Journal of the

Colour Group

Number 9 March, 1967

Colorimeters

The March, 1966, meeting was on instrumental colour measurement. Two instruments were described and the results of a comparison of colorimeters presented. (report by K. H. RUDDOCK)

THE ISHAK-WRIGHT VISUAL COLORIMETER

W. D. Wright

The instrument is designed for the measurement of small differences in luminance factor between two samples and it can be adapted by the insertion of suitable colour filters to yield chromaticity differences. The filters are designed to convert the spectral sensitivity of the eye to the C.I.E. x and z functions.

A single source is used in the instrument, but the illumination on each sample consists of two components, one a fixed level of illumination coming directly from the source and the other a lower variable level which is incident on the sample after reflection in a mirror. The two mirrors (one for each sample) can be moved in opposite directions through a linked mechanism, so as to give small differential changes in illumination. These changes in illumination can thus be controlled and measured toa high precision. This photometric control is operated to provide an illumination difference on the two samples which just compensates for their difference in luminance factor, as judged in a Lummer-Brodhun type contrast photometer. An approximately linear relation is obtained between the displacement of the mirrors and the difference in the illumination on the two samples.

The samples are mounted on a rotatable table and the settings are repeated with the samples interchanged, which eliminates errors due to lack of symmetry in the system and makes the measurement truly differential. A precision of about 0.2 per cent can be obtained in the setting, and the comparison of the luminance factors of dark samples appears to be particularly satisfactory in comparison with other instruments.

THE COLORCORD, MARK 2

J. Hambleton

The instrument is a filter colorimeter, designed to give high accuracy and speed in use. It consists essentially of a source, an integrating sphere, coloured filters which attenuate the beam emerging from the sphere, and a photo-electric detector.

The integrating sphere is sufficiently large to make the exit ports equal to only 1 per cent of its total area. The light strikes the sample at 7 degrees to the normal and provision is made for direct measurement of the specular reflection. The diffuse reflection is collected from a ,limited angle of the integrating sphere ' surface. As the sample is mounted horizontally, crystalline and liquid materials can be easily held in the sample plane.

The filters are placed in the exit port of the optical system and are made up of coloured gelatine layers, arranged in segmented circles, with their composition computed to yield the appropriate C.I.E. distribution curves. The computation allows for the wavelength variation in the energy distribution of the source, in the sensitivity of the photo-detector and in the reflection coefficient of the integrating sphere. Filters can be computed to yield 2/, 10/ or uniform chromaticity co-ordinates for different illuminants.

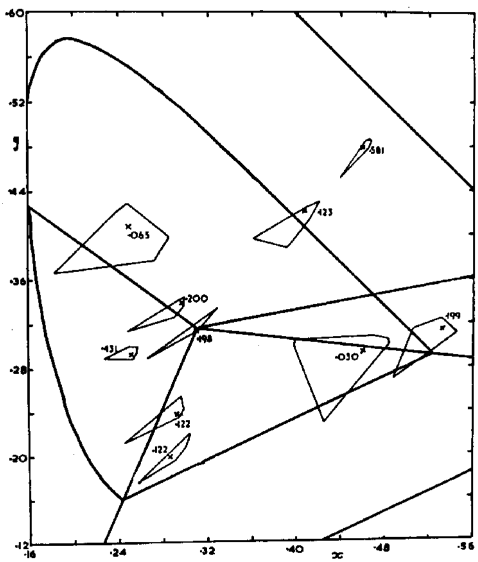
A fibre optics bundle pipes a sample beam from the source to a controlling photo-cell which compensates the detector photo-cell for source fluctuations. An electrical reference provides the balancing current for the null-method measurement. Each of the three chromaticity co-ordinates is measured by a separate potentiometer unit, thus reducing the amount of re-setting required from sample to sample. Results for twenty ceramic tiles show reproductibility within ±½ N.B.S. unit and give good agreement with data from a non-recording spectro-photometer.

During the discussion, Mr. Hambleton pointed out that any ageing effects in the instrument, such as in the photo-detector wavelength sensitivity curve, could be compensated by re-calculating the colour filter composition.

