Journal of the

Colour Group

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Recent International Recommendations in Colorimetry

At the invitation of The Institute of Physics and The Physical Society, the Colour Group is taking part in the 1965 Physics Exhibition, where, in Room D1 of the Renold Building, Manchester College of Science and Technology, the decisions taken by the C.I.E. Colorimetry Committee in Vienna, 1963, are being illustrated in words and pictures, models, charts, and working demonstrations.

The C.I.E. (Commission Internationale de l'Eclairage) is an international body set up to co-ordinate national activities in the field of illumination. International agreement on units and methods of measurement is achieved through regular C.I.E. meetings at which representatives from the member countries resolve on recommendations required to standardise local practice. The C.I.E. system for measuring and specifying colours is a three-dimensional framework based on the principle of additivity of colour mixtures, represented by the colour-matching functions of the human eye.

At the most recent meeting of the C.I.E., the Expert Committee on Colorimetry made four recommendations which were designed to extend the usefulness of the system. The Colour Group exhibit sets out the background of these recommendations, with demonstrations of some of the problems that have had to be faced; a detailed list of the exhibits starts over the page.

The exhibition is open from Monday, 5th April, to Thursday, 8th April. from 10 a.m. to 8.30 p.m. daily (except Thursday, when closing is at 5.30 p.m.); admission is by ticket only.

Guide to the Exhibition

1. STANDARD OBSERVER

A colour match made by one observer is not always a match for another; therefore the C.I.E. adopted a Standard Observer (in 1931) consisting of tables of spectral values for three functions representing the colour-matching data for an average eye. This was based on matches made with a 2/ field of view, the restriction being necessary because of the uneven distribution of the light-receptors in the eye and the failure of additivity with large fields. Nevertheless, large fields of view give more precise matching in practice, and accurate colour-matching data for a 10/ field of view are now available.

Recommendation I tabulates these 10/ tristimulus values for a supplementary Standard Observer, to be used whenever better correlation with large-field visual colour matching (more than 4/) is desired.

1.1 The structure of the eye is shown in a series of photographs; anatomical differences between small and large field retinal locations are emphasised.

1.2 Analysis of the photo-pigment system which gives rise to visual sensations has been carried out by means of fundus reflectometry and retinal spectrophotomicrography.

1.3 One of the most important causes of differences between large and small field colour matching is the macular pigmentation.

1.4 The C.I.E. 2/ (small field) Standard Observer is illustrated in model form.

1.5 The 2/ and 10/ tristimulus values are shown graphically.

1.6 A photoelectric colorimeter can be converted to correspond to the new distribution data for the 10/ field by the provision of a special set of tristimulus filters. Filter sets for 2/ and 10/ fields are here shown side by side. These filters are for use with the Hilger J.40 Colorimeter.

1.7 In practical application, the effect of field size upon the appearance of metameric pairs is particularly important. Examples of such pairs are exhibited.

1.8 The C.I.E. system controls viewing conditions so that certain visual effects are eliminated. For instance, when the visual angle is made very small (less than 20') the colour appearance alters.

1.9 Another factor left out of account in the C.I.E. system is the effect of the surround on the colour appearance of a sample.

1.10. The C.I.E. system applies only to colours seen by people with normal colour vision; a chart shows characteristic colour confusions associated with defective colour vision.

1.11 Diagnostic plates are used for detecting defective colour vision.

2. LIGHT SOURCES

Recommendation 2 suggests that any future sources developed for use as standards in colorimetry should be defined by spectral energy distributions. Practical sources should duplicate these distributions within prescribed tolerances.

2.1 Photographs illustrate the variety of illuminants encountered in everyday life and their effect on the appearance of objects.

2.2 Three identical collections of objects are seen under three illuminants. The middle set is lit by ordinary tungsten light. The upper set is seen under light of higher colour temperature and the lower set under light having the same correlated colour temperature as tungsten but a very different spectral distribution.

2.3 A cabinet shows three similar collections of objects side by side seen under sources A, B and C respectively. These standard sources were specified by the C.I.E. in 1931 to facilitate the comparison of object colours.

2.4 In order to provide a practical illuminant, source A is defined as a gas-filled tungsten lamp operating at a fixed correlated colour temperature. The spectral power distribution was taken to be that of

a Planckian radiator. Several different types of lamp fulfilling the definition are shown with power distribution curves showing that these are not perfectly Planckian.

