Journal of the

Colour Group

Number 10 July, 1967

Editorial

This is the tenth issue of our journal in its present form and it is time, perhaps, to take stock. Our main purpose so far has been to keep members who cannot attend meetings in touch with the activities of the Group, so most of the space has been allotted to accounts of the meetings. Here the Editor must express his thanks to the correspondents who have submitted these accounts; there has been no question of the Editor having to write this Journal himself.

But the Editor, and the Group's Committee, must now consider how the Journal is to develop in the future. It can remain an informal, and irregular, news sheet; but if it is to be successful in this form, many more people must submit the short items and illustrations that will make it a more lively compilation. Alternatively, should we solicitmore complete papers and attempt to build the Journal into a recognised medium for the publication of original work? We must consider the likely demand for such a Journal, and the extent to which it would overlap the fields of other Journals. Unnecessary proliferation of Journals is to be avoided.

Views of the members of the Group would be welcome and may be sent to the Editor or to a committee member. Please, though, let us have constructive comments. "Shoot the Editor" is no help to anyone. But "Dispose of the Editor because I am willing and able to do the job better" merits consideration, particularly if the ways in which the job would be done better are detailed.

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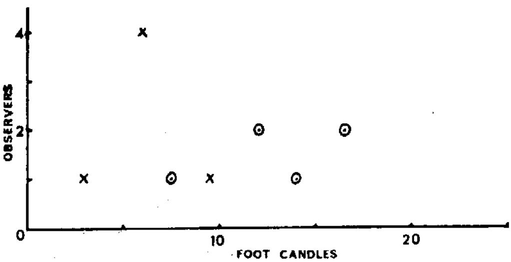
Light in Museums

The dark folds of the curtains in the lecture room of the Victoria and Albert Museum surrounded the Colour Group during the January, 1967, meeting. The subject was the problem of Light in Museums: enough light for the exhibits to be seen caused damage to the exhibits; if the light was reduced to a level at which no damage occurred, the exhibits could not be seen. The talks and demonstrations were given by Mr. G. Thomson of the National Gallery and Mr. E. R. Beecher of the Victoria and Albert Museum.

The meeting started with demonstrations of damage by light. Mr. Beecher explained that the wide variety of materials exhibited in the Victoria and Albert Museum made his problem particularly difficult. Textiles faded severely and examples were shown of fabrics that had been partly covered during display. The loss of reds was most noticeable, and was often complete. Light also caused a loss of strength of the fabric. Wood also fades on exposure to light, and drawers from inside and the front of a secretaire demonstrated this. This was an interesting case, as the varnish, with which the wood is covered and which contributes to the colour, would be expected to darken on exposure. Finally Mr. Beecher passed round a plain sheet of paper, carefully mounted, which he assured us had once been correctly catalogued as a red crayon drawing.

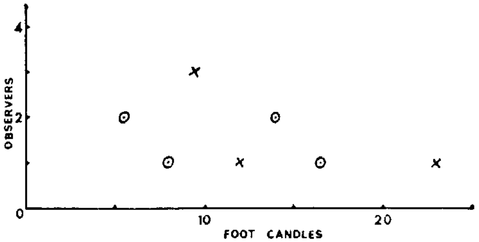
Mr. Thomson continued with slides showing pictures in the National Gallery which had suffered damage. Many old paintings had lost colour completely from some areas, and scenes with white leaves and pale clothing resulted. A common practice among classical painters was to form flesh tints by a wash of pink over a greenish under-painting. Light removed the pink and the resulting unhealthy pallor increased the apparent saintliness of the subjects. A once green copper resinate gave the brown trees that are now a prominent feature of so many old paintings. There was some discussion at this point on whether it was worth carrying out research on the restoration of copperresinates. If one had the means to restore the more brilliant greens to old paintings, would one be permitted to use it? At present restoration of pictures is confined to repairs and removal of obscuring varnish.

The incident radiation causing damage could be measured in Megalux hours. Fugitive paints showed changes after an exposure of about 15 Megalux hours, and textiles lost strength after 50 Mega-lux hours. An improvement was obtained if shorter wavelengths were filtered out, and for most subjects a filter cutting off betwen 400 and 450 Mg could be used without appreciably affecting colour rendering.



Number of observers against just adequate illumination level for neutral bock-ground. Crosses, illumination increasing. Circles, illumination decreasing.

It was generally accepted that an illumination level of 150 lux was adequate when viewing objects displayed in galleries and museums, and with normal opening times this gave an exposure of about 0.5 Megalux hours per year. This could mean a life for some objects of 30 to 100 years, and research was in progress to find if the level of illumination could be reduced.



Number of observers against just adequate illumination level for dark brown background. Crosses, illumination increasing. Circles, illumination decreasing.

