INTER-SOCIETY COLOR COUNCIL
NEWS LETTER

NUMBER 165-166 May-August 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 May 29, 1963.

Individual Members	Particular Interests
Mr. Ernest C. Ansley, Jr. Linley Publishing Co., Inc. 1872 West 54th Street Los Angeles 62, California	All phases of color as they pertain to the manufacture and application of decorative coatings.
Mrs. Hedy Backlin 45 Fifth Avenue New York 3, New York	Education of designers, manufacturers and the public; display and lighting problems in connection with color (in museum work).
Miss Barbara Davis Deering Milliken Inc. Marketing Research 1045 Sixth Avenue New York 18, New York	Historical usage and forecasting.
Mr. A. Douglas Graham, Jr. Deering Milliken Inc. McCormick Mill McCormick, South Carolina	Color tolerances. Currently making study of acceptability vs. perceptibility deviations from standard in terms of MacAdam tolerance ellipses. Also determining iso-hue & iso-chroma lines for Simon & Goodwin chromaticity charts.
Mrs. Martha F. Halbrooks 161 Harris Avenue Needham 92, Massachusetts	I teach interior decoration and am interested in color trends, color schemes, the effects of lighting on color, color names and descriptions of color.
Mr. Richard E. Hansen 4821 Warner Avenue Chicago 41, Illinois	Matching and formulating of colors in surface coatings-especially by instrumental means. Also interested in color tolerance and computer systems related to coatings.

Indivitual Members (Cont'd.)	Particular Interests
Dr. Antony G. S. Heathcote 276 McKee Avenue Willowdale, Ontario, Canada	The detection by group and individual testing of colour vision defects in school children. Other problems related to defective colour vision.
Mr. Paul H. Holsing 5049 Yukon Street N. W. Canton 8, Ohio	Standardization and control.
Mr. Laurence R. Irvin 3827 N. Keystone Avenue Chicago 41, Illinois	Reproduction of color thru printing. Analysis of copies before starting reproduction.
Mr. Charles G. Leete The Harshaw Chemical Co. 1945 East 97th Street Cleveland 6, Ohio	Instrumental color matching for various mediums employing spectro, digital computers, and other equipment.
Mr. David A. Lieberman Welch Scientific Co. 7300 North Linder Skokie, Illinois	Development of color measuring instruments.
Mrs. Dorothy I. Morley The Metal Box Co. Research Department Kendal Avenue London W3, England	Colorimetry in the printing industry.
Mr. Elwynn E. Nelson Miles Laboratories, Inc. 1127 Myrtle Street Elkhart, Indiana	Color degradation in pharmaceuticals.
Mr. Isadore Nimeroff 6505 Greentree Road Bethesda 14, Maryland	Standardization, specification, uncertainty of measurement of color, color vision.
Mr. Aldo Radioni 146 Columbia Heights Street Brooklyn 1, New York	Psychology of colors.
Mr. Allan M. Raff Smith Kline & French Laboratories 1500 Spring Garden Street Philadelphia 1, Pennsylvania	Establishing a method for doing colorant stability studies in pharmaceutical dosage forms.

Individual Members (Cont'd.)	Particular Interests
Mrs. Bette A. Roby Bette Sanford Designs 223 East 62nd Street New York 21, New York	Color trends in product planning, nomenclature of color, psychology of color, color in photography.
Mr. C. Bernard Stiles 60 Boston Street Salem, Massachusetts	Spectral radiometry of light sources and specifications of their color rendering properties.
Mr. Roy H. Vining E. I. duPont de Nemours & Co. 3500 Grays Ferry Avenue Philadelphia 46, Pennsylvania	Color control and research.
Mr. Thomas G. Webber 1722 Forest Hill Drive Vienna, West Virginia	Color matching and color control in plastics.
Mr. Philip T. Wheeler 4 East Parkway Glen Farms Newark, Delaware	Printed reproduction.
Mr. Quentin D. Dobras General Electric Co. Nela Park - #480 Cleveland 12, Ohio	Use of lamps and lighting techniques in solution of color problems. I am also involved in the improvement of color rendition properties of lamps or in the development of new light sources in regard to their spectral characteristics.

