adornment in public parks as well as of the gardens attached to private houses, they are favourite subjects for colour photography as also for pictures to illustrate publications dealing with various aspects of town and country life. There is a further reason for the great interest shown in reproducing pictures of flowers. A great industry has grown up devoted to the production and marketing of flowering plants and especially new varieties thereof. Colour plays a highly important role in the selection and popularity of the new varieties, and horticulturists are therefore at great pains to produce literature in which the nuances of colour of their productions are accurately displayed.

As an illustration of the foregoing remarks, we may mention a recently published pocket encyclopaedia of roses in which no fewer than 421 varieties of roses have been illustrated in colour, together with their origins and pedigrees and a detailed description of the blooms. The colours of the roses have been

classified into nine distinct groups. A systematic examination of all the pictures reproduced in this publication showed that in all except three cases, the colour mosaics showed only three inks, viz., yellow, black and red, besides white areas. The three exceptions were roses which displayed lilac coloured hues, the distinctive colour being evidently due to the presence of cyan as one of the components in the mosaics.