The apparatus used for determining the minimum illumination level that would enable the exhibits to be seen was derived from the colour rendering experiment of Dr. Crawford. It had been brought into the lecture hall, and six members of the Group were volunteered to take part in an experiment. They gathered, clutching bellpushes, in front of three dimly-lit objects, and watched as the illumination level was raised. Their instructions were to press their bellpushes when the illumination was just adequate. The experiment was repeated with decreasing illumination and with the objects on neutral and dark brown backgrounds. The results were summarised in the graphs, and show a fair amount of scatter, as would be expected in an initial trial with untutored observers. More comprehensive experiments are planned and it will be interesting to see whether an average preference can be derived.

J. M. A.

Television

Three papers on Colour Television Cameras made up the programme of the April, 1966, meeting of the Group at Imperial College.

THE SEPARATE LUMINANCE COLOUR TELEVISION TUBE

I. J. P. James

The N.T.S.C. system is based on the fundamental laws of colorimetry, as expressed in the Maxwell triangle and Grassman's laws, and the main concern of this talk was to explain the role of a luminance pickup tube in a colour television system.

The laws of colorimetry are linear, hence the approximate square-law characteristics of cathode ray tubes require input signals of square root form (diode gamma correction). Three so corrected output signals, obtained with suitable dichroic filters and photo-multipliers would provide the basic colorimetric data. However, such a system would require three times the bandwidth required for monochrome transmission. To reduce bandwidth, the colour signals are added to yield a luminance signal. Narrow band colour-difference signals are generated and modulated on to a subcarrier and this is added to the luminance signal.

In a direct view colour television camera, as opposed to a film scanner, three pickup tubes are required by this system and displacement of the separate images can occur, e.g. due to beam bending caused by localised charge concentrations. It is, therefore, difficult to obtain good monochrome registration and contrast with such a system. To overcome this problem, a luminance ($V\lambda$) pickup tube is utilised, receiving, say, 20% of the original light, the remaining 80% being transmitted as with 3-tube systems. The 4-tube pickup has the following advantages :

(a) No registration problem occurs with monochrome transmission from the $V\lambda$ signal.

(b) Better contrast and resolution are obtained with simpler optics.

(c) The colour tubes do not contribute to luminance and hence have lower rejection tolerances.

(d) Better vertical resolution.

(e) Elimination of cross-talk and higher sensitivity.

CONSIDERATIONS IN THE DESIGN OF COLOUR TELEVISION CAMERAS

C. B. B. Wood

In order to provide a colour television transmission which is compatible with existing black-and-white receivers, the technique adopted in all the proposed colour television systems is to create first a signal proportional only to the luminance of each point in the scene. This is used by the black-and-white receiver, while two extra signals, known as colour-difference signals, convey to the colour receiver information of the hue and saturation. Differences between the various colour television systems proposed relate only to the methods by which the colour-difference signals are conveyed to the colour receiver.

Colour analysis of the scene is usually performed by separation into components of Red, Green and Blue. The luminance signal is obtained by adding together suitable proportions of the three colour-separation signals, but recent proposals have claimed advantages for the inclusion in colour cameras of a fourth pickup tube, especially to create an entirely separate luminance signal. The value of this lies in the fact that accidental misregistration of the scanned images in the three colour-separation pickup tubes of a three-tube camera will cause a degradation of the sharpness of the luminance signal, since it is made up by taking contributions from all three signals. In a four-tube camera, the luminance component, which mainly controls the sharpness of both the blackand-white picture and the colour picture remains undisturbed by misregistration. Three-tube and four-tube cameras both produce colour fringes in the colour picture in cases of misregistration, but this is found to be a somewhat less serious degradation than loss of sharpness.

Subjective tests show that the four-tube camera offers a significant improvement only in respect of tolerance of misregistration. It therefore follows that, if the registration of a three-tube camera can be made sufficiently accurate, and maintained free from drift during operations, the advantage of the four-tube camera will not justify the additional cost and complexity. Only a prolonged practical test in normal operations will decide the issue.

COLORIMETRIC ASPECTS OF 3- AND 4-TUBE COLOUR TELEVISION CAMERAS

W. N. Sproson

This paper is concerned with the colorimetric aspects of three- and four-tube colour television cameras. The spectral mixture curves for real red, green and blue stimuli consist of nine positive or negative components, but may be approximated to by the three main positive sections. The N.T.S.C. system utilises broadband spectral response tubes which approximately reproduce the main positive lobes of the spectral mixture curves, but these broadband response curves produce marked desaturation effects. The B.B.C. has specified narrower curves, having the same cross-over wavelengths as the N.T.S.C. curves, but with lower output values at these points. With these response characteristics, higher saturation may be attained, but hue errors are liable to occur in the yellow-orange range, and there is a sensitivity reduction of some 3 dB.