A COMPARISON OF COLORIMETERS

J. M. Adams

Mr. Adams was unable to be present to give his paper, and it was read by Mr. R. W. Brocklebank. 1 he paper described a simple experiment in which a selection of Munsell colours was taken to a number of commercial laboratories and manufacturers' demonstration rooms and measured on the instruments normally used there. The main result of the experiment was a considerable increase in the knowledge and experience of the people carrying it out, and their main comments were that most colorimeters are not as easy to learn to use as they might be, and that instruction books were not always clear and occasionally contradictory. The results showed considerable differences between instruments, and are summarised by the figure, which is a portion of the C.I.E. chromaticity diagram with polygons just enclosing the measurements made by the various instruments.



Paintings

The May, 1966, meeting of the Colour Group was held in the Lecture Theatre of The National Gallery, Trafalgar Square. (Report by G. WICKHAM)

PICTURE RESTORATION

H. Ruhemann

A profusely illustrated lecture showed the measures taken to ensure that no damage was done to works of art that are cleaned. The cleaner is forewarned by X-rays of hidden flaws and older restoration. Examination under ultraviolet radiation will show if varnish, invisible to the eye, has been removed.

Photographic records during the cleaning process demonstrate clearly that it was impossible to see details and the correct colour balance behind very brown varnish with which paintings were covered, particularly during the nineteenth century. The loss of brilliance and contrast was illustrated by lantern slides in which areas with and without varnish were compared. The loss was most crucial in the rendering of flesh where luminosity was paramount, especially with painters such as Rubens who used the "turbid medium" effect of translucent paint to produce optical greys—the "blues of the half shadows." In this, the case of Delacroix demonstrated the importance of cleaning pictures in the course of art history. He believed such blue greys seen through the yellow varnish to be green until he saw cleaned paintings of Rubens which emulated the green colour in his own work.

In answer to questions, Dr. Ruhemann explained how the cleaning was done, using as solvents alcohol and acetone diluted to well within a safety factor based on tests on less important areas in a painting. The solvent attacked the resin varnish which was soluble but left the insoluble oil medium. Paintings that cannot be cleaned in this way are those of artists who, like Sir Joshua Reynolds, mixed their paints with resin. Mr. Wickham recalled having heard Dr.

Ruhemann when The National Gallery's cleaned pictures were first exhibited in 1947. At that time there was much controversy over the cleaning of pictures, but most people now accepted that pictures were improved by cleaning, and Mr. Wickham was disappointed that a note of defensiveness was still to be detected in what had been heard at this meeting. Dr. Ruhemann regretted that this was so, but one had only to go to Paris to find masterpieces that are still almost impossible to see.

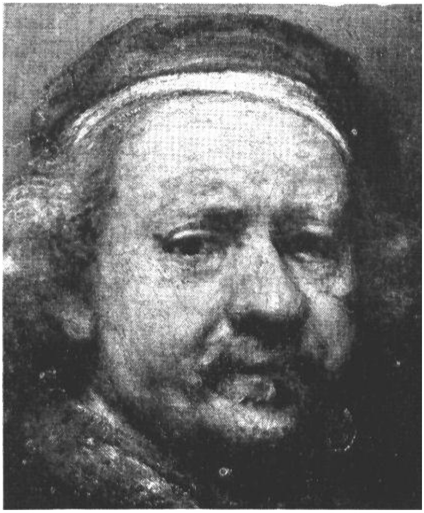
PIGMENTS IN PAINTINGS

Joyce Plesters

Miss Plesters traced the history of artists' pigments from historic times to the present day. Earth pigments with charcoal black and chalk or gypsum white have always been the basic colours for painting but there has been a continuous striving for more brilliant and permanent colours. One such of great antiquity was Egyptian Blue, a crystalline copper/calcium silicate, that was lost to painters until only a few years ago when its true nature was re-discovered. Verdigris, lapis lazuli and smalt—a cobalt silicate glass—blues came to be used by the Middle Ages. Dyes like saffron and indigo were also known but were not permanent. Metal foils, particularly gold and silver were used.

