INTER-SOCIETY COLOR COUNCIL
NEWS LETTER

NUMBER 168 November-December 1963

NEW MEMBERS The following applications for individual membership were accepted at the last meeting of the Board of Directors held in New York City on October 14, 1963.

Individual Members	Particular Interests
Mr. Victor L. Carmona Dan River Mills, Inc. 111 West 40th Street New York 18, New York	Color in art (Painting, ceramics, etc.) Color in fabric styling.
Dr. Edwin B. Carton Cabot Corporation Dispersion Division 2250 East Ontario Street Philadelphia 34, Pennsylvania	Instrumental and visual color matching and control in plastics, and research problems related to the best techniques for accomplishing these objectives.
Mr. David A. Engdahl 65 Sharon Drive Rochester, New York 14626	Color printing, color measurement.
Mr. Dan Genin 44 Livingston Drive Hamilton Square, New Jersey	As a professional artist and in the physical properties of colorants as they relate to my work in the plastics industry.
Mr. Olle E. Haggstrom, Manager Industrial Design Operation General Electric Company 1285 Boston Avenue Bridgeport 2, Connecticut	Home furnishings, appliances, wood applications, packaging, etc.
Mr. George K. C. Hardesty Box 156 Mayo, Maryland	Those applicable to visual display devices in control consoles - principally illuminated displays - also psycho-physical criteria, specifications, and spectroradiometry in support of the above.

Individual Members	Particular Interests
Mr. James R. Kearl 259 Prospect Street Newport Beach, California	Color chemistry and optics, esthetics, philosophies of notation, psychological implications, physiological involvements in color perception. Pigmental and optical interactions in color vision.
Mr. T. A. Larned 2017 Calvert Avenue Costa Mesa, California 92626	Selection and specification of colors for missiles, space vehicles, and their associated ground support equipment and architecture.
Dr. Joseph A. Marano 10654 1/2 Wilshire Boulevard Los Angeles, California 90024	I am interested in how refractive errors of the eye alter the appearance of colored objects.
Mr. John Todd McLane Code 812 U. S. N. Marine Engineering Laboratory Annapolis, Maryland 21402	Research in field of illuminant color - glass filter, interference filter, color under ambient lighting conditions, colorimetry equipment design, psycho-physical color.
Mr. Laurence S. Miller W. P. Fuller & Company 450 East Grand South San Francisco, California	Colorant mixtures, color coordination of all applications relating to paint and surface coatings.
Mr. Joseph P. Neary E. I. du Pont de Nemours & Co. Inc. D & C Technical Laboratory P. O. Box 386 Wilmington 99, Delaware	Color measurement and formulation, spectrophotometry, colorimetry - fluorescent and non-fluorescent materials; have participated in activities of subcommittees on Problems 16 and 18 at and since New York meeting in March.
Mr. Hugh G. Neil 312 West Vine Avenue Knoxville, Tennessee 37901	Development of instrument techniques for color evaluation.
Mr. Donald E. Robinson 1410 Lincoln Road Bloomington, Illinois	Color comp., color styling, productivity in plants and offices, schools, hospitals, etc.
Dr. Ernest Rohner Pretema Ltd. Birmensdorf-Zurich Switzerland	Color measurement and its technical applications in the industry, color tolerances and recipe predictions.
Mr. Ralph Stanziola 2857 Nazareth Road Easton, Pennsylvania	Instrumental color formulation and control.

Individual Members	Particular Interests
Mrs. Beglan Birand Togrol Moda, Rizapasa Sok. 2. Kadikoy Istanbul, Turkey	Color perception, especially related to the perception of color combinations.
Mr. Gunnar T. J. Tonnquist Radjursstigen 44 Solna, Sweden	Organization of color research and color measurement in Sweden.
Mr. P. Donald Watson 2215 Brookline Road, Fairfax Wilmington 3, Delaware	At the present time I am writing my college thesis on "The Profitable Use of Color in the Business Enterprise." I am also very much interested in the phenomena of color.

ISCC ANNUAL MEETING Color in Education is the topic for the next annual meeting of ISCC. The topic is especially appropriate since the publication of the book, Color: A Guide to Basic Facts and Concepts. The meeting will be held at the Statler Hilton, New York City, May 4th and 5th. The World's Fair will be open during this time. It will be an excellent opportunity to schedule a dual purpose excursion to the big city.

GERMAN STANDARD "DIN" SYSTEM COLOR CHARTS NOW AVAILABLE Dr. Manfred Richter in 1941 started work on construction of an official German Standard Color Chart (DIN-Farbenkarte) which was intended, in the interest of application to all fields of industry and commerce, to sample the whole of color space as uniformly as possible. In 1953 a draft of the system, consisting of 168 gelatine filters showing the suggested hue circle division, and saturation scales of 24 hues at the same degree of darkness, was distributed to the German committee which decided to establish it as a German Standard, but to provide charts with mat surface samples.

In 1953, ISCC Newsletter 108 carried a review by Dr. Henry Hemmendinger of the work planned and presented by Dr. Richter and his colleagues in a group of papers in Die Farbe 1 (1953) outlining the basis of the system which the mat surface charts would illustrate. In March 1955 the Journal of the Optical Society carried a paper by Dr. Richter, translated by Drs. Judd and Wyszecki, which described the Official German Standard Color Chart. Since then there have been papers by Dr. Richter in Die Farbe 10 (1961), and more recently in DIN-Mitteilungen 42 (1963).

The charts of this system, DIN 6164, for which production of mat samples was started in 1956 and completed in 1962 by the firm of Muster-Schmidt, were made available to your reviewers through the courtesy of Dr. Richter and of Mr. Olaf Hansen-Schmidt. They make a most imposing array of 25 charts that contain 569 chromatic samples on 24 charts of constant dominant wavelength, varying from 15 or 16 samples on the purple charts to a high of 32 in the Y and GY charts, and 16 neutral samples on chart #25, an over-all total of 585 samples. Meanwhile, a new edition of DIN standard 6164, May 1961, contains corrections and refinements in the numerical tables.

The system is specified in terms of three numbers representing T:S:D, Farbton, T, Sättigungsstufe, S, and Dunkelstufe, D, translated as hue, saturation, and darkness. Observers divided the hue scale into 24 equal steps by selecting equal intervals from a 120-part Ostwald circle. The same 24 dominant wavelengths are then used at all saturation and darkness levels. Since "hue" is thus defined as constant dominant wavelength, the system fails to allow for the recognized variation of dominant wavelength for constant hue in the subjectively perceived sense. Saturation scales are based on judgments made first for equality of saturation for samples of moderately high saturation, then for equality of steps between neutral and the chosen level of saturation for each hue, this linear division being smoothed and extrapolated to higher saturations. The result can be very simply graphed on the CIE diagram, since the colors in each saturation series, S, have the same dominant wavelength and purity. See Fig. 1.

In the original diagrams for the DIN system, the chromaticity values were given in relation to the light source CIE C plotted at the center of the diagram, at $x = 0.333$, $y = 0.333$. This replaced the conventional and familiar method of plotting CIE chromaticity data with the light source placed in relation to an equal energy center point, in which case C plots at $x = 0.310$, $y = 0.316$. One must be very careful to avoid confusion on this point, for much of the DIN published data are in tristimulus and chromaticity numbers that are not comparable to CIE "C" data as they are published for color samples in this country. This warning must hold, even though tables and diagrams are now supplied with the DIN charts that follow both conventions. One set is on yellow paper, with C plotted at the center point; and another set is on blue paper, with C at the conventional point.

Regarding saturation, different constants are necessary in each of the 24 hues. The specification for darkness, D, is not a specification for constant luminance, but is based on a scale of "relative brightness value," h, in which $h = A/A_0$ is defined, A as the tristimulus value, and A_0 as the limit value Y that is possible for a non-luminous sample of the same chromaticity. This is based on the assumption that colors having equal values of this relative brightness are "equivalent" colors, based on a concept established many years ago by Rösch. Darkness, D, is then derived from a logarithmic function, $D = 10 - 6.1723 \log (40.7\,h + 1)$. This concept that colors with the same "relative brightness" value, h, and the same saturation degree seem also to be "equivalent" in a painter's sense, is of basic importance in this system. In this feature the system differs considerably from the Munsell system in which value, or lightness, for both chromatic and achromatic samples is defined in terms of luminance, Y. It also differs from the Ostwald System concept of equivalent colors which are those with the same white and black content (same position in the triangle). Superficially the charts, which are beautifully prepared, look somewhat like the Munsell hue charts, but it is soon apparent that the "Dunkelstufe" concept makes them quite different.

Diagrams are provided for converting to or from CIE chromaticity data, and a slide rule is available for working out ΔE color-difference data.

Each chart is mounted in a folder which contains three tables of constants for each hue, plus specifications for each sample in terms of CIE tristimulus values, Munsell hue/value/chroma, and Ostwald color constants. These tristimulus values are not the conventional ones; they relate to C at the center of the diagram, and must be converted (by multiplying X by .9804, Y by 1.0000, and Z by 1.1181) if they are to be used in the usual manner. The Munsell renotations provide very useful data for they seem to be of high accuracy. Indeed, they provided the data by which these reviewers were best able to study the charts of the DIN system, particularly the gamut covered by the samples. On the other hand, inclusion of Ostwald notations provides no help to American users, indeed may be more confusing than useful since the Ostwald notation used evidently refers to a transformation published by Dr. Richter in 1957 for which no collection of chips seems to exist. These notations appear to bear no relationship to those of the Color Harmony Manual which is widely used in this country to represent the Ostwald system. (In fact, it is hard to understand why Dr. Richter makes no reference to this best known and most widely used set of Ostwald charts, nor to the 1944 symposium on the Ostwald system published in the JOSA.) (It also should be mentioned that in practice the Ostwald letter notation has come to be used primarily as a notation grid, and the colors of samples assigned to each notation differ for each edition of chips, so that when the Ostwald notation is used as a specification it is imperative to refer to a particular Ostwald edition.)

On the 25 color charts, each color sample is shown on one side of a removable chip, 21 x 28 mm. and 0.5 mm. thick with an additional area 14 x 15 mm. centered on one end, serving as the tab. The other side is white cardboard with the DIN notation printed on it. Chips for each hue are contained in a gray slotted card which is page 3 of a 4-page folder, the other pages containing formulas, tables, and graphs of colorimetric data that relate to that hue. A plastic box with a padded wrap-around gray cover with snap fastener closure contains all 25 folders. The charts may be purchased from Beuth-Vertrieb GmbH, Berlin W 15, Cologne, or Frankfort, at a cost of DM 1340, about $338.