TWO CIE COMMITTEES REACH AGREEMENT IN VIENNA

CIE Committee E-1.3.1, Colorimetry; and E-1.3.2, Color Rendering of Light Sources; agreed on recommendations at their meetings in Vienna, June 18-26. Deane Judd is chairman of CIE Committee E-1.3.1 and of USNC-CIE E-1.3.1, the U.S. National Committee. Dorothy Nickerson is the U.S. expert member on CIE Committee E-1.3.2, and chairman of the USNC-CIE E-1.3.2 committee.

The following reports for the Newsletter were prepared by Miss Nickerson:

CIE Committee E-1.3.1, Colorimetry

At presession meetings on June 15 and 17, 1963, the experts, corresponding members, and consultants of CIE Committee E-1.3.1, Colorimetry, met in Vienna. Agreement was reached by the experts on recommendations reported at the formal meeting of the committee held during the June 18-26 CIE sessions. At the presession meetings, a very great deal of work was successfully accomplished, much of it owing to the skillful way in which the chairman organized, prepared for, and followed a very tight agenda. Colleagues expressed their regret at his announced intention of relinquishing the secretariat of E-1.3.1, and expressed their admiration for the accomplishments of the committee during the years it had been under his chairmanship. (The secretariat will now go to Canada.)

At the presession meetings there was presentation and discussion of a very considerable amount of spectral energy and color data for various phases of daylight that recently has been measured in England, the United States, and Canada. From preliminary analyses it seems entirely possible that these spectral energy curves, which cover a representative variety of sky conditions, may be analyzed statistically and by the method of Eigen vectors provide a basis for reconstituting spectral energy curves for daylight of any specified color. It is hoped that an average and two vectors (one to control changes in the direction of yellow-blue, the other in the direction of red-green) may be sufficient for this purpose. This would be a major breakthrough that would make it possible to implement recommendations 2 and 3 in a very practical manner.

At the presession meetings two brief presentations were made: (1), by Dr. G. Wyszecki, a color-difference formula developed to extend the usefulness of the 1960 CIE-UCS system (this paper will be published in the September J.O.S.A.); (2), by C. D. Reilly, a cube-root basis for computing from CIE data a color space that provides--except for the very extremes of light and dark--a useful approximation to visually uniform spacing. The presentation of Dr. Wyszecki, which incorporates use of the cube-root in the formula for lightness, is the basis for Recommendation 4, and this in turn provided the basis for Committee E-1.3.2's use of a lightness formula in computing its Special Index ratings. At the formal meeting of the committee, held on June 21, a paper was presented by M. A. Bouman and P. L. Walraven (Netherlands) on the discrimination of just perceptible color differences from the quantum-theoretical point of view.

The following text of the four recommendations agreed upon by the experts of E-1.3.1 at Vienna is from a summary report prepared by Dr. Judd.

1. The colour matching functions $\bar{x}_{10}$, $\bar{y}_{10}$, $\bar{z}_{10}$, proposed in 1959 (Compte Rendu, 14th Session, Bruxelles, Juin 1959, page 45) are recommended as a supplement to the 1931 CIE colour-matching functions ($\bar{x},\bar{y},\bar{z}$) whenever more accurate correlation with visual colour matching of fields of large angular subtense (more than 4° at the eye of the observer) is desired.

2. In the development of any standard sources for colorimetry to supplement CIE standard sources, A, B, and C, it is recommended that the supplementary sources be defined by spectral energy distribution and that artificial sources be recommended for actual laboratory and inspection use which duplicate the specified distribution within prescribed tolerances.

3. It is recommended that definitions of standard sources of four correlated colour temperatures, 3900, 5500, 6500, 7500°K, be developed to supplement CIE standard sources, A, B, and C. With the exception of the source of correlated colour temperature 3900°K, these supplementary standard sources are intended to represent phases of daylight over the spectral range 300 to 830 nm.