Around 1500 A.D. the painting of landscapes produced a demand for natural greens. A resinous verdigris green was developed but unhappily turned brown with time, not only altering the picture but in turn affecting eighteenth century taste so that brown trees became a requirement in landscape compositions. Pigments using aluminium hydroxide as a base for glazes of madder and other vegetable dyes also proved fugitive. The discovery in 1704 of the ferrous cyanide colour Prussian Blue has helped to date paintings and detect forgeries and retouching. Scheele's green and emerald green, both copper arsenates, lost their popularity because of their poisonous effects. In 1809 chromium was discovered and the brilliant chromates—yellows and oranges—became available, but paintings using these pigments have blackened with time. Since then more and more synthetic colours of increasing brilliance and reliability have become available.

X-ray photograph of Portrait of the Painter in Old Age *by Rembrandt, showing the areas painted in lead white, which is opaque to X-rays. (Reproduced by courtesy of the Trustees, The National Gallery, London.)*



Portrait of the Painter in Old Age *by Rembrandt. (Reproduced by courtesy of the Trustees, The National Gallery, London.)*

The Scientific Department of The National Gallery uses every means available to detect and analyse the pigments of paintings, and in this way are able to assist both Art Historian and Restorer. In restoration pigments are, where possible, matched with like and experiments are undertaken to reconstitute pigments. Resinous greens can be revived in situ, but as the colours are sealed in the medium this would mean destroying the surface of the picture. Madders are typical of colours that debase with time and so are difficult to analyse with certainty. These and other less permanent colours are matched with their modern equivalent. The lecture gave a fascinating picture of modern scientific methods applied to historical and artistic studies.

In the later discussion Dr. Ruhemann paid tribute to the very close relationship between his own work and that of the Scientific Department in such matters.

Picture Display

Members with time to spare in London should visit the Alwin Art Gallery at 56, Brook Street, W.1. The gallery exhibits works by living painters and sculptors, and these are shown against dark walls and illuminated by spot lamps having a cut-off at the edge of the picture. It is interesting to see the effect of each picture existing without any apparent surround. Dates and times of exhibitions are advertised in the Press.

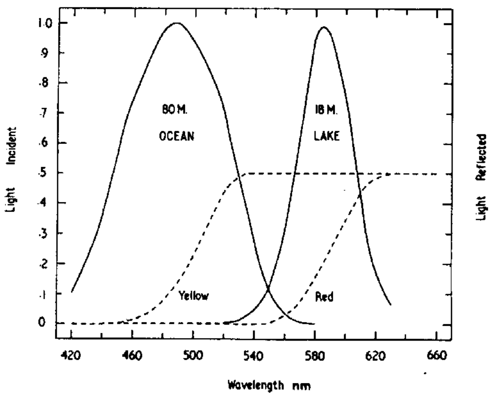
J. M. A.

Colour Under Water

Dr. J. N. Lythgoe, of the Vision Research Unit at the Institute of Ophthalmology, gave his lecture on "Conspicuous Fish and the Water they Swim In" to the October, 1966, meeting of the Group. Dr. Lythgoe's summary of the lecture is given below. The interest of the lecture itself was increased by the large number of colour slides illustrating the points made, and by an informal display of the photographic equipment used.

The lecture was followed by a film, "The Colour of a Dream" by James Dutcher. Although intended as a fantasy relying on the unfamiliar environment of under water for its effect, the film gave a further demonstration of the relative visibility of colours.

Pure water is blue, having its wavelength of maximum transmission at about 470 nm; inshore and fresh water, on the other hand, is usually green due to yellow products of vegetable decay and the great abundance of chlorophyll-containing algae. It would be surprising if this colour difference had no effect on the appearance of coloured objects underwater, and indeed in clear blue oceanic water it is the yellow parts of fishes which show the greatest colour contrast against the water background, whereas in fresh waters it is the red parts which show the greatest contrast.