Production information, supplied by Mr. Olaf Hansen-Schmidt of Muster-Schmidt KG, Göttingen, who produced the color chips and charts under the direction of Dr. Richter, indicates that the chips were made by first coating white cardstock with a pigmented, heavily plasticized nitrocellulose type lacquer of appropriate color. Then a sheet of transparent cellulose acetate 0.14 mm. thick was applied over the wet lacquer which served as the adhesive. This sheet, glossy on one side and mat (mechanically etched) on the other, was applied with the mat surface up. This provides a very practical surface for matching, also one that can be cleaned easily with a cloth dampened with water or alcohol. Since the white cardstock is opaque, there is no variation due to showthrough.

Maximum color stability with age is perhaps the most important single feature which standard color chips should possess since it is almost impossible to duplicate the color with sufficient accuracy in successive chip productions. From a list of the pigments used (their English equivalents were provided by Max Saltzman) it is evident that the choices were generally the best that could be made. It would seem that better choices could have been made in place of the brilliant light blue, the thio indigo red violet RH, and the chrome yellows.

However, the main problem today in producing stable color chips lies with the binder in which the pigments are dispersed, to minimize yellowing with age. The choice of a nitrocellulose type lacquer may not have been the best because it is known to yellow at perhaps 5 to 10 times the rate of cellulose acetate. But with cellulose acetate lacquers, the plasticizer balance is critical to film flatness and difficult to maintain, so that production techniques may not have permitted its use. Also, there have been improvements in nitrocellulose lacquers in recent years so that a real test of the stability of these chips can be determined only by measurement after appropriate periods of aging. Instructions on the charts recommend that for the most accurate use the chips be re-measured at intervals not to exceed two years.

Each color was formulated to match a standard colorimetric specification and although no check measurements on the chips have been made by the reviewers, except by a visual comparison of the Munsell renotations that are provided on each chart, the technical excellence of the matching seems very high. In fact, this may be one of the outstanding achievements of the charts for it is far more difficult to make chips to an accurate colorimetric specification than to approximate ideal values and then measure the color after the actual chip production has been completed to see what one really has. Samples were produced to a color tolerance of "accuracy 1" (Genauigkeitsstufe 1) which corresponds to a value of 0.35 in 1962 ΔE_{DIN} units. (In practice Dr. Richter finds that 1 ΔE_{DIN} corresponds approximately to 5 or 7 ΔE_{NBS} units, which means that "accuracy 1" is equivalent to about 1.7 to 2.3 NBS units.) Measurements made on a photoelectric spectrophotometer at the Muster-Schmidt factory were checked by the DIN Laboratory in Berlin. The lacquer color for each chip was successively approximated until it came within the stated tolerance. This matching technique helps to explain the relatively high cost of the charts.

Nineteen chromatic pigments in addition to black and white should be more than adequate to cover the industrially important color range of the maximum color gamut, so one would expect it to be sampled adequately by the charts. However, the system itself samples the constant hue section in a way unrelated to the maximum color gamut since the colorimetric specifications for each color are chosen from uniform intervals on the grid of D and S. This restriction is most evident in the light, clear tint range for yellows and oranges (hues 1 to 4) where the colors are a good half step value darker than samples now provided in Munsell chips. See Figure 2. At first glance, this will not be evident when viewing the charts because the gray background tends to make the light yellow chips appear lighter than they are. When viewed on a white background, the relative darkness of the D=1 series in these hues is readily apparent. A supplement containing samples with D values of 0.5 would have provided a more adequate sampling in this range.

For the hue circle, the maximum color gamut is sampled about as well as one could expect for mat surface chips of DIN hues 6 to 20. When compared to the mat sides of the third edition of the Color Harmony Manual, the DIN gamut is equal to or slightly better in these hue regions. However, for DIN hues 21 to 5, the maximum saturation color is significantly grayer. It is probable that this situation exists because the next unit step of saturation is outside the gamut of the colorants and cannot be matched. Therefore, one must back off to the nearest step of saturation that can be matched. Another reason is that the extra interface provided by the cellulose acetate film does not permit quite as saturated a color as when a pigmented lacquer forms the top surface. In this connection it should be mentioned that the darkest chip in a number of the hues appears to have been given an overcoating of a colored lacquer in order to eliminate the effect of the extra interface. This is easily noticed by viewing the chips at grazing incidence.

The DIN constant saturation scales may portray Ostwald shadow series (colors of constant purity) more accurately than the Color Harmony Manual chips but most people consider this to be an academic feature that hardly compensates for the restrictions in the maximum color gamut and near-gray color ranges of the DIN charts compared to those of the Manual. A comparison of the DIN and Munsell gamut of samples shows that the Munsell glossy sample gamut has not been met. A comparison of the DIN and glossy Manual gamuts shows generally the same restrictions in the region from full color to black. The gamut of Munsell mat samples currently available is not met in some cases and is exceeded in only a few cases.

Nevertheless the DIN charts do provide a beautiful, and carefully produced set of color samples that provide scales of constant darkness, a concept not heretofore portrayed, which now will provide an opportunity to evaluate the usefulness of this scale which appears to be intermediate between the chromatic series of constant Munsell value and the Ostwald series of equal black content. Technically, the charts of this system provide samples that in quality stand with those of the Munsell and the Ostwald Color Harmony Manual charts produced in this country. But while it represents a really elegant effort in an attempt to build everything into one system, in this it fails to succeed. It does not provide the user with a system superior to either the Munsell or Ostwald, and for far fewer though larger samples (585 vs. about 1,200 mat, and 1,435 glossy chips in the currently available Munsell series, 949 in the Ostwald) the cost is considerably greater.* Nevertheless, for those interested in the careful development of color charts, this is a contribution well worth further study. For those who make constant or careful use of color charts it will provide another sampling of color space, provided with accurate colorimetric data, that may contain just that color sample that may be needed and is missing in other collections.

D. Nickerson and
W. C. Granville

*The currently available mat surface Munsell opposite hues edition and the full cabinet edition of glossy Munsell samples each retail in the United States for $155, the Ostwald Color Harmony Manual for $175.

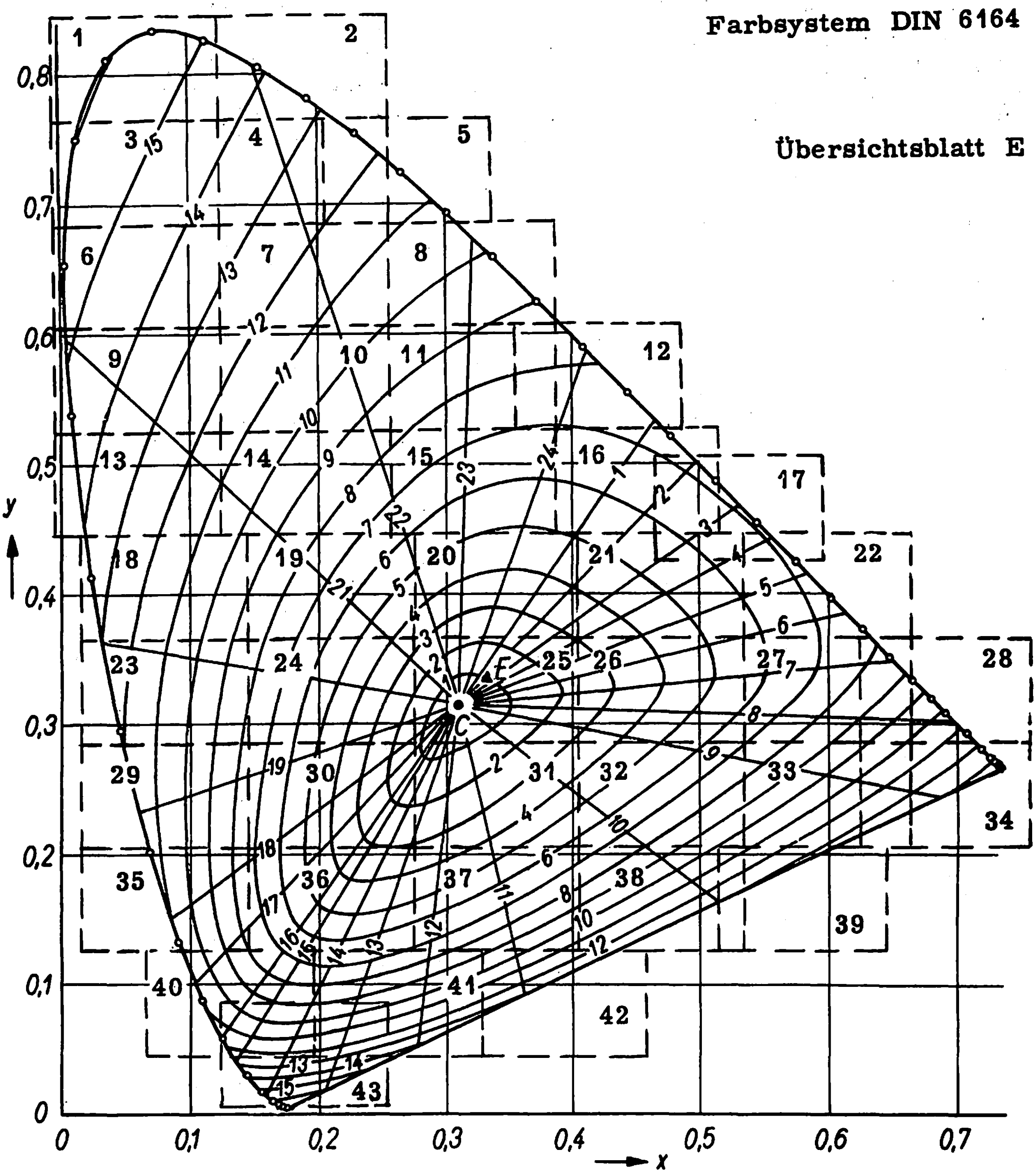

Figure 1.--German DIN 6164 color system plotted on a CIE (x,y)-diagram. This represents an enlarged series of 43 diagram sections (reproduced on blue paper) in which C is plotted at x = 0.310, y = 0.316. A similar series is available (on yellow paper) for C at x = 0.333, y = 0.333.