A general fault of almost all three-tube cameras is that high luminance errors occur, particularly for the blue colours, due to the absence of the balancing negative lobes. With a four-tube camera, the luminance tube having a "photopic" response, such errors can be largely eliminated provided that delta-L correction is used. However, chromaticity errors are more or less independent of the characteristic of the luminance channel of a four-tube camera.

An alternative approach is to derive, by electronic matrixing, a new set of response curves from the original optical analysis plus tube response characteristics. By suitable choice of the matrix elements, corrections for luminance and chromaticity errors are obtained. The optimum values for the matrix elements may be conveniently determined by means of a computer. The brightness correction is nearly as good as with the four-tube camera, and less than 1 dB loss of sensitivity occurs. All-positive (X,Y,Z) systems have been considered, but yield low sensitivity.

Pigments

The March, 1957, meeting of the Colour Group was the first to be held in the Manchester region, and was, perhaps to the surprise of some of the London members, well attended. The weather was mild and springlike and belied the reputation usually attributed to it over this part of the country. Perhaps the absence of test matches was responsible. Due to the good offices of the Geigy Company their excellent lecture theatre was placed at the disposal of the Group. Every conceivable refinement was present—tip-up seats, electrically-operated blackboards and curtains, dimming lights and a push-button signalling system to the projectionist. The performance was marred only by an absence of more complete communication with the projectionist which made it necessary to shout loudly when procedures were required which were more complex than the showing of the next slide. These exchanges were a source of some light relief during the session.

After the minutes of the previous meeting had been read and approved, a paper was presented by Mr. H. D. Brearley of the Geigy Company on the subject of "Some aspects of pigment dispersion." Pigments were divided into groups: lakes, metal toners, metal chelates, metal free azo pigments, cationic dye complexes, phthalocyanine pigments, vat pigments and non-vat poly-cyclic structures. Examples of each type were given with their respective structural formulae.

The physical make up of pigments was then considered in terms of the primary particles, crystallites and of the secondary particles, crystalline aggregates and agglomerates, and electron micrographs shown of various pigments to illustrate the propositions made. Dispersion was next considered, firstly in terms of the equipment to be used for its production and then in terms of its stability after manufacture.

Both stabilisation by "steric hindrance" in non-ionic systems and stabilisation by "electrical double layers" in ionic systems were discussed. Examples were shown of good and bad dispersions of phthalocyanine blue, toluidine red, and of a calcium 4B toner. Of great interest was the fact that whereas the opacity of the toluidine red increased with improved dispersion, the calcium 4B toner became more transparent.

The paper was concluded by a description of ways in which the dispersib.lity of pigments can be improved. The whole was a well-balanced outline of a subject which must be new to many members.

After a break for tea a second paper was presented by Dr. J. D. Moreland of the Institute of Ophthalmology on "the blue arcs of the retina." He explained that, like many workers over the last century, he had rediscovered a visual effect first published by Purkinje in 1823. When a small field is fixated within 8/ of the fovea a transient arc is seen entoptically. The arc corresponds topographically to the band of retinal nerve fibres serving the area stimulated and is always blue no matter what stimulus colour is used.

The effect was demonstrated by flashing intermittently on to the screen a red crescent-shaped patch, with a fixation point. After a time the blue arcs appeared radiating from the ends of the red patch. A further demonstration showed straight arcs between the fovea and blind spot.

Three hypotheses were suggested for the formation of the arcs-

1. Scattering of light by the nerve fibres.
2. Bioluminescence.
3. "Crosstalk" between adjacent nerve fibres or between nerve fibres and ganglia or bipolar cells.

The observation that the arcs were always blue, whatever the colour of the stimulus, eliminated the first hypothesis. In choosing between the other alternatives, knowledge of the anatomy of the eye was used to predict the expected shape of the blue arcs, particular attention being paid to whether they were aiming towards the stimulus or not and whether they continued beyond the stimulus. Experiments were described indicating how the form of the arcs had been determined and which indicated that the third hypothesis of crosstalk between nerve fibres and ganglia was most likely.

The third and concluding lecture was given by Dr. D. A. Palmer of the Institute of Ophthalmology on "A System of Mesopic Photometry." The mesopic region is the range of luminance intermediate between the photopic and scotopic regions where both rod and cone sells are operative. The problem was to find a simple non-visual way of measuring luminance in this region to replace subjective visual assessment. In either the photopic or scotopic regionsthe problem could be easily overcome by production of a photocell/filter combination to publicate each response. In the mesopic range both photopic and scotopic luminances were measured by these photocells for a range of spectral sources whose luminance had been determined visually by either normal or flicker photometry. These results have been plotted with photopic and scotopic luminances as ordinates to give contours of equal luminance. Sufficient measurements have been performed to enable the luminance of any new light source to be obtained by interpolation of the above plot once the photopic and scotopic luminances have been measured.