2.5 Examples of the Davis-Gibson solutions, to be used as filters with source A to represent sunlight (source B) and average daylight (source C) respectively, are shown with various types of glass cell. The variations with can occur in making up the Davis-Gibson solutions are also shown.

2.6 The new recommendation establishes a different approach from that adopted in 1931. Sources A, B and C were intended as practical sources; standard sources are now to be defined absolutely on a theoretical basis.

2.7 An experimental method of assessing illuminants: Two composite light sources in which the spectral composition of the, light can be varied to show the effect produced by removing a part of the spectrum or changing the correlated colour temperature of the light source.

2.8 The C.I.E. recommends the adoption of a method of assessing lamps based on the colour appearance of a number of Munsell samples.

3. NEW STANDARD SOURCES

Recommendation 3 gives the correlated colour temperatures of four new sources to supplement A, B and C; three of them represent phases of daylight, taking into account the ultra-violet radiation of the source.

3.1 The C.I.E. 2/ x, y diagram is shown with the black body locus and illuminated points marking the positions of sources A. B and C and the four new sources, at 3,900. 5,500, 6,500 and 7,500/K respectively on the colour temperature scale.

3.2 Uses for the new sources are indicated.

3.3 The C.I.E. intends that the standard illuminants recommended at the higher colour temperatures should imitate phases of daylight.

3.4 Graphs show the results of measurements of daylight.

3.5 Now that data on the spectral composition of daylight is available. attempts have been made to produce artificial imitations. Some of these are shown.

3.6 The spectral range defined for the new sources includes the near ultra-violet. Two identical sets of objects are displayed illuminated by light having the same power distribution in the visible but differing in ultra-violet content. This shows how ultra-violet radiation affects the appearance of some objects.

4. UNIFORM COLOUR SOLID

Recommendation 4 proposes a three-dimensional perceptually uniform colour space, thus extending the two-dimensional u,v chromaticity space adopted by the C.I.E. in 1960. Uniform colour space is of practical importance in that colour tolerances can be defined by a single increment independent of its position in the space.

4.1 The lengths of experimentally determined chromaticity discrimination steps are plotted in the u,v plane, compared with corresponding steps in the x,y plane.

4.2 A locus of constant saturation is shown on thy and x,y diagrams.

4.3 A colour solid illustrates some of the properties of the three-dimensional U,V,W system.

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Report of Science Meeting

COMPUTERS

The subject of the 24th Science Meeting of the Group was "Computers and Colorimetry." The Meeting was held on 6th January, 1965, at Battersea College.

The afternoon's programme started with demonstrations arranged by Mr. A. W. S. Tarrant, on the Battersea College " Sirius " Computer.

Mr. Tarrant followed the demonstration with an introductory lecture on " The Use of Computers in Colorimetry," in which he compared the relative merits of desk calculators and digital computers for this type of work. Originally computers were inefficient for colour work because their cost was high, and the programming was complex, even for simple calculations. This meant that computers were best suited to carrying out long complex calculations on small amounts of data. The use of autocode programming and highspeed data feed-in by magnetic or punched tape and the principle of sharing a computer among the different types of work had now made it possible to carry out large numbers of colour calculations economically.

The second lecture was given by Dr. E. Atherton (I.C.I. Dyestuffs Division, Manchester) on " Colour Matching by Remote Computer."

The Instrumental Match Prediction Service provided a means for customers of I.C.I. Dyestuffs to obtain quick and accurate information on the dyes and dyeing procedure necessary to match a given sample colour. Having purchased a recommended tristimulus colorimeter to measure samples. the customer could submit a matching problem to I.C.I. from any part of the world by teleprinter and receive a formulation by the same means.

Mr. J. L. R. Landry (Davidson & Hemmendinger, Brussels) gave the third lecture entitled " Spectrophotometry and Colorimetry Practical Instrumental Colour Matching." Mr. Landry illustrated how the Davidson & Hemmendinger Colorant

Mixture Computer (C.O.M.I.C.) operated. A close approximation was first made to a spectrophotometric match to the sample, using the computer to mix the spectral curves of three, four or five dyes. In the second stage the computer took this spectral approximation and calculated the tristimulus differences ΔX, ΔY, ΔZ between it and the original sample as the spectral match was varied by small amounts. The condition giving minimum colour differences which was also close to a spectral match was taken as the recommended dye combination.

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