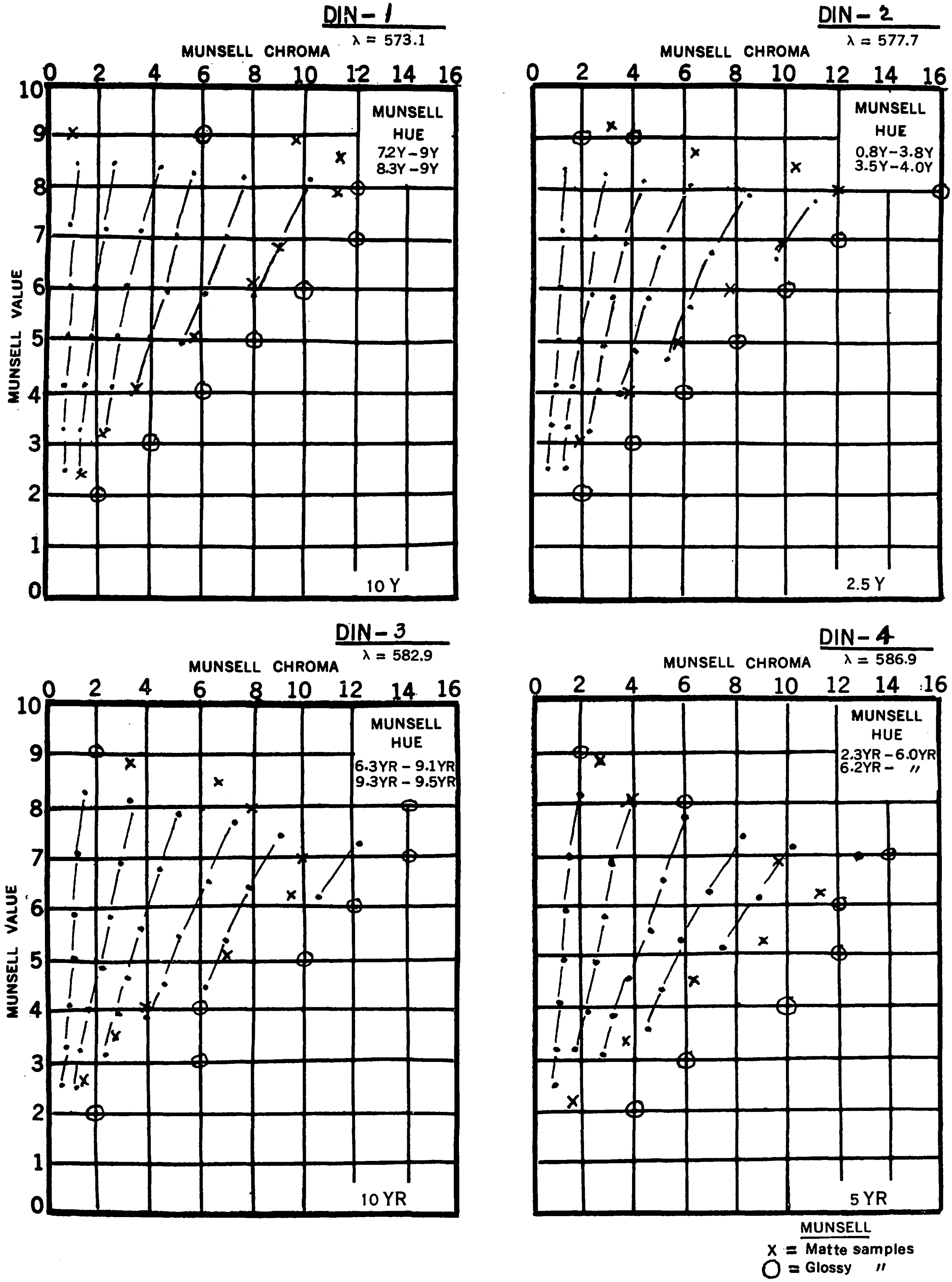

Figure 2.--Samples of DIN hues 1 to 4 are represented on Munsell value/chroma diagrams by solid dots. Munsell samples for limit colors of mat and glossy series are indicated for comparison.

ELECTIONS Early in 1964 voting delegates will elect four officers and four directors of the Inter-Society Color Council. Three of the delegates from each of the 29 member bodies are eligible to vote. Ballots will be mailed from the Secretary's office to voting delegates. The board decided to publish photographs and biographical material about the candidates so that voting delegates and other council members could know more about the candidates.

For President

RALPH E. PIKE
Senior Supervisor - Flint Development Laboratory
E. I. du Pont de Nemours & Co.
Flint, Michigan

Member

American Chemical Society
Federation of Societies for Paint Technology

Council Status

Vice-President, Inter-Society Color Council
Voting Delegate from the Federation of Societies for Paint Technology

***

For Vice-President

WARREN L. RHODES
Head, Graphic Arts Research Department
Rochester Institute of Technology
Rochester, New York

Member

Technical Association of the Graphic Arts
Fellow, Institute of Printing (England)
Technical Association of the Pulp & Paper Industry
Society of Photographic Scientists and Engineers
International Club of Printing House Craftsmen
Litho Club of Rochester

Council Status

Editor, Inter-Society Color Council Newsletter
Voting Delegate from the Technical Association of the Graphic Arts

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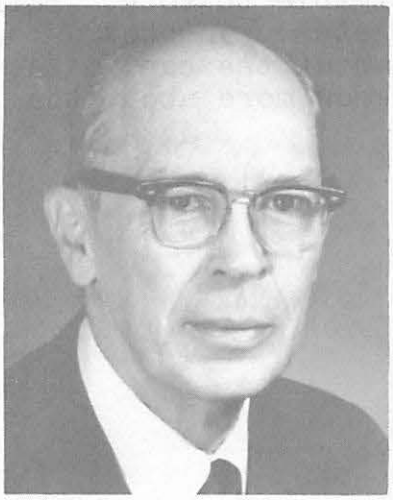
For Secretary



RALPH M. EVANS, Director
Photographic Technology Division
Eastman Kodak Company
Rochester, New York

Member

Illuminating Engineering Society
Optical Society of America
Photographic Society of America
Society of Motion Picture and Television Engineers
Society of Photographic Scientists and Engineers

Council Status

Secretary, Inter-Society Color Council
Chairman of the Delegation from the Society of Motion Picture and Television Engineers

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For Treasurer

NORMAN MACBETH, President
Macbeth Corporation
Newburgh, New York

Member

Illuminating Engineering Society
Optical Society of America
Society of Motion Picture and Television Engineers

Council Status

Treasurer, Inter-Society Color Council
Chairman of the Delegation from the Illuminating Engineering Society

***

For Directors

FRED W. BILLMEYER, JR.
Research Associate
Research and Development Division
Plastics Department
E. I. du Pont de Nemours & Company, Inc.
Wilmington 98, Delaware

Member

American Chemical Society
American Physical Society
Optical Society of America
Society of Plastics Engineers

Council Status

Chairman of the Delegation from the Society of Plastics Engineers

***

MILO D. FOLLEY
Partner in Charge of Design and Research
Sargent, Webster, Crenshaw & Folley
2112 Erie Boulevard East
Syracuse, New York 13224

Member

American Institute of Architects
Building Research Institute
Manufacturing Chemists Society

Council Status

Voting Delegate from the American Institute of Architects

***

For Directors (Cont'd.)

RANDALL M. HANES
Senior Staff, Applied Physics Laboratory
The Johns Hopkins University
Silver Spring, Maryland

Member

American Association for the Advancement of Science
American Psychological Association
Optical Society of America

Council Status

Chairman of Subcommittee for Problem 20: Basic Elements of Color Education
Voting Delegate from the American Psychological Association
Director, Inter-Society Color Council

***

WARREN B. REESE, Vice-President
Macbeth Corporation
Newburgh, New York

Member

Illuminating Engineering Society
Optical Society of America
Research and Engineering Council of the Graphic Arts Industry, Inc.
Society of Motion Picture and Television Engineers
Society of Photographic Instrumentation Engineers
Society of Photographic Scientists and Engineers
Technical Association of the Graphic Arts

Council Status

Voting Delegate from the Research and Engineering Council of the Graphic Arts Industry, Inc.

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INTERNATIONAL COLOR MEETING, 1965

At a meeting held recently at Strasbourg an International Executive Committee was formed to organize the International Color Meeting 1965. Representatives of eight European countries were present; three further European countries and four extra-European Color organizations agreed to participate. This meeting will probably be held at the beginning of June 1965 at Luzern (Switzerland); the general theme will be: "Scientific and Practical Aspects of Color." The chairmen of this Executive Committee are Prof. Y. LeGrand (Paris) and Dr. E. Ganz (Basle); the secretary is Prof. M. Richter (Berlin).

THE COLOUR GROUP OF GREAT BRITAIN

At the Colour Group meeting at Imperial College on January 16 three papers on aspects of daylight were presented in early 1963.

Dr. B. H. Crawford of the National Physical Laboratory gave the first paper entitled "Some Measurements of the Color Temperature of Daylight at Teddington," in which he reported work carried out by Mr. Collins of the NPL. Color temperature measurements of the four quadrants of the sky were measured at 9 a.m., 12 noon, and 3 p.m. on working days using the Harding visual color temperature meter. Each of the measurements involved integration of the light from a full quadrant of the sky, and was taken through an open window. Before presenting the results it was to be emphasized that any such measurement involved the choice of a convention in the averaging process. In this case, either the color temperatures themselves could be averaged or the mired readings might be used.* The two results would in most cases not be the same. The average of mired readings had been chosen for this work. The grand mean of all the readings gave a color temperature value of 6,800°K with most of the individual values lying between 5,500°K and 7,500°K. Direct sunlight was excluded from all measurements taken. Plots of color temperature at different times of day for the individual sky quadrants showed that in the north and south a minimum in color temperature occurred at noon, whereas in the east and west the values rise and fall respectively throughout the day. Measurements were now being extended to the integrated value of the whole sky.

Mr. G. J. Chamberlin of the Tintometer Limited gave the second paper entitled "Notes on the Related Color Temperature of North Daylight in Southern England." Observations were made at noon about every three days for a period of a year. The position chosen was a north window in a color matching room about 20 feet above ground level. The readings were taken through the glass of the window and the effects of the window were later found to be equivalent to a decrease of 2 mireds in color temperature. The results presented, however, included the effect of the window, since this was representative of color matching conditions in many industries. A Lovibond-Schofield comparator was used for the readings, the light incident through the north window being reflected into the instrument from a magnesium oxide surface inclined at 45°. The reflecting surface was freshly smoked for each set of readings. The comparator readings were recorded in terms of the Lovibond scale and the weather conditions at the time of the reading noted. The overall luminance was measured with an SEI Photometer. Readings were converted to CIE chromaticity coordinates and to color temperature only after the full year of readings had been obtained.

* 1 mired = $10^6/T°K$.

Mr. Chamberlin, in presenting the results, pointed out that all the chromaticities were very close to the black body locus and seemed to be about equally distributed on either side of it. The bulk of the values had correlated color temperatures between 6,700°K and 7,500°K. Mr. Chamberlin observed that color graders working in the same room were able to work happily with illumination levels from 50 to 500 lm/ft^2. A slightly hazy sky was preferred, but either a bright clear sky or a very overcast one were said to be objectionable.