Typical spectral energy curves for clear oceanic water (Jerlov type III) and water stained with the yellow products of vegetable decay (Jerlov type IX). The depths chosen are those where there remains just sufficient light for colour vision. For comparison are shown idealised spectral reflectance curves for red and yellow objects.

As daylight penetrates into a body of water, it becomes more monochromatic, and at depths where the incident light is just bright enough for colour vision only a rather narrow spectral band remains, and any features of spectral reflectance outside this band are irrelevant to vision. From the figure it can be seen that those coloured objects that show a sharp change in spectral reflectance at about the wavelength of maximum daylight penetration are those that allow the possibility of greatest colour contrast with the general backgroundillumination to the greatest depth. In clear blue water such a colour would be a yellow or its complementary blue. In fresh water the corresponding complementary pair are red and blue-green. In the Mediterranean, for instance, the yellow tails of such fish as the Painted Comber (*Serranus scriba*) and the Rainbow Wrasse (*Coris julis*) are very conspicuous below about 10 metres, as are the deep blue young of the Damsel] Fish (*Chromis chromis*). The situation is different in fresh water where it is the red fins of such fish as the Rudd (*Scardinius erythropthalmus*) and the Perch (*Perca fluviatilis*) that show up most vividly. Although not described underwater, it is likely that the Stickleback (*Gasterosteus aculeatus*), with its red belly and greenish-blue eye, would be particularly conspicuous.

It also follows from the figure that red would be indistinguishable from black at even moderate depths in clear oceanic water, and indeed, red fishes in the Mediterranean do not appear coloured at depths greater than, perhaps, 15 metres. Furthermore, yellow objects in fresh water would be indistinguishable from light grey, and this is also supported by observations on the yellow tail of *Engraulocypris argenteus* in Lake Victoria.

So far, we have considered the situation where an object remains close to the eye as the diver descends. At any single wavelength the contrast between object and background remains unchanged, but the available light decreases with depth, and hence the observer's ability to distingish contrasts ultimately decreases. A more natural situation is one where both observer and object remain at the same depth but the object recedes from the eye. In this case the bright veil of scattered light between object and observer causes the contrastpresented by the object against its water background to decrease exponentially as the object recedes. At present there are not enough data to put this on a satisfactory quantitative basis, but observations and photographs of a series of yellow, orange and red tiles, with spectral reflectances of the same form as the idealised ones in the figure indicate that for distant, horizontally-seen objects it is again the red targets that show the greatest colour contrast against their background in fresh waer and the yellow ones that show the greatest colour contrast in clear blue oceanic water.

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1 Underwater Visibility *S. Q. Duntley* in The Sea, Vol. I., Ed. M. N. Hill, Interscience (N.Y.) 452-455.

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R.H.S. Colour Chart

The Royal Horticultural Society first published a colour chart in 1941. This was prepared by Mr. R. F. Wilson, and printed using a halftone process. Each page illustrated one named colour, which was shown as a solid film and three tints.

The new chart shows several differences from the earlier edition, the most obvious being the change to a fan display. There are four fans, each covering different groups of colours, and the number of colours illustrated has been increased. One difficulty with the old chart was the lack of colours sufficiently brilliant to match present-day cultivated flowers.

The nomenclature has been simplified by abandoning the use of specific colour names, and by numbering the hues around a colour circle. Each colour is still illustrated together with three tints, and these are lettered A to D. In the atlas the circle of saturated colours is completed in three fans, while the "greyed" colours are grouped together in a fourth fan.

Correlations are provided, where possible, between the new chart and the earlier edition, with the Nickerson Fanand also with the British Colour Council's Dictionaries of Colour. C.I.E. specifications of each colour, from measurements by the Applied Optics Department of Imperial College, are also given.

The colours in the new chart were printed by the McCorquodale Colour Display Company, using their process in which each coloured ink is mixed separately, and led by a duct to its appropriate place on the card. Some saturated purples could not be printed in this way, and the tints of these are formed by halftones, as in the earlier edition.