4. Pending the development of an improved coordinate system, the use of the following coordinate system is recommended whenever a three-dimensional spacing perceptually more nearly uniform than that provided by the XYZ-system is desired. The recommended coordinate system is formed by plotting the variables U, V, and W, along orthogonal axes where U, V, and W are defined in terms of the tristimulus values X, Y, Z as:

$$W = 25\,Y^{1/3} - 17,\ 1 \leq Y \leq 100;\ U = 13\,W\,(u-u_o);\ V = 13\,W\,(v-v_o)$$

where u and v are defined as follows:

$$u = 4X/(X + 15Y + 3Z)$$

$$v = 6Y/(X + 15Y + 3Z)$$

and u_o, v_o are values of these variables for the nominally achromatic colour placed at the origin of the (U, V)-system.

This is a development from the 1960 CIE-UCS diagram (Compte Rendu. 14[e] Session, Bruxelles, Juin 1959, Vol. A, Page 36).

Note 1: For object colours the choice of u_o, v_o to correspond to the illuminant is satisfactory.

Note 2: In this system the measure ΔE of the perceptual size of the difference between colour (U_1, V_1, W_1) and colour (U_2, V_2, W_2) is:

$$\Delta E = \left[(U_2 - U_1)^2 + (V_2 - V_1)^2 + (W_2 = W_1)^2\right]^{1/2}$$

This measure ΔE is expected to apply satisfactorily to comparison of differences between object colours of the same size and shape viewed in identical white to middle-gray surroundings by an observer photopically adapted to a field of chromaticity not too different from that of average daylight.

Note 3: If the angle subtended at the eye of the observer by the pairs of object colours being compared is more than 1^o and less than 4^o, the tristimulus values, X, Y, Z, calculated from the 1931 CIE standard observer should be used for the calculation of U, V, and W. If this angular subtense is greater than 4^o, the tristimulus values, X_{10}, Y_{10}, Z_{10}, calculated from the 1964 CIE supplementary standard observer should be used for the calculation of U, V, W.

CIE Committee E-1.3.2, Color Rendering of Light Sources

For something over ten years a subcommittee of the Illuminating Engineering Society's Light Sources Committee has worked on the problem of specifying the color rendering properties of light sources. In July 1962 this committee's recommendations, following approval by the Council of the IES in April 1962, were published with the committee's full report in Illuminating Engineering.[1]

The full report provides the background of the committee's studies, a report of related work by the International Commission on Illumination (CIE) committee E-1.3.2, and the reasons for limiting the IES recommendations to an "Interim Method of Measuring and Specifying Color Rendering of Light Sources." It recommends that an index of color rendering, limited to lamps of the same or nearly the same chromaticity, be based on a general comparison of the length and direction of chromaticity vectors on the CIE 1960-UCS diagram. It also recommends that this index be field tested by committee members and others for use as an interim method of rating lamps until a more rigorous method can be developed.

In June 1963, at Vienna, the experts of CIE committee E-1.3.2, color rendering of light sources, reached agreement on a CIE Interim Method of Measuring and Specifying Color Rendering of Light Sources. It is based on unanimous recommendations to the Vienna meeting of a 3-man subcommittee (experts of Germany, The Netherlands, and the United States) that succeeded in working the separate proposals of each country into a single proposal.

The resulting CIE recommendation is a "Test-Color Method" based on the colorimetric shift of a group of test objects. It was agreed that the method be considered the fundamental method for the appraisal of color rendering properties of light sources. Supplementary or abridged methods for making routine measurements on individual lamps may be used when they provide results that agree with the recommended Test-Color Method.

The rating consists of a "General Color Rendering Index" based on a set of eight test-color samples recommended in the method. This rating may be supplemented by a set of Special Color Rendering Indices based on these or other special individual samples, six of which are listed in the method--a strong red, yellow, green, blue, and samples representing complexion and foliage colors. The indices are based on a general comparison of the lengths of chromaticity-difference vectors on the CIE 1960-UCS diagram for samples under a test source against vectors for the same samples under a standard reference illuminant of the same or nearly the same color.