Dr. S. T. Henderson of Thorn Electrical Industries Ltd., who presented the third paper, said that the work he was to report was carried out for a British Standard Committee set up to specify an artificial daylight source with particular interest in the ultra-violet content of daylight, in which the present Source C was deficient. The intention of the work was to record the relative spectral energy content of various phases of British daylight. There appeared to be no published literature on the subject in this country although the Americans had a large literature.

The instrument used was a portable Hilger grating spectrograph using two photomultiplier detectors with overlapping spectral sensitivities so that measurements of equal validity could be made from the near ultra violet to the near infra red. The spectral bandwidth was about 10 mμ. Total integrated sky light was measured using a horizontal diffuser as the collector. Measurements both with and without direct sunlight were made. The sun, in general, seemed to reduce all color temperatures by about 2,000°K. The time needed to take one measurement was about fifteen minutes.

Dr. Henderson illustrated the plots of calculated chromaticities of his readings. They lay about an average line parallel to the black body locus but on the green side at a slightly higher y value (average about plus 0.007y). The probable error of the measurements would not explain the difference between the average line and the black body locus. Average values of correlated color temperature lay between 5,500°K and 7,000°K. The mean of the first 206 runs gave a correlated color temperature of 6,690°K; 110 north sky observations averaged 7,290°K; 80 measurements on total sky without sun averaged 6,910°K.

The spectral distribution of north sky light was found to cover a wide range of color temperature values which were not remarkably different from the total sky light without sunlight. The spectral character of north, total, and total sky plus sun, were all very similar so it seemed feasible to average in spectral bands even although the individual color temperatures were very variable.

In commenting on the detailed character of the spectral curves Dr. Henderson said that it appeared that blue sky had a greater deficiency of ultra-violet relative to a full radiator, than had the lower color temperature phases of daylight.

In conclusion, Dr. Henderson mentioned that apart from his results being used by the British Standard Committee, they were being used by Judd and his workers in America, to combine with the Eastman Kodak workers' results and Wyszecki's results obtained in Ottawa. They hoped to obtain the most probable spectral distribution for a range of color temperature phases of daylight.

At the February meeting Mr. R. N. Jackson and Mrs. M. L. Beeforth of the Mullard Research Laboratories gave two related papers entitled "Color in a Television System" and "The Effects of Unmatched Taking and Reproducing Primaries in Color Television Systems."

Mr. Jackson gave a survey of the basic principles of color television, emphasizing the defects and advantages compared with other color reproduction systems such as photography. The choice of Source C as the standard reproduction white was based on the public's acceptance of monochrome television screens as white, but the choice was unfortunate since the viewers' eyes were normally adapted to Source A illumination in the average home. The use of imaginary primaries to reduce all color distortions except saturation, and the complications of the gamma correction, were presented and led to an account of the methods used to code color information for transmission. The paper concluded with a demonstration of a photographic transparency color chart presented by direct optical projection side by side with a duplicate transparency presented on a color television screen. A liquid filter photoelectric colorimeter with a spectral response adjusted to match that of the eye was used to compare the two color charts.

Mr. Jackson opened the second paper with a comment on the practical importance of the choice of taking primaries. With a mass medium such as television the choice of transmission standards must be very carefully considered bearing in mind the great difficulty in changing such standards later. The taking primaries are amongst such standards. On the other hand, the reproduction primaries are not so restricted and production changes can be made at any time, using matrixing units to compensate where necessary. Mrs. Beeforth continued the paper with a discussion of the effects of errors in the reproduction primaries. Of the three variables, luminance, hue, and saturation, it was far more important to reduce distortions in hue than in saturation. However, errors of luminance could be most striking and could originate in differences in the primaries. Mr. Jackson then described the limits on the choice of primaries so that for the same luminance contributions the chromatic errors were a minimum. The paper concluded with a series of demonstrations on two color tubes using different green primaries. The over-all effects could be matched by using suitable matrixing in one of the tubes. Mr. Jackson showed a series of color transparencies reproduced by these tubes, and described viewer reaction experiments which were normally carried out to test the validity of theoretical conclusions.

At the March meeting Dr. Hunt gave the retiring Chairman's address entitled "Printing of Color Negatives." At first sight it might be imagined that color negative photographic materials have fewer advantages than reversal materials. Taking a color negative and then printing it to obtain a positive has the following four advantages: (1) Lateral inversion of the image could be eliminated; (2) It was very easy to obtain many positives from the same negative; (3) Enlargements or black and white prints were simple to obtain at the printing stage; and (4) Color correction systems could be introduced.

Kodacolor, of the original type made in 1942, did not correct for the color degradations introduced by imperfect dyes. Although saturation could be improved in such cases by using high contrast, this technique necessarily caused a loss of detail in the shadows and highlights. Masking to correct for imperfect dyes was first introduced as a low contrast positive neutral image in the color negative. A further improvement was made by using individual masking of the negative dyes by colored masks. A yellow mask corrects the blue absorption of the magenta dye and a pink mask the blue and green absorptions of the cyan dye. Dr. Hunt described the difficulties experienced in printing a large range of customers' shots. The requirements of color balance are even more demanding with paper prints than with transparencies. This was so largely because the eye had no opportunity to adapt to a highlight cast in prints whereas it had some opportunity to do this with a projected transparency. Prints from negatives must therefore compensate very fully for the following types of variation from one shot to another--(a) wide ranges of average exposure level, (b) large differences in the color of the light illuminating the subject, (c) differences between the spectral transmissions of camera lenses, (d) differences between film batches, and (e) processing differences from one time to another.

SYMPOSIUM ON "LIGHT FADING AND COLOUR ASSESSMENT"

(Meeting of the Society of Dyers and Colourists at St. Annes-on-the-Sea September 11, 12, and 13, 1963; a report by Max Saltzman.)

This past September I had the pleasure of attending the Symposium on "Light Fading and Colour Assessment" organized by the Society of Dyers and Colourists in England. Approximately 300 persons attended this symposium. Among these were 48 from countries other than the United Kingdom including eight representatives from the United States (of whom seven were members of the Inter-Society Color Council).

The program, while presented mostly by SDC members from the United Kingdom was international in having two papers by Americans, two from Holland, and one from Switzerland. (Contrary to the conventional ideas about England, the weather was magnificent. In fact people were apologizing about how unusual the beautiful weather was.) The conference was well organized with sufficient time for both formal and informal discussion. It is to be regretted that this procedure is not followed more in meetings here in the United States.

A list of the papers, all of which will be published (along with the discussion) in the Journal of the Society of Dyers and Colourists, is appended. Since my own interests concern themselves more with spectrophotometry, colorimetry, and its applications in industry the papers on the theoretical aspects of lightfastness held less interest for me. The discussion on Friday, September 13, on the papers by Miss Rawland and Messrs. Jaeckel Ward and Hutchings, however, provoked considerable discussion of the highest caliber. The spacing of the blue wool standards, used as actinometers in light fastness testing, is of considerable importance and there is still, after many years of use, much controversy about them.

The papers which were of most interest to me included: H. R. Davidson, H. Hemmendinger, and J. L. R. Landry, Jr., "A System of Instrumental Color Control for the Textile Industry." This paper was an excellent presentation of the use of the D&H colorant mixture computer (COMIC) as an aid to formulation and production control. The success of this system is attested to by the fact that there are at present over 80 instruments in use, both in the United States and abroad. The presentation was clear, lucid, and was well received. As in any presentation limited in time, some historical data as well as some questions regarding the suitability of the equipment were not included. The theory of this analog computer derives from Park and Stearns (JOSA 34, 112 (1947) which, unfortunately, was ahead of its time. As a matter of fact the contributions of Stearns and his group have not been given the credit which they deserve for the pioneering efforts in the field of color measurement and color matching with the use of instruments. All of us who owe so much to this pioneering group should be conscious of our debt to them.

One other point (with which I have always disagreed with D&H in conversations varying from friendly to furious) comes from their assumption that the Colorant Mixture Computer can be used to select colorants for exact matches. This may be true for a limited gamut and for an experienced colorist familiar with spectrophotometry. If, however, one accepts the need for a spectrophotometric match, then the use of exactly the same colorants as were employed in making the sample to be matched is necessary. This is achieved using all tools available, including standard analytical methods for the identification of pigments and dyestuffs as well as recognition of curve shape. (Note: Now that my axe has been ground I can let go of that one.) The presentation was well received and the discussion both in and out of the lecture room was considerable.

Miss D. L. Tilleard of the Paint Research Station at Teddington covered the application of the "COMIC" computer to the paint and plastic fields. One must remember that this was the laboratory which used instrumentation and the Kubelka-Munk formulation techniques before any other that is known to me, and it was done the hard way. The availability of computer techniques vindicates the foresight of Dr. Duncan and his associates but unfortunately makes their plain hard work required for this type of calculation a thing of the past. Elimination of these tedious routine computations is, in my opinion, the greatest justification for the use of computers leaving time for the people involved to "THINK."

Some comparisons were made by Miss Tilleard between results obtained on "COMIC" and those obtained using the digital computer technique of ICI. For the limited amount of data presented, the agreement between the two techniques clearly indicates that the one to be used would depend on questions other than the ability of the system to work; that is the question of cost, availability of equipment, etc. It is to be emphasized that there should be no comparison between digital and analog techniques as though it were an either or proposition. Both techniques can be made to work. Factors other than their technical suitability are almost always the over-riding consideration for a choice of method.

Two other papers on the same morning presented a technique using instruments for the computation of color catalogues from pre-selected colorants, in this case dyes. The paper by Guthrie and his group at Courtalds clearly indicates the limitation of this technique in indicating that such a catalogue is useful for a limited gamut, be it a limited number of pigments, dyes, or in this specific case a limited number of mass pigmented viscose fibers. The work suffers, in my opinion, from the fact that colorimeters are used for the initial formulation. Perhaps, in the case of making a match with pigmented viscose that is not serious since metameric matches will result when making blends of spun-dyed fiber to match dyed or painted standards. The extent of this error is not clear but experience, I am certain, will give us enough data to judge whether this is truly significant. The work of this group is a continuation of work begun many years ago and is a tribute to both the individuals and the organization involved who were able to see the potential in such work long before the tools were really available for efficient utilization of the theory.

The second paper in this group by Bell, Gailey and Ogelesby of J. & P. Coats Limited is one which displays, in all fairness, something which I view with absolute horror - namely, the fixing of a system of colors based on a limited number of dyestuffs and investing the program with so much work that it will be almost impossible to make any changes. If we had perfect dyestuffs, covering the complete color range, the selection of the proper dyes so that we used no more than three dyes for any particular hue would be a worthwhile problem. In the absence of "perfect" dyestuffs, the fixing of a system based on existing dyes destroys all incentive for improvement.