This is an example of a colour chart designed for a specific purpose. The colours have been selected as those most likely to be required when describing flowers, and the system of classification describes these colours only. However, the descriptions of the colours in terms of the C.I.E. system link this chart with the main stream of colour science.

A fuller description of the chart, with illustrations, was given in the Journal of the Royal Horticultural Society for October, 1966, and the chart itself is published by the Society at 5 guineas.

J. M. A.

I.C.I. Plastics

Summer Visit, June, 1966

Unfortunately I was in a malleable mood when our respected Secretary and Editor both bore down on me and extracted a promise to write an account of this visit. I warned them of their folly but in vain.

Our party assembled in the cinema and after a short welcoming speech by Mr. Spencer-Palmer, and having been fortified with coffee and biscuits against the trek ahead, we divided into four groups filing meekly behind our four guides on a labyrinthine tour of the laboratories.

Luckily our guide led us first to the "Butakon" laboratory where, after dutifully admiring a demonstration of latex paper coating, I was able to beg a piece on which to jot down a few notes. Moving on to the Exhibition Room we were confronted with production and consumption statistics of the plastics industry in this and other countries since 1958. A wide range of products was displayed made from Acrylics, Nylon, PVC and vinyl copolymers, PTFE, Polythene, Polypropylene, Polyethylene terephthalate, Butadiene and Vinylidene copolymers and various thermosetting powders and resins.

Calling next at the injection moulding room, I stood watching fascinated while a machine making small hand magnifying lenses was being "run in." Articles as diverse as hair combs and car facia panels were also being made. I came out of that room with great treasure: two combs still joined by the "sprew" and with uneven teeth. Next we should have visited the Extrusion Laboratory, but my notes were not much help here containing only the cryptic words "lighting fittings!" I was probably too engrossed in twirling my two-comb propeller to notice.

At 1 o'clock we sat down to a memorable luncheon. An excellent wine delighted the palate, but took its usual toll of the brain's higher centres and my notes on the afternoon showed a just noticeable loss in precision.

In high spirits we set off for the Colour Laboratory where colour samples and standards were set out demonstrating changes due to dispersion instability and the fading, bleeding and blooming effects of exposure to light. Samples were also shown which had been subjected to various simulated weather conditions.

From thence to the Colourant Mixture Computer. This I remember as a large aesthetically shaped light grey box with many knobs. We were informed, however, that it had facilities for sources A, B and C and used the Kubelka-Munk and Duncan equations in its programme to specify a first prediction mixture. Reflectance measurements on a sample made to this specification using a Hardy Spectrophotometer then provided a first correction to the prediction. Usually only one correction was required.

We passed through the sheet shaping laboratory where my notes indicated that shaping was done pneumatically at 160/C., and then through the development laboratory where we saw machines packing and sealing cigarettes and food with polypropylene film.

Gathering again in the cinema we were entertained to tea and an I.C.I. film "An experiment in construction," showing the many new and versatile uses of plastics in the construction and furnishing of an experimental house.

Voicing our thanks to our hosts for all their efforts to make this visit both pleasant and interesting we dispersed at 4.15.

J. D. MORELAND

Surveys of Instruments

The Association of Clinical Biochemists has published two lists of spectrophotometers available in this country. The lists summarise the manufacturers' specifications of the instruments, and pay particular attention to the features that are important in biochemical applications. There are also two critical surveys of absorptiometers (called colorimeters) used for routine analysis. The first covers the Eel Flowthrough Spectra, the Gallenkamp Colorimeter, the Linson 3 Photometer and the Unicam SP 1300 Colorimeter. The second survey describes the Eel Absorptiometer, the Eel Portable Colorimeter, the Biochem Absorptiometer, the Spekker Absorptiometer and the Bausch and Lomb Spectronic 20 Colorimeter. The critical surveys are detailed, and are the result of using instruments loaned by the manufacturers in hospital laboratories. Full references of the reports are given below, and they are obtainable, at the prices indicated, from

Mr. J. T. Ireland,

Biochemistry Laboratory,
Alder Hey Children's Hospital,
Liverpool, 12.

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J. M. A.

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