The eight samples used in computing the General Color Rendering Index include selections of hues that represent the entire hue circuit, each in moderate chromas, and all approximately the same in lightness (Munsell 6 value, 4-8 chroma). Color differences caused by differences in lightness are therefore inconsequential in computing the General Color Rendering Index, and the formula for it can be kept very simple. In the case of the Special Indices, in which samples may vary considerably from the Munsell 6/ level of lightness of samples used for computing the "General Index," provision is made for assessing the effect of lightness. This is particularly important since changes in both chroma and hue may sometimes be large when there is a lightness difference in samples that have the same chromaticity coordinates.

[1]Available from Illuminating Engineering Society, 345 East 47th Street, New York 17, New York, as a separate publication, reprinted from the July 1962 Illuminating Engineering, price $1.15.

The rating procedure and method of calculation, complete with six tables of necessary data are contained in the draft of the method agreed upon by the E-1.3.2 experts in Vienna. This is now being prepared for transmittal to the CIE Central Bureau which will, in turn, circulate it to the national committees of the CIE for approval. On approval, it becomes effective after a 6-month waiting period.

As chairman of the IES subcommittee on color rendering, and U. S. A. member of the 3-man CIE subcommittee which reached unanimous agreement in making the present proposal at Vienna, I can say that our subcommittee is well pleased that we have been able to resolve our differences in making this "test-color method" proposal. We do not propose it as a perfect solution--that is why it is called (as it was in the IES report) an "Interim Method." But we do think it provides a good start, one that our preliminary but fairly extensive field tests indicates is quite practicable in application. Further experience will teach us much that we need still to learn. We agree that any ultimate version should provide for inclusion, and rigorous treatment, of chromatic adaptation. We also agree that supplementary or abridged methods--such as the band method, or instrumental methods--are needed for testing individual lamps. Authorization for such studies is included in the stated purpose of the method proposed by E-1.3.2, provided only that the results agree with the color-test method.

Dorothy Nickerson

REPORT OF PROBLEM 20 SUBCOMMITTEE

We have been advised by the publisher, John Wiley & Sons, New York, that the report of our Problem 20 Subcommittee will be published in book form about the middle of August at an expected price of $8.50. The title of the book will be "Color: A Guide to Basic Facts and Concepts."

By special arrangements between the Council and the publisher it has been possible for us to secure one copy of the book for each of our delegates and members. These will be mailed directly from John Wiley around the middle of August. There is no charge for these books; further copies can be obtained through your book dealer at the above price.

The committee that produced this report is continuing under the chairmanship of Dr. Randall Hanes, and he is particularly anxious that any errors found in the book be called to his attention. He would also like to receive comments of any kind, good or bad.

Ralph M. Evans,
Secretary

ISCC MAILS NEW BYLAWS TO MEMBERS

Members of the Inter-Society Color Council have by now received their copy of the new Bylaws of the Inter-Society Color Council. These bylaws reflect the revisions voted in 1961. A number of important changes have been made in the bylaws which were recommended by ISCC members, board members, and acted upon by the Revision Committee, W. J. Kiernan (Chairman), Ralph Evans, and Norman Macbeth. A report of these revisions was made in ISCC Newsletter No. 151, January-February 1961.

The most important changes to look for in the new bylaws are: the distinction between associate and affiliate individual members has been resolved; fixed membership dues have been deleted; the system of succession of officers has been established (officers will assume their duties at the end of the annual meeting following election); five permanent committees have been established; finance problems; president's advisory; publications, and membership.

JOURNÉES INTERNATIONALES DE LA COULEUR

The 7th International Conference on Color sponsored by the Centre d'Information de la Couleur, Paris; Association D'Optique Italienne, Italy; and Institut National de la Couleur, Italy; was held May 2-7, 1963 in Florence, Prato, and Padoue.

As before, the sessions were divided into four sections: 1) colorimetry; 2) physiology, psychology, and aesthetics; 3) industrial applications; and 4) teaching of color. Many familiar names were on the program from France, Germany, Switzerland, Italy, England, Sweden, Scotland, Japan, Portugal, and Belgium.

M. Déribéré, Secretary General of the Centre, asked the Newsletter to call to the attention of the ISCC the scope and importance of the work of the Journées Internationales de la Couleur. ISCC members and others who are qualified are invited to submit papers for presentation at the Eighth Congress to be held in Switzerland, June 1964. Everyone interested in color is invited to attend.