In addition, this work was not supported by experimental data indicating the error involved in making the dyeings which form the grid points in their system. Further the measurement again is based on colorimeters and unless they have, in England and Scotland, colorimeters which are capable of giving the same results in absolute terms, the system will run into considerable trouble. The fact that it is backed up by an atlas of samples will be of considerable assistance. It is interesting to me to note that here, too, the early work in this field has been ignored. In response to a question regarding the uniformity of spacing of the samples being dyed for the grid, the response was given that they would finish the making of the atlas and then would examine the sample to see how uniform it was. In this, the work of Davidson and Luttringhaus* in making a Munsell book of color in dyed wool seems to have escaped notice on the European side of the Atlantic. The major objection I find to the system used by Coats is that it will foster continued use of old dyestuffs even if newer, better dyes are produced because of the work involved in changing the atlas. Perhaps this will not be so and some smaller competitor who has not prepared a complex atlas will use new dyestuffs and force a larger company into using the newer materials.

Papers by Dr. McLaren of the Society of Dyers and Colourists Fastness Tests Coordinating Committee and Dr. Friele were of great interest but are the kind of papers which must be read and studied quite carefully in order to make any judgment on them. It would seem to me that the paper by Dr. Friele on the conditions of Xenotest exposure which correlate with natural exposure should be of great interest to us even though the use of Xenon arc equipment here is still limited.

I will mention only briefly a few of the other papers of interest - one by Dr. Gugerli and Dr. Buchner of Sandoz was an exceedingly complex presentation of a technique for color formulation which I feel has been outmoded before it has had a chance to start. It must not be overlooked, however, that this work was started many years ago and the newer techniques of formulation had not yet

*Journal of Optical Society of America 41, 623-625 (1951).

come into being. One very important point which was made by Dr. Gugerli, perhaps too casually, was the importance of the ability to make reproducible dyeings. Among all the speakers he was perhaps the only one who emphasized the fundamental problem of sample preparation in all measurement and matching problems. It is too bad that this important point is buried in the complexity of the rest of his paper.

The paper on Friday morning by Alderson, Atherton, Preston and Tough on "The Practical Exploitation of Instrumental Match Prediction" excited perhaps the greatest interest of all the papers presented at the symposium. This paper proposed a technique whereby the dyestuff manufacturer would undertake to supply initial dyeing formulations plus correction factors for any user upon receipt of a) tristimulus values obtained from a known type of colorimeter; b) the necessary information regarding substrate, dyeing method and fastness properties desired. This service now in commercial operation as IMP serves to provide the consumer with rapid (in most cases less than one hour and in many cases in a matter of minutes) color matching service. The philosophy underlying this technique is based on the assumption that the dyestuff manufacturer has always been the person to whom the customer turns for help in color matching and computer techniques are but a natural extension of this.

The work of the ICI group is an outgrowth of some twenty years of development in which they have come to the conclusion that the digital computer technique, in the hands of the manufacturer, is superior to the use of an analogue computer in the hands of the consumer. Whether this will prove to be true only time will tell. The technique employed by this group has been described in the Journal of the Society of Dyers and Colourists for December 1961.

In this work which, as I have stated, is in commercial use, the matches obtained which were shown at the meeting seem to be quite good. In my opinion for non-spectral matches the technique will work quite well. Where matching in all illuminants is required there will be other problems. It is, however, a moot point as to whether it is better to get 20 to 30% of one's requests for color matches correct within an hour or two as compared with getting all of them correct in a two-week period. These of course are extremes and it will be very interesting to see the development of this work. (Unfortunately, I could not attend the AATCC meeting in Boston in October where examples of this type of prediction were shown.) From the examples which I saw at St. Anne's the matches were certainly satisfactory as first approximations. It is important to note that the original use of this system was to make new formulations based on the Procion range of dyestuffs which, in every case, would result in a non-spectral match. Given the proper first approximations, the skill of the dyer would do the rest. How well it will work for exact spectral matches remains to be seen. In the case of this work, again I was distressed to see that the pioneering work of Park and Sterns as well as the work of Billmeyer was not given credit. I trust that this will be rectified in the final published version of this work.

The work presented by Professor Wright on "High Accuracy Colorimetry" is an excellent review of the problem and is recommended reading for all who are concerned with color measurement. The data which he presented showed a considerable spread in the results obtained in various laboratories using the G. E. spectrophotometer. The fact that this spread exists should not be taken to mean that better work cannot be done but should serve as a warning that even the best equipment is of little value unless carefully checked and maintained in calibration.

The Friday afternoon meeting chaired by Professor Wright in which a discussion panel of Mr. Warburton, Mr. Derbyshire, Mr. Greenwood, and Mr. Mudd discussed the question of "Color Discrimination" was a most interesting session. It is hoped that the discussion which this meeting provoked will be available. From the amount of material which I received as indicating my remarks at this meeting, I am afraid that much of this very interesting discussion will be lost. The paper itself, even without the discussion, is recommended reading for all who are concerned with the problem of color discrimination and color tolerances.

In conclusion it must be stated that this symposium was one of the most stimulating I have ever had the pleasure of attending, and it is hoped that a meeting of this kind can be held here in the United States in the not-too-distant future. I was struck by two major points - first that the British (and Europeans as well) seem to rely on three-filter colorimeters to a far greater degree than we do here and seem to get away with it. Whether it is true that metamerism is of less importance in Europe I do not know, but I seriously doubt this. The second point is the fact that we, in the United States, are far ahead of our colleagues in England and Europe in the use of instruments for color measurement and color matching and while we owe our thanks to the theoretical work done by Kubelka-Munk and others, the practical application of this has been done here. This was clearly indicated in the International Color Day Meeting in Dusseldorf in 1961 as well as in this symposium.

It is my opinion, which I hold very strongly, that color measurement and color formulation with the aid of instruments has reached the stage where a full dress discussion is in order. It would be well to prepare for such a meeting by requesting and inviting papers on this subject from those whom we know are working actively in this field. Instead, however, of just requesting papers I believe we should specify the kind of information which we would like covered and which has, in the past, been for the most part ignored. I do not mean that these papers should be simple answers to general questions but they should cover the major points involved. I believe that Roland Derby would be an excellent person to chair such a meeting and would be perfect for preparing the list of points to be covered by any speaker who was advocating a particular technique or combination of techniques.

All in all it was a fine meeting and as they say on the post cards, I wish that you had been able to be there.

Max Saltzman

Technical Papers

H. R. Davidson, H. Hemmendinger, and J. L. R. Landry, Jr., Davidson & Hemmendinger, Easton, Pennsylvania, "A System of Instrumental Colour Control for the Textile Industry."

Miss D. L. Tilleard, Paint Research Station, Teddington, "Some Applications of the Davidson & Hemmendinger Colorant Mixture Computer to Paints and Plastics."

Miss A. Miller, Miss J. Moir, J. C. Guthrie, and P. H. Oliver, Courtaulds Ltd., "A Computed Colour Catalogue of Fibre Blends and Its Use in Match Prediction."

J. R. Bell, I. Gailey, and S. Oglesby, J. & P. Coats Ltd., Paisley, "The Creation of Comprehensive Colour Ranges by Computer."

K. McLaren, S. D. C. Fastness Tests Co-ordinating Committee, "The Problem of Humidity Measurement in Fading Lamps."

L. F. C. Friele, Vezelinstituut TNO, Delft, Holland, "A Comparative Study of Natural and Xenotest Exposure Conditions for Measuring Fading and Degration."

B. Stevens and W. S. W. Bingham, University of Sheffield, "The Fading of Rhodamine B in Aqueous Acetone Solutions."

U. Gugerli and P. Buchner, Sandoz, Basle, "The Gradient Method: A Contribution to Metameric Colour Formulation on the Basis of Colour-difference Measurements."

W. Ingamells, I. C. I. Dyestuffs Division, Blackley, "The Enhanced Fading of Dyes Caused by Crease-resistResins--A Proposed Mechanism."

H. C. A. van Beek and P. M. Heertjes, Technical University, Delft, Holland, "Photochemical Reactions of Azo Dyes in Solution with Different Substrates."

A. H. Little and J. W. Clayton, Shirley Institute, Manchester, "Photochemical Tendering and Fading of Dyed Textiles at Different Humidities."

R. S. Asquith and B. Campbell, Bradford Institute of Technology, "Relationship between Chemical Structure and Fastness to Light and Gas Fumes of Nitro-diphenylamine Dyes."

V. S. Salvin, AATCC Lightfastness Committee RA50, "The Effect of Atmospheric Contaminants on Light Fastness."

Miss O. Rawland, British Titan Products, Billingham, "Fading of the British Dyed-wool Light-fastness Standards in the U. K.--Some Energy Measurements."

S. M. Jaeckel, C. D. Ward, and D. M. Hutchings, Hosiery and Allied Trades Research Association, Nottingham, "Variations in Assessment of Light Fastness, and in Rates of Fading and Spacing of the Blue Standards."

J. V. Alderson, E. Atherton, C. Preston, and D. Tough, I. C. I. Dyestuffs Division, Blackley, "The Practical Exploitation of Instrumental Match Prediction."

Miss S. Johnson, D. H. Phillips, A. R. Robertson, and W. D. Wright, Imperial College of Science and Technology, London, "High-accuracy Colorimetry--A Review of Some Recent Work."

F. L. Warburton, Wool Industries Research Association, "Colour Discrimination" (presented as a Panel Discussion, led by Mr. Warburton).

COLOR-RENDERING SYMPOSIUM, LONDON

A symposium on color-rendering held December 11th, 1962, at a meeting of the Illuminating Engineering Society of Great Britain, is now available, in the Transactions of the I. E. S. (GB), Vol. 28, No. 2, 1963. It includes three papers which are summarized by their respective authors below. It also includes the discussion, with leading contributions from Dr. S. T. Henderson and Mr. K. McLaren, besides a dozen others, and replies from the authors of the papers. Incidentally, the principal authors, as well as the Chairman, Professor W. D. Wright, are all well known members of the British Colour Group.

The report nearly fills the whole issue of the Transactions. Copies may be obtained, for 10s. 6d. each, by writing to:

Mr. G. F. Cole, Secretary
The Illuminating Engineering Society
York House, Westminster Bridge Road
London S E 1, England

Ralph Brocklebank

Color Perception and Color-Rendering

M. H. Wilson and R. W. Brocklebank

Color perception is important in color rendering problems because in the end success depends on the observer being satisfied that the colors he perceives are correct. In this paper the authors demonstrated the subjective nature of color perceptions, and distinguished them from the specifications made by the science of colorimetry. On the other hand, they maintained that the various factors influencing color perception could in principle be formulated scientifically.