Owing to the length of the session the discussion period for these two papers was cut short to allow members to catch their trains. In view of the good attendance at the meeting it is hoped that in future they will be held in the North more frequently.

R. SMITH

Books

In December, 1964, a meeting of the Group was devoted to reviews of historic books on colour. This meeting was very successful, so a further meeting on the same lines was planned for February, 1967. This time the reviews were of books published within the past five years. The English books were reviewed by their own authors, while the three American books were each dealt with by "an authority on the subject."

Dr. H. Kalmus opened the programme with some general remarks about reviewing books and some special comments on the problems of reviewing one's own. He then reviewed his own recent book on "Diagnosis and Genetics of Defective Colour Vision," and in doing so accepted two points of criticism that had been raised by other reviewers, though regarding many of the eleven reviews he had seen as ill-informed.

Dr. R. A. Weale reviewed his book "The Ageing Eye," explained his reasons for writing it, and revealed that it contained one-and-a-half errors of fact.

Dr. C. A. Padgham in his review of his monograph, "Subjective Limitations on Physical Measurement," stressed the need to impress on students of physics (for whom the work was written) the fact that all our knowledge of the physical world comes through the channel of the senses, particularly vision.

Dr. W. S. Stiles reviewed "Color, a Guide to Basic Facts and Concepts," by Burnham, Haines and Bartleson. He gave a clear account of the unusual aphoristic style in which the book was written and drew attention to a number of details that might be open to question.

Mr. D. Tough reviewed "Principles of Color Technology" by Billmeyer and Saltzman, explained that it was directed to the unacademic technologist, and judged it a useful presentation.

Mr. G. B. Townsend reviewed his book, jointly written with Mr. Carnt, on "Colour Television," and demonstrated in an illustrated gallop through the pages that the title was in fact much longer, that the chapters contained concise summaries, that he was well ersedin the methods of commercial television, and much else besides.

Mr. G. J. Chamberlin declared in his review of "The Color of Foods" by Mackinney and Little that, quite apart from any reference to food, it gave the clearest introduction to colorimetry he had encountered, reinforced by plenty of worked examples.

Informal discussions following the Newton lecture. Foreground, left to right: Dr. K. Ruddock and Dr. R. Lakowski. Background: F. Malkin, J. Moore, F. Simon and D. Tough. The Newton lecture will appear in the next issue of the Journal.

Lamps

About 40 members were present at the meeting held at the Hirst Research Centre of the Wembley Laboratories of the General Electric Company, who had arranged for speakers and demonstrations and acted as hosts to the Group.

After introductions by Mr. Harris, Public Relations Officer, and Mr. Ferguson of the Lamp and Lighting Division, Mr. R. A. Evans spoke of the development of high pressure mercury metal iodide lamps. Difficulties involved in adding other metals to the mercury vapour lamp to improve its colour rendering have been reduced by using their iodides. The iodides, in vapour form near the walls of the envelope, do not attack quartz while at the centre the iodides dissociate and function as required. Mr. Evans showed three coloured lamps containing indium, sodium and thallium iodides respectively, and a white lamp containing a mixture of iodides and giving good colour rendering.

Mr. S. A. R. Rigden then described the high pressure sodium lamps. He explained that, although the pressure was higher than in a low-pressure lamp, it was still below atmospheric pressure. The arc temperature was higher than in a low-pressure lamp, and a major difficulty had been finding materials which would withstand chemical attack by the sodium under these conditions. A translucent ceramic was used for the lamp envelope. The lamp has a warm appearance, colour temperature 2,100 degrees K, high luminous efficiency and a life of four to five thousand hours.

Mr. W. A. Price dealt with customer preferences for lighting and described some experiments carried out in this field. The lively discussion following this presentation indicated the considerable interest in and some strongly held opinions on the subject.

Finally Mr. G. Mainwaring showed a plan of the high pressure sodium lamp installation lighting the road outside the G.E.C. Research Laboratory and said that the level of lighting was about three times that usual for such a road. The meeting then moved outside to see the installation. The improved colour rendering and comfort are readily apparent.

Colour Appearance

The two papers presented at the December, 1966, meeting have recently been published in full, so summaries are not given here. The references are:

Scales of Apparent Brightness. *C. A. Padgham and J. E. Saunders*. Trans. Ilium. Engng. Soc. 31. 4. 1966. 122-142.

Measurement of Color Appearance. *R. W. G. Hunt.* J. Opt. Soc. Amer. 55. 11. Nov. 1965. 1540-1551.

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