Address inquiries to M. Déribéré, Secrétaire Général, Centre d'Information de la Couleur, 23 Rue Notre-Dame des Victoires, Paris 2, France.

THE COLOUR GROUP OF GREAT BRITAIN

The April meeting of the Colour Group consisted of a three part program--a symposium, an exhibition, and the first Newton Lecture. The symposium included four lectures.

In the first, Mr. J. M. Adams (Printing, Packaging and Allied Trades Research Association) discussed "The Measurement of Whiteness."

> "It is possible to place a set of near-white materials in an order of increasing 'whiteness,' and this suggests that it should be possible to devise a scale that would enable the whiteness of a material to be represented by a number. Many such scales have been proposed, but none is completely satisfactory. Most of the simpler scales are applicable to yellowish near-whites only, and the more universally applicable scales are complicated. The scales can be broadly classified as those based on spectrophotometric measurements and those based on colorimetry."

In the second lecture, "The Scan-Test Reference Instrument for Reflectometry," Mr. A. Stenius (Central Laboratory of the Swedish Cellulose Industry) stated that,

> "Reflectometers are usually calibrated against one another by the use of secondary standards consisting of tabs of selected papers measured in a reference instrument and distributed by an authorized laboratory. Before doing so, it is necessary, however, to take certain measures with regard to the reference instrument, viz.

"1) checking its photometric linearity and thereafter
2) adjusting its photometric characteristics
3) checking its spectral characteristics and its effective wavelength and thereafter
4) adjusting this wavelength to within certain limits, and finally
5) checking the 100 per cent point of the instrument."

The third lecturer described his fluorescent measuring unit in his paper, "The Colorimetry of Fluorescent Whites."

"The first part of the paper surveyed instrumental requirements, including the essential sequence in the optical train, simulation of daylight in the light source, and the geometry of illumination and reflected light. How these requirements can be met was illustrated in the second part of the paper by a description of a new colorimeter. The most novel feature of this colorimeter is the use of miniature 6 watt fluorescent tubes. Colour Matching and Actinic Blue tubes as light and u-v sources are used separately. A six filter wheel, including four C. I. E. type filters, is used to analyse the reflected light."

The final lecturer of the symposium was Mr. F. E. Large (A. E. I. Lamp and Lighting Company Limited). The title of his presentation was "Light Sources for Matching Near Whites."

"For the precise assessment of colour it is necessary that the illuminant should have closely controlled characteristics. The spectral energy distribution should be a sufficiently close approximation to an agreed phase of daylight, and should extend into the ultra-violet region so that fluorescent materials are sufficiently excited: this is particularly important in the case of near whites. Available light sources which meet these requirements were reviewed including fluorescent lamps, alone and in combination, and xenon lamps."

Professor W. D. Wright received the honor of being selected to present the First Newton Lecture. This inaugural lecture is the first in a series to be held at intervals of two or three years. Each lecture is to be given by a person eminent in the field of color.

SOCIETY OF DYERS AND COLOURISTS AWARDS GOLD MEDAL TO WILLIAM D. APPEL

Our congratulations to William D. Appel, for many years chairman of A.A.T.C.C.'s delegates to the ISCC, on his award of the Gold Medal of the British Society of Dyers and Colourists. Mr. Appel had been elected a Fellow in 1954. The Gold Medal Award was made in recognition of the valuable services rendered by Mr. Appel in connection with the Colour Index as the Chairman of the A.A.T.C.C.'s Colour Index Editorial Committee.

In Mr. Appel's absence, his medal was received by Mr. C. O. Clark of the Colour Index Editorial Board. The award was made during a special awards ceremony of the Society held at the Victoria Hotel in Bradford, England, on Wednesday, February 6, 1963.

COLOR SEMINAR IN BRAZIL

Hanns Struck of P. Alegre, Brazil, informed the Newsletter that he and Mr. Mário Peixoto held a seminar on Color in Modern Living. Sessions were held evenings from May 13 to May 18.