The first demonstration showed that a color patch could remain the same colorimetrically (the physical light being unaltered) while the perceived color changed when the background changed. At the same time, a color could change colorimetrically and still be perceived as the same color, if its relationship with the changing background stays constant. Therefore the first principle in formulating color perceptions is that these are dependent on the relation between the individual color patch and the total visual scene.

The average color of the scene determines the physiological adaptation of the eye, and thus the context in which any individual color patch is seen; but equally important is the mental effect of perceiving the relationship between object and illuminant. If the illuminant is colored, this color is typically discounted when judging the colors of objects, so that these remain constant even when the color of the light reflected from them changes with a change of illuminant. This was demonstrated by means of a three-component picture projection, with variations in the color balance of the three projectors.

The authors suggested that it might prove to be simpler to formulate this effect of color constancy if the colors of objects were reckoned in a system of reciprocal chromaticity--just the opposite of the system used successfully for the colors of lights. Objects, after all, get their colors by darkening or absorbing the light, and the absorption bands are independent of the illuminant. This reciprocal system has white (the absence of darkness) for its zero, colors as partial selective darknesses, and black as total darkness, instead of having black as the absence of light, colors as partial lights, and white as the totality. The logic of this dual system was demonstrated with a spectrum of mercury lines in both its normal and its complementary dark-line form.

Finally a word was said about the importance of ideas, of the fitting of concepts to percepts, for any complete understanding of the process of perception.

Color-Rendering Tolerances and the Color-Rendering Properties of Light Sources

B. H. Crawford

Problems of color rendering date from the introduction of the fluorescent lamp, since this light source makes it possible to produce endless variety in color and spectral distribution of power. The shock which started off serious investigations into color rendering was the fact that a fluorescent lamp, of attractively high efficiency, could be, indeed was, produced which closely imitated the color (chromaticity) of daylight, but which was seriously deficient in red light. The consequence was that many things had a disappointing, disagreeable, or at least different appearance to that familiar by daylight. Complexions looked sickly, tea and coffee repulsive, meat looked prematurely faded and past its prime, butter and cheese had an unnatural yellow pallor and so on. The remedy for these troubles would seem obvious, more red in the light from fluorescent lamps. Unfortunately, this had proved far from easy in practice. Red, a good rich red, is difficult to produce by fluorescence, and its production is inefficient. It is necessary to compromise on the minimum acceptable amount of red. This leads to the essential center point of color rendering--tolerances. How little red, or any other component, can be tolerated? Is too much as bad as too little?

Many workers all over the world have nibbled at this apparently tough problem, but few have come to grips with the central core, the determination of tolerances. The direct determination of color rendering tolerances has been the aim of the work at the N. P. L. which is described in this paper. The N. P. L. has proposed a complete system of assessment of the color rendering properties of a light source.

In the task of specifying color rendering it is necessary first to simplify the problem by dividing the spectrum of the light source into a limited number of bands for each of which a tolerance can be determined. This implies a standard, which may be daylight, the light from tungsten filament lamps, or something intermediate. Tolerances for various combinations of bands must also be determined.

The deviations of a light source beyond the permitted tolerances give a measure of the badness of its color rendering; their sum forms a useful over-all assessment. It is possible to turn this figure of badness into a figure of merit, by relating it to a light source as bad in color rendering as it can be; e.g., a sodium lamp. The figure of badness of a light source, subtracted from the figure of badness of the sodium lamp, gives a figure of merit. This scale of figures of merit can be turned into a series of classes of merit, approximately equal, a system which is not inconvenient for the general assessment of light sources from the color rendering point of view.

Practical Problems of Specifying and Measuring Color-Rendering Properties

G. T. Winch

This paper reviews and appraises the practical problems and techniques involved in the measurement of those physical radiation characteristics of the stimulus which, under critically specified conditions of illumination and view, are related over a limited range with color-rendering perception. The proposals may have particular interest in respect to color-rendering clauses in national and international specifications for fluorescent and other electric discharge lamps, and also in connection with the revision of B. S. 950 for artificial daylight.

The visual sensations involved cannot be measured directly, but subjective experience shows some correlation, over limited ranges, with the spectral energy distribution (radiant power) of the light incident on the surfaces and objects illuminated, when they are viewed under strictly defined conditions. The practical problems which arise in color-rendering measurement and specification are reviewed and appraised; in particular, attention is drawn to the difficulties of the associated accurate spectroradiometry, maintenance of the necessary light standards, and the complex nature of the color-shift method, now preferred by the U. S. A. and Germany.

Suggestions are made bearing on the possible proposals to the C. I. E. in 1963 concerning the revision of the C. I. E. 1948 provisional recommendations in relation to the measurement and specification of color rendering. An interim modified spectral band system with new wavelength intervals is suggested. The ultra-violet region of the spectrum is included because of its importance in relation to the color appearance of objects and materials which are fluorescent. As in the C. I. E. 1948 system, color-rendering in the objective sense would be specified in terms of chromaticity objectives with close tolerances, and also by objectives and appropriate tolerances in relative luminance in the visible spectral bands; these latter would be based on the Crawford system which takes account of the effects of contiguous bands. In the ultra-violet region, appropriate weighting factors would be applied.

Because of the importance of chromaticity and spectral energy distribution measurements in relation to color-rendering, reference is made to the accuracy currently achieved, both in the standardizing laboratory and when using commercial apparatus and techniques at present available to industry. Possible future developments are also indicated.

FEDERATION OF SOCIETIES FOR PAINT TECHNOLOGY

Charles W. Finegan, Technical Director of Rinshed-Mason Company, Anaheim, California was installed as the 42nd President of the Federation of Societies for Paint Technology on November 1, 1963, during the Federation's 41st Annual Meeting in Philadelphia, Pennsylvania.

Edward J. Dunn, Jr., of National Lead Company, Hightstown, New Jersey, was named President-Elect; Carroll M. Scholle of Jewel Paint & Varnish Company, Chicago, Illinois, was elected Treasurer.

Three of the papers presented at the meeting are of general interest to ISCC. The following are abstracts of the papers, reprinted from the program:

<u>Color Correction by Three-Filter Colorimetry</u>

The Los Angeles Society

The direct application of the Kubelka-Munk equations to the broad bands of tristimulus colorimetry are found experimentally to give good results in predicting the pigment compositions of pastel tints. The theoretical limitations in extending the method to deep tones are analyzed, causes of errors determined, and remedies suggested. Validity of the remedies is based on calculations relating the Kubelka-Munk equations in narrow band spectrophotometry to the broad bands of tristimulus photometry by means of specially weighted ordinate calculations.

Two methods of solving the necessary sets of simultaneous equations are presented. One is a matrix method reduced to its simplest form, and the other comprises a simple, home-made voltage analog computer featuring low cost, slide-rule accuracy, rapidity, and multiple-choice solutions of redundant pigmentations. The computer appears to make fully practicable the use of current three-color photometers for color correction of plant batches. With suitable reference chips, complete initial color formulation may soon be possible.

<u>So You Want to Set Color Tolerances</u>

The New York Society

The available literature dealing with color tolerances and current industry practices in setting color tolerances has been surveyed. A possible procedure for setting color tolerances has been evolved from studying the problems that arise. Comparisons of color differences obtained by measuring the same colors with different instruments; i.e., recording spectrophotometers and available colorimeters (Color Master, Color Eye, and Hunter) are reported along with visual comparisons of the same color to the standard. A glossary of terms and a bibliography for further study are included.

<u>Modern Chemistry of Organic Pigments</u>

Dr. H. Gaertner
Ciba Limited, Basle, Switzerland

The object of this paper is to present a short survey of the more recent developments in the field of organic pigments. The restriction to organic pigments would seem to be justified since it is in this field that development has been most extensive. However, the field still remains so vast that the scope of this paper has to be narrowed down to groups of primary interest.

Discussion, therefore, deals mainly with those developments which have led to the creation of particularly high grade pigments. There is a growing demand for pigments of a high degree of fastness in all sectors of the pigment-consuming industries; for example, the use of pigments in automotive finishes, high quality printing inks and plastics for outdoor use, or for the spin coloration of man-made fibres, and the pigment printing and pigment padding of textiles, etc. The growing variety of uses has considerably increased not only the degree but also the number of fastness properties required.

Developments are considered in their approximate chronological order, first discussing briefly the position of the classical pigments before the advent of the phthalocyanines and the impact of the latter on further developments, and then going on to describe in greater detail how the search for high-grade pigments extended to more and more chemical classes. To conclude, a summary is given of what has been achieved to date.

INDUSTRIAL DESIGNERS INSTITUTE

Three Bronze Medals representing the highest awards of the industrial design profession were presented October 4 by the Industrial Designers Institute to Douglas Deeds of San Diego, California; George A. Beck, FIDI, and Stuart G. Mundt of Utica, New York; and the Raymond Loewy/William Snaith, Inc., Product Design Division, Joseph M. Parriott, FIDI, Joseph Rinaldi, and Douglas Long of New York City. These awards were made at the 13th Annual Design Awards banquet at the Sheraton Hotel in Rochester, New York.

Douglas Deeds of Deeds Design Associates received his medallion in the Design for Home category for the design of the Fin Light for Peter Pepper Products of Wilmington, California. The Fin Light is an "open light," of which the translucent, reflective quality of its sheet vinyl fins allows for a maximum of soft diffused light.

George A. Beck, FIDI, and Stuart G. Mundt of the LMED Division of General Electric Company will be awarded a medallion in the Design for Industry category for the design of the Square Pulse Bonder, a device for bonding (welding) a variety of metallic wires and ribbons to thin films, printed circuits and glass and ceramic substrates for use by the electronics industry in micro-miniaturized circuit manufacture. Mr. Beck is Manager of Industrial Design of the LMED Division, Chairman of the IDI Advisory Council, and a Vice President of the International Council of Societies of Industrial Design. Mr. Mundt is Vice Chairman of the Central New York Chapter of IDI.

The Raymond Loewy/William Snaith, Inc., Product Design Division, Joseph M. Parriott, FIDI, Joseph Rinaldi, and Douglas Long will be awarded a medallion in the Design for Business category for the design of the Dictaphone Time-Master/7 for the Dictaphone Corporation. This full-sized dictating machine has been designed into a smaller, lighter unit; it was selected for exhibit earlier this year at both INTERPLAS in London, and the exhibit at the Louvre in Paris, France, of the International Council of Societies of Industrial Design. Mr. Parriott is Eastern Vice President of IDI.

FORREST DIMMICK ESTABLISHES A CONSULTING PRACTICE

Dr. Forrest Dimmick, formerly of the U. S. Naval Research Laboratory, U. S. Naval Submarine Base, New London, Connecticut, has established a private consulting business. Dr. Dimmick has been an active member of the Inter-Society Color Council for many years, and is presently a delegate of the American Psychological Association. He was one of the individuals who, working on Subcommittee #10, Color Aptitude Test, developed the ISCC Color Aptitude Test. That subcommittee is now actively developing a revised edition.

The ISCC wishes Dr. Dimmick success in his new venture--a consultant in color vision, night vision, and color aptitude testing. His new address is 772 Williams Street, New London, Connecticut.

COOPER UNION MUSEUM

Last summer Cooper Union trustees aroused a controversy by announcing that they were "...studying plans for the possible discontinuance of the Museum for the Arts of Decoration and the relocation of its collections." When the announcement became public, a "Committee to Save Cooper Union" was formed to protest the action. The chairman of the Committee was Mr. Henry duPont and the vice-chairman was Mr. Howard J. Sachs. The trustees maintained that too little use was made of the museum (13,000 last year according to Time, August 9, 1963) while the Committee claimed that the number of users did not indicate the true importance of the museum because these users were scholars who used the collections for research. The president of the American Association of Museums, Mr. Charles van Ravensway, wrote, "...if someone had written to tell me that the Statue of Liberty and Mount Vernon... were being discontinued because they seem to meet no contemporary need, I wouldn't have been more shocked..." In July the museum was closed to the public (not to qualified scholars).

In a November 13 news release the Cooper Union announced that the trustees have accepted the offer of the American Association of Museums(chairman, Charles van Ravensway) to aid in the study of the future of the Cooper Union Museum. Among the proposals to be considered is the recommendation by the Committee to Save the Cooper Union Museum which would transfer the museum into the control of a new organization. The Curator, Mr. Calvin Hathaway, has resigned. The rest of the staff remains on a temporary basis until the fate of the Cooper Union Museum for the Arts of Decoration is decided.

BOOK REVIEW

Principles of Color Sensitometry, A Report of the Color Sensitometry Committee, C. F. J. Overhage, Editor, Francis H. Gerhardt, Chairman of Subcommittee. Society of Motion Picture and Television Engineers, New York 17, New York, 1963, p. 102, 5 1/2" x 9".

Following a brief introduction, seven chapters describe some of the methods used for testing and evaluating three-component subtractive color photographic processes, exclusive of prints examined by reflected light.

The chapters involve: sensitometric exposure, processing of sensitometric tests; density measurement; density transformations; applications; statistical aspects.

In comparison with the 1950 paperbound edition, the committee on revision omitted items such as: obsolete apparatus; references to specific equipment; instrument comparisons. Some material has been added such as: references to recent articles and books; recent American Standards (without, however, mentioning PH 2.21-1961, the standard method for determining the speed of color reversal films); one page on color duplication; two pages on other applications; one page summarizing the filters used in representative color densitometers; one sentence concerning films for color television. No index is included. It is perhaps a tribute to the original authors that the committee made so few changes, considering the lapse of thirteen years.

Welcome material would have included suggestions about methods of estimating physical characteristics of the color image, "false" color systems and infrared-sensitive films. The SMPTE publication Control Techniques in Black and White Processing is a useful companion to this book.

Principles of Color Sensitometry is an authoritative, if greatly condensed, survey. For one who is generally familiar with the field, it provides a useful outline. It is too brief to comprehend detailed examinations of methods for one who needs an introduction to the subject. It will disappoint those seeking solutions to everyday problems.

H. N. Todd

POCKET SIZE COLOR ATLAS

Reinhold Color Atlas, A. Kornerup and J. H. Wanscher, N. Y. Reinhold 1962, 224 pages (4-5/8" x 7") $8.75. This book, printed in Denmark in pocket size pages, contains 30 hues on double-page color charts, 48 samples to a chart, arranged A to F horizontally, 8 to 1 vertically. They extend from A8, the full color, to A1, white, each alphabetical column being decreased in lightness from A to the darkest column, F. It is the authors' purpose that the two coordinates for each chart, which in translation are called shading and density, shall be uniform from plate to plate, so that swatches at corresponding positions resemble each other. If the book is held sideways, so that the row of samples which represents the gray scale at the bottom of each page is in a vertical position, the pages represent a cylinder formed around a central gray axis. The charts thus illustrate a three-dimensional arrangement of hue, lightness, and saturation. Dr. Wanscher has for years been seriously interested in color charts, particularly for horticulture, that might serve to facilitate an understanding of color descriptions when one has no color atlas before him. Consequently, a considerable portion of the text is devoted to the definition of color names in terms of the chart notation.

The color printing is well done; we do not believe it could be done as well in this country for the price at which the color atlas sells. The pocket size of the book is a convenience in using the charts, but the text type is consequently so small that it is objectionable.

While the charts are well printed, and are a bargain for the price, nevertheless they have the objection to all charts of this sort, that the user must refer to this particular book and edition in using the notation. We agree with a review in the AIA Journal by Eric Pawley in which he sees little need for still another system of indexing colors; and prefers to stick to the more serviceable Munsell designations. In fact, we find it unfortunate that the names were not defined in terms of the ISCC-NBS word designations, for this would have provided a connecting link between the charts in this publication and those already in use that are now interrelated through use of the ISCC-NBS method.

Dorothy Nickerson

FABER BIRREN 1963 BOOK

In Newsletter No. 157 we reviewed briefly, but quite warmly, two books by Faber Birren, particularly his Creative Color which we thought distilled a fine book, particularly for reference to designers and artists, of his many years of experience in this field. Since then we have noted in Newsletter No. 162 his paperback edition of Color in Your World, and in Newsletter No. 165-166 the facsimile publication of the early Moses Harris book, a useful and interesting contribution to the literature on color for which he was responsible, and for which he wrote the introduction and explanation.

About his latest book, Color--A Summary in Words and Pictures, from Ancient Mysticism to Modern Science, University Books, New Hyde Park, N. Y., 1963, LC62-18889, we cannot be at all enthusiastic. It seems almost like a scrapbook not well edited for publication. It consists of three parts, the Mystic Beginnings, Impact on Science and Culture, Implications for Modern Life, none of which provide digested information for presentation to the reader. It is too bad not to have a better book from the pen of a man gifted with its use.

Dorothy Nickerson

SECOND EDITION OF COLOR IN BUSINESS, SCIENCE AND INDUSTRY

(In an earlier issue of the Newsletter Ralph Pike reviewed this Second Edition. I happened to see Dorothy Nickerson's letter to the authors, Dr. Deane B. Judd, National Bureau of Standards, Washington 25, D. C.; and Dr. Günter Wyszecki, National Research Council, Ottawa 2, Ontario, Canada. Her letter so well expressed the views of many color workers I have talked to that I asked her permission to reprint the portions of it which follow. Ed.)

Dear Deane and Günter: To each of you my congratulations on the new book. While it is a second edition, it is a really new book, one with considerable international flavor and orientation, which is fine! Color in Business, Science, and Industry, in its 1963 edition makes it now inexcusable for any serious student of color to be unaware of the many basic, and often complicated facts that underlie the science of colorimetry.

The rearrangement of some of the material, all of the new material--on color vision theory, the metric of UCS (quite a discussion, and remarkably clear for a subject so completely mathematical!), chromatic adaptation, color rendering, object color perception in complicated scenes, the better index (by author and subject separately)--make it an outstanding book, and far more up-to-date than generally is expected of a technical book.

It is a profitable partnership to colorists that the two of you, each with such a wide understanding of the field, could get together on one book. It is much better for colorimetry than if you had written separate books. The first edition was good, one of the best we had, yet not enough. This one is the only single book I would be willing to recommend on colorimetry, for your references are well given, and would provide a liberal education in the subject to any student who needed more than the text provides.

I shall not wait to finish the book before telling you how enthusiastically and gratefully it has been received by this reader. Both of you, in your daily work, do a lot for colorimetry but in this book so much has been crystallized! The new crop of colorimetrists, as well as the old, should be very grateful to you (though they never can have as much fun as those of us who have watched and helped this infant science grow to its present stature).

To you both, my thanks and congratulations. Dorothy Nickerson*

*In allowing use of this personal letter to express my overall enthusiasm I should, however, note that I agree with Henry Hemmendinger (see Applied Optics, 2,1108, Nov. 1963) that the deletion of Table 19 from the first edition is serious. The reader needs it, or other guidance, to provide information concerning the approximate relationship of units of color difference, ΔE, that are based on different formulas. I note also that references in the first edition made to available materials are not always revised in the new edition to cover the many useful changes that have occurred in these materials since 1952. Nor have needed titles been added for Tables A, B and C of the Appendix. D.N.

COLOR WORKSHOP A Color Workshop sponsored by Colortone Press was held at the International Inn, Washington, D. C., for over 150 editorial, art, advertising, and public relations executives. Al Hackl, President of Colortone Press, acted as moderator for a panel of five "color experts." They discussed: (1) the importance of color in advertising and promotion -- from publishing to political campaigning; (2) the impact of new technology as a means of reducing cost of color (while most other costs in printing have increased, cost of color has constantly decreased); (3) the latest scientific developments in color such as electronic color separation and color Polaroid.

The panel members included: Roy N. Barnes, Sales Promotion Manager, E. I. duPont de Nemours & Co.; Emil Landau, Eastern Technical Supervisor, PDI Scanning Div., Time, Inc.; John Sandbo, Color Technical Representative, Polaroid Corporation; Joe Taney, Instructor in Commercial Art, Corcoran School of Art; Roy Teller, Art Director, Ketchum, MacLeod & Grove.

THE IDEAL LOVIBOND COLOR SYSTEM Users of the Lovibond Color System will be interested in a report on the Lovibond Color System published in the Journal of Research, National Bureau of Standards, Vol. 66, C No. 2, April-June 1963 (Engineering and Instrumentation). The article was written by Deane B. Judd, G. J. Chamberlin, and Geraldine Haupt. The abstract appearing in the Journal of Research is reproduced here.

The Ideal Lovibond Color System

Deane B. Judd, G. J. Chamberlin, and Geraldine W. Haupt

Lovibond red, yellow, and blue glasses, widely used as color standards in industry, are assigned numerals in accord with the basic plan of marking each glass with the number of unit glasses of the same type through which light must be passed to produce its color. It is possible to compute from the spectral transmittances of the unit glasses defining the Lovibond scales the CIE specifi-

cation of the color produced by all combinations of any number of unit glasses. Such specifications were computed in 1939 not only for all ideal red, yellow, and blue Lovibond glasses illuminated by CIE sources B (representing noon sunlight) or C (representing average daylight) but also for two-part (red-yellow, yellow-blue, or blue-red) combinations thereof. The present paper gives the results of such computations for CIE source A (representing gas-filled incandescent lamps). Although actual Lovibond glasses must unavoidably depart somewhat from this definition of the ideal Lovibond system, the computed color specifications serve to indicate with good reliability not only the CIE specification of the color produced by single glasses and two-part combinations, but also the choice of Lovibond glasses required to produce a color of any desired chromaticity within the gamut of the system.

MISCELLANY Woman "Sees" Colors with Fingertips.

The December 5th Flint Journal reported that Mrs. Stanley, a Flint housewife, can identify colors through her fingertips. The testing which led to this extraordinary announcement was performed by Dr. Richard P. Youtz, Barnard College. Elaborate precautions were taken to assure Dr. Youtz that Mrs. Stanley did not see objects which she identified by touching them with her fingertips. Similar precautions were taken to prevent mental telepathy. Dr. Youtz reports that Mrs. Stanley's ability to identify colors goes beyond the possibility of chance. Dr. Youtz's work is sponsored by the National Institute of Mental Health, Bethesda, Maryland, and Barnard College.

Mrs. Stanley says, "A light color feels smoother and thinner, and a dark color feels thicker, heavier and rougher. I don't know how to say it." Her unusual talent was observed by her high school teacher in Owensboro, Kentucky, and confirmed by Dr. Youtz's associate at Barnard. Mrs. Stanley was located by the professors after they read a report of a Russian woman with similar talents, Rosa Kuleshova.

The item was brought to the attention of the Newsletter by ISCC Vice-President, Ralph Pike, who writes, "...that color may be perceived without benefit of either illumination or visual receptors should shake the ISCC to its foundations. You can be sure that your faithful reporter will be standing by, waiting for the shock of the first assault to subside, and alert to new developments."

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Analysis of Color Trends at the International Motor Show, London, 1963. (This press release is based on a survey undertaken by Paints Division, Imperial Chemical Industries Ltd.)

Pastels are in the ascendancy at Earls Court this year; it could be that the ladies are having things more their own way than hitherto. What is more, these particular pastels appear to be crisper than we have ever seen them - ranging from cool blues to clean grays and a wealth of fresh creams and ivories. Gone were those old porridge colors, and in their place are well formulated tints which enhance the fine styling of so many of the cars at the show. Strangely enough there are very few pastel greens this time.

Among the brighter colors some very aggressive reds are dominant suggesting that youth too is having its say in car colors. At the other end of the scale deep red-blues and blue-greens add a well chosen dignity to quite a number of the larger cars. Blacks, as in last year's show, are again very scarce.

Metallic finishes seen mainly on the higher priced cars, are up in number on last year, favored tones being some very rich deep red-blues, maroons, and a wide selection of bright grays.

Slightly fewer duo-tone schemes are on show this year, and the bulk of these has the second color only on the roof. The dividing flash is losing ground in popularity since this tends to break up the "newlook" styling. Popular duo-tone combinations are deep and pale fawn, green and ivory, two tones of blue, and many varieties of gray groupings.

One significant point at the 1963 show is a break away from matching interior fabrics. Some of the contrasts to be seen between exterior paint work and interior upholstery are striking to say the least.

Wheels too are undergoing a change. These seem to be played down in color and low gloss. Metal trims of the most complicated patterns appear to be on the way in. White-walled tires or narrow white bands, while in evidence are not increasing in significance.

By and large, colorwise, this is the brightest, smartest show ever, and the public is getting what it wants.

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Visual Effects Put to Work.

If you missed the Art section of <u>Time</u>, July 19, 1963, and if you still have a copy available, go back and take another look (Pages 56-9). The article refers to Richard Anuszkiewicz and his paintings, which are illustrations of visual effects. According to the article, he became interested in color phenomena while taking a course under Josef Albers at Yale. Although only two illustrations were reproduced in <u>Time</u>, at least these reflect the designs and color combinations in Mr. Albers' book.

Seven of Anuszkiewicz's paintings were on display (and perhaps still are) at the Manhattan Museum of Modern Art.

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Now You Can Mix Shoe Dyes.

However unique the color of a garment is, you can match your shoes, belt, handbag to it simply by mixing up a brew of hues in the kitchen.

Although dyeing shoes with the ease of changing the nail polish on your toe nails is still an innovation hardly a year old, competition has mushroomed. The upshot has been a variety of improved products.

The latest is the color multiplier system called Mix and Match. It enables you to match your swatch, or garment, to a color chart of 120 different shades. The rest is like mixing paints. Under each color sample is the recipe, telling how much of which of the company's basic 24 shades should be mixed together.

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Japan Markets Milk in Colors.

Milk in all the colors of a Japanese lantern now is being marketed in Japan. Red, green, yellow, and blue powdered milk is made by incorporating additives during the drying process.

The green powder contains vegetable vitamins; the yellow, egg yolks and honey; the red, carrots and oranges; and the blue, sugar.

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Colors Help Prisoners Read.

Many San Quentin prisoners may learn to read by use of colors.

Charles Rhinehart, Sonoma State College teacher, and Stanford University professors developed a system using colors to represent vowel sounds.

Rhinehart said the system enabled a nonreader to identify a sound with a color and the confusion of several sounds for the same letter was avoided.

Of San Quentin's 4,500 prisoners, about 900 are below fifth grade ability in reading.

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Unforeseeable Fuchsia in Shirts.

About a year ago Eagle Shirtmakers, Inc., and its agency, Freeman & Gassage, Inc., placed magazine ads denouncing uninspired names given to colors--light green, dark blue, etc. They asked readers to conjure up new names of colors for men's shirts.

W. R. Goodwin of N. Caldwell, New Jersey, and Janet Lauren of New York City won the company's Afflerbach Fellowship.

Eagle will publish a list of some of the more creative entries such as Gang green, unforeseeable fuchsia, Freudian gilt, hole-of-Calcutta black, hash brown, navel orange, Barrywater gold, dorian gray, hillmob lavender, blind-date lemon, Willie maize, statutory grape, unshrinkable violet, whizzer white, hiho silver, people-eater purple, sick bay, and forever amber.

A shirt of "unforeseeable fuchsia" will be on the market shortly.

Afflerbach Fellowships, which are named after the company's forelady, Miss Afflerbach (she never uses a first name) entitle the winners to "a glamorous weekend at Quakertown, Pennsylvania (Eagle's headquarters), with a free sight-seeing trip into romantic Philadelphia.

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LOCAL COLOR MEETING IN WASHINGTON

(Last minute item.) On Wednesday, December 4, the National Capital Section of the Optical Society, with members of the local Colorists group as guests, met at Georgetown University. Following a social hour and buffet dinner held in the Faculty Lounge, an unusual and very colorful lecture was presented by Dr. Wallace R. Brode. The subject, "Colorful Americans - Dyes and Dyeing Processes Used by the American Indians," is one that covers a long time hobby. Not only were many colored slides used to illustrate the skill, methods, and background country of Indian colorists, but Dr. Brode, with Mrs. Brode's help, had arranged a very colorful exhibit of American Indian rugs.

The audience was large and enthusiastic with a number of ISCC visitors from out-of-town. The next meeting will be held on February 19 at Johns Hopkins University featuring spectroscopic research at Johns Hopkins University and a tour of their new physics building.

LIST OF ARTICLES ON COLOR RECEIVED BY NEWSLETTER

"Age and Colour Vision," R. Lakowski, The Advancement of Science, No. 59, pp. 231-236 (December 1958).

"Automatic Color Inspection," John W. Ward, Color Engineering, 1, No. 3, pp. 15-21 (September 1963).

"Caution Required in Absolute Color Measurement with Colorimeters," F. W. Billmeyer, Jr., Off. Dig., 34, No. 455, pp. 1333-1342 (December 1962).

"Chemistry and Color Photography," P. W. Vittum, SMPTE Journal, 71, pp. 937-941 (December 1962).

"The Choice of Colour in Ancient Art," Prof. Karl Schefold, Palette, No. 13, pp. 3-19 (Summer 1963).

"Chromatic Adaptation," David L. MacAdam, Annual Meeting Opt. Soc. Amer., Biltmore Hotel, Los Angeles, Calif., 1961. (Abstract in J. Opt. Soc. Amer., 51, No. 12, p. 1458, 1961.)

"Color and the Use of Color by the Illuminating Engineer," Anon., Illuminating Engineering, LVII, No. 12, pp. 764-776 (1962).

"Color Blend and Harmony," Helen Maidment, Master Painter Aust., 13, No. 7, pp. 18, 20, 29 (1961).

"Color Control in Industry," W. D. Wright, Paint Tech., 25, No. 9, pp. 19-22 (1961).

"Color Correction by Three-Filter Colorimetry," Los Angeles Society for Coatings Technology, Off. Digest, 35, No. 466, pp. 1119-1133 (November 1963).

"Color of Daylight from North Sky," Y. Nayatani and G. Wyszecki, J. Opt. Soc. Amer., 53, No. 5, pp. 626-629 (May 1963).

"Color Difference Evaluations," Angela C. Little and G. Mackinney, Annual Meeting Opt. Soc. Amer., Biltmore Hotel, Los Angeles, Calif., 1961. (Abstract in J. Opt. Soc. Amer., 51, No. 12, p. 1458, 1961.)

"Color in Factories," Anon., Decorator, 60, No. 716, p. 38 (1961).

"Color of Fluorescent Paints," Y. Nayatani and G. Wyszecki, J. Opt. Soc. Amer., 53, No. 6, pp. 744-749 (June 1963).

"Color Makes a Difference," Anon., National Safety News, 87, No. 3, pp. 50-52 (March 1963).

"Color Matching Lamps -- An Inquiry into Members Wishes," K. McLaren, J. Soc. Dyers and Colorists, 77, p. 435 (1961).

"Color Measurement of Metal Surfaces," J. M. Williams, J. Opt. Soc. Amer., 51, No. 6, pp. 654-656 (June 1961).

"Color in Memory in Relation to Photographic Reproduction," C. J. Bartleson, Photographic Science and Engineering, 5, No. 6, pp. 327-331 (November-December 1961).

"Color Vision Research and the Trichromatic Theory: A Historical Review," Shakuntala Balaraman, Psychol. Bul., 59, pp. 434-448 (1962).

"Color Vision Screening in Prince George's County," Mary A. Thompson, The Sight-Saving Review, XXXII, No. 4, pp. 216-217 (Winter 1962).

Newsletter Committee:

Warren L. Rhodes, Chairman
Katherine Chandler
Waldron Faulkner
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Helen D. Taylor

Send Newsletter Items to Editor,
Warren L. Rhodes
Graphic Arts Research Department
Rochester Institute of Technology
Rochester 8, New York

Other Correspondence to Secretary,
Ralph M. Evans
Color Technology Division
Eastman Kodak Company
Rochester 4, New York