Topics covered in the seminar by Mr. Struck were:

1. How do we perceive color?
2. Physiological and psychological aspects of color.
3. Color as ambiental element.
4. Color in packaging.
5. Who buys colors and why?
6. Which colors are bought more?

Mr. Peixoto's subjects were:

1. How to research color preferences.
2. The methods used to find color preferences.
3. Motivational research the best way to locate color preferences.
4. Increase selling through color.
5. Relation between the product and color.
6. The Brazilian market in colors.

25TH ANNUAL MEETING AND 13TH DESIGN AWARDS PROGRAM OF INDUSTRIAL DESIGNERS INSTITUTE

The Industrial Designers Institute has announced that its 25th Annual Meeting and 13th Annual Design Awards Program will be held in Rochester, New York, October 3, 4, and 5. The three-day session will include two days of member-guest meetings, one day of which, October 4, will be spent as the guests of the Eastman Kodak Company. The third Annual Symposium will be held on Saturday, October 5.

Tucker P. Madawick, Manager of Industrial Design for RCA Sales Corporation in Indianapolis, is Executive Vice President of IDI in charge of the 13th Annual Design Awards Program. Mr. Madawick says that this program has been greatly expanded to cover Design for Home, Business, Industry, Transportation, and Recreation. Over 2,500 submission forms were mailed to industrial designers, manufacturers and architects inviting them to participate. Only products produced in the United States are eligible. The IDI Bronze Medals for meritorious and unusual approach to product design may be awarded in each category, with Certificates of Design Merit also being given for designs the judges find to have special merit. All awards will be made at a banquet to be held at the Sheraton Hotel in Rochester, Friday evening, October 4.

SYMPOSIUM OF COLOR PHOTOGRAPHIC SYSTEMS

The Society of Photographic Scientists and Engineers will hold a symposium on "Color Photographic Systems" in Washington, D. C., October 17-19, 1963.

Special emphasis is being put on the relationships between photographic materials, equipment, and processing. The term "system" however, will be interpreted broadly; all topics in the field of color photography will be considered. Each presentation will be scheduled for a 15-minute period, with an additional short time allowed for questions.

Papers Chairman for the symposium is H. N. Todd, Rochester Institute of Technology, 65 Plymouth Avenue South, Rochester 8, New York. Non-members of the society are urged to participate. Mr. Todd will consider all titles and abstracts submitted to him.

MARTHA JUNGERMAN CITED BY GRANT

ISCCer Martha Jungerman was cited in Grant's house organ, Grant Game. Martha is Color Coordinator for Grant Stores.

According to the article, "The customer wants color, Grants must give it to her." It is Martha's job to aid Grants' buyers in choosing popular colors and in insuring that related departments will have complementary shades of the same color.

The title of the article in Game is "There Is a Rainbow of Color Around Us." The following are some of the quotations from various department managers intended to illustrate the point.

"Sixty percent of chenille bedspreads bought in Grant stores are white." "For the bathroom any color is right as long as it is pink." "...but also keep an eye on the deep tones now being added in bathroom lines." "...predominant (kitchen) accent color is the yellow-to-browns; turquoise is second, and pink is third." "...careful not to use blue-red (children's clothing) because that hue of red does not appeal to children." "...small electrics and appliances call for activity colors such as turquoise, cobalt blue, and other vibrant colors....stay away from red because this color, somehow, connotes cheapness." "The more color and patterns that appear in men's clothing, the more neutrally designed the package."

"DAY OF COLOR" CO-SPONSORED BY COOPER UNION MUSEUM

According to a story which appeared in the New York Herald Tribune, the Cooper Union Museum and the National Home Fashion League sponsored a "Day of Color" in May 1963.

Faber Birren, who spoke at the conference, said that we have countless theories of color but we're about to throw them out and start over. He said that we're in a primitive stage in the new world of color perception. The latest is induced color. Certain drugs make one see luminous jewel colors. Without benefit of drugs various visual stunts cause one to see color and pattern where none exists. This psychological response to color is the newest interest.

The story's author, Harriet Morrison, relates that Psychologist Rudolph Arnhein of Sarah Lawrence College said that ideas of what constitutes harmonious colors are changing. He compared new theories of dissonant color harmony with dissonance in modern music and noted that dissonance does not necessarily create ugliness.

We need to re-define harmony. Beauty has something to do with an unknown order and when this order is broken a color combination is considered ugly. He also said that designers need to learn use of color from painters. People need to find themselves in color terms. His studies indicate that an individual's idea of harmony in color is related to physical appearance. Blue-eyed blonds tend to like blue and blond color combinations.

Kaye Leighton, lighting consultant for General Electric, stressed the importance of selecting a fabric for home decoration under the same light to be used at home. The forecast for fall decorating - tortoise shell, putty and amber.

BOOK REVIEW Color in Business, Science, and Industry, Second Edition 1963, Deane B. Judd and Günter Wyszecki, published by John Wiley & Sons, Inc., 605 Third Avenue, New York 16, New York.

No single publication has better served the total aims and purposes of the ISCC than Judd's 1952 edition of Color in Business, Science, and Industry. This singular authoritative reference brought into focus the state of knowledge and the thought disciplines of the many technical and commercial activities in the broad field of color. Even more, it subtly added to this compendium the brilliant perceptive projections of the author. To the commercial technologist it was a springboard for application of basic concepts and a stimulant for advanced exploration. After ten years of reliable service and advancing technology, Edition I has earned retirement and replacement with Edition II.

Edition II, a product of Dr. Judd's collaboration with Günter Wyszecki, has retained the basic format of Edition I with some minor editing of familiar classic technology and improved illustration. It very significantly alters and adds new information in those areas of applied color research which have been actively under investigation during the past decade in the C. I. E., the Optical Society, and the Problem Committees of the ISCC and the ISCC Member-bodies. It is exciting to find between the same two covers an objective appraisal of the current state of knowledge in such fields as:

Theories of Color Vision
Colorimetry of Fluorescent Materials
Color Rendering of Light Sources
Measurement of Degree of Metamerism
10° Color Matching Functions
Status of Activities of the OSA Committee on Uniform Color Scales
Chromatic Adaptation
Provisional 1960 C. I. E. - UCS diagram
Object - Color Perception in Complicated Scenes

Some aspects of the new material seem particularly worthy of added review comment. These are impressions which this reviewer found most retentive after a scanning comparison between editions.

The value of the second edition seems most greatly enhanced by the updating of subject matter related to experimental tools and techniques. For example, as a result of the widely expanded use of spectrophotometry and colorimetry and the extremely diverse commercial techniques for reduction and interpretation of data, this field has become very confusing to the newcomer. The completeness of the treatment from historical, practical, and conceptional viewpoints guides the perspective of the reader to the basic issues. The detail for techniques in treatment of spectrophotometric data are complete enough to permit him to experiment directly in a framework of established hypothesis and proven fact. The common pitfalls and fallacies are sufficiently delineated that the path to successful application can be relatively direct.

The second edition's major contribution lies in effective revelation of the major limitations which adversely influence instrumental color standardization and effective commercial application. Observer and light-source metamerism, chromatic fluorescence, limitations in instrument design, uniform color scale deficiencies while separately treated can be integrated by the reader to significant advantage in the endless problem of correlation of color experience with appropriate numbers. The reader is also made conscious of the timeless changing of definition, as our knowledge moves hopefully forward.

For example:

Edition I: "Color perception is what we see apart from variations in time and space."

Edition II: "Color perception is one of the fundamental ways by which we find out about the things around us."

There is valuable enrichment of material related to techniques for evaluation of color reproduction processes. This is accomplished through the general enhancement in subject matter related to color space metrics, amplification of mathematical procedures for handling light primary addition, and supplementation of new information on fidelity of photographic and television systems. A new dimension is also added in a brief but basic new section which merely hints at the nature of the problem and inadequacy of present color technology to handle quantitatively object-color perception in complicated scenes.

It is very highly probable that many specialists may take issue with the points of view of the authors, simply because of the intrinsically controversial nature of specific subject matter. This should be viewed as a desirable consequence. Stimulated and responsible controversy can more quickly lead to truth. For example, this reader finds it very difficult to accept immediately the definitions and data treatment for handling color differences involving varying degrees of metamerism as anything more than a starting point. It is to be expected that the 1970 Edition, however, will reflect the natural argument and agreements which lead to a progressive expansion of our knowledge and understanding.

The only constructive criticism which this reviewer would venture is related to the organization of topical material. It is recognized that this is a reference work and in a reasonable period of time and use the reader becomes sufficiently familiar with the content that he can locate a segment of desired information. Topics are presented in Part II, Tools and Techniques, with no apparent attempt at systematic continuity. The casual reader, it would seem, could be easily lost by the absence of transitional explanation and the need for selecting from this random collection of topics those sections which may be most pertinent to his area of investigation. To grasp fully the value of the information, this book cannot just be read but must be assimilated in its entirety.

As we discard our much worn copy of Edition I with the Munsell cover, replace it with the Munsell cover of Edition II, we eagerly await the opportunity to measure the coming decade of progress of color technology in Edition III.

Ralph Pike

MOSES HARRIS ON COLOR IN 1776

A facsimile edition of what is described as perhaps the rarest known book in the literature of color has recently been privately printed in a limited edition, with historical notes and commentary by Faber Birren. It is The Natural System of Colours, written about 1766 by Moses Harris, an engraver and entomologist, who illustrated what he had to say about color theory and organization by signed engravings.

While the book is quoted by a number of later authors on color, for many years it was thought by F. Schmid (The Practice of Painting, Faber and Faber, London, 1948, see also The Art Bulletin) that he might have the only copy in existence. But in 1956 a copy was offered to Faber Birren by Lucien Goldschmidt of New York who commented that he had never seen or heard of the publication before. You can well imagine the excitement of a collector in making such a "find." He tells you about it, and the history of the book and of early color theory in his commentary.

The Harris Treatise, dedicated to Sir Joshua Reynolds, president of the Royal Academy, is contained in eight pages of text. The title page consists of what might be paraphrased as an abstract: "The Natural System of Colours, wherein is displayed the regular and beautiful Order and Arrangement, Arising from the Three Premitives, Red, Blue, and Yellow, the manner in which each Colour is formed, and its composition, the dependence they have on each other, and by their Harmonious Connections Are produced the Teints, or Colours, of every Object in the Creation, And those Teints, tho'so numerous as 660, are all comprised in Thirty-Three Terms, only - By Moses Harris" . . .

The reproduction is a beautiful job in which many cooperated. The two original plates of "Prismatic" and "Compound" colors had badly deteriorated. They had been engraved on two copper plates as keys, and the colors washed in by hand. For reproduction the key engravings were reworked as Harris had done them. Fresh colors were applied, and the two charts were then reproduced in process lithography. All other black and white pages are literal, full-size, offset reproductions from the first edition. As Mr. Birren says, "This is all in tribute to Moses Harris and to bring back into the literature of color a reproduction of one of its most remarkable treasures."

Distribution will be handled by the Whitney Library of Design, 18 East 50th Street, New York 22, New York. The retail price will be $12.50.

D. N.

COLOR PLANNING FOR HOSPITALS AND SCHOOLS

The ISCC Board is pleased to again make available to ISCC Newsletter readers an excellent and beautiful treatise on the use of color. It is Color Planning for Hospitals and Schools, a manual prepared especially for architects and builders by Martin-Marietta Company. This is the fourth in a series produced for Martin-Marietta Company by Walter Granville and distributed to Newsletter readers. We are sure you will enjoy this pamphlet as much as you have enjoyed previous ones. You will surely be intrigued by the beautiful illustration of colors on the back two pages.

BRONZING

Enclosed with this copy of the Newsletter is an illustration of bronzing. This is one of the most effective demonstrations of the bronzing phenomena I have ever seen. This example was called to my attention by a Newsletter reader who sent me a copy of R-B-H Trends, an informative bulletin about pigment dispersion from the R-B-H Sales Group for customers of the Color and Chemicals Division of Interchemical Corporation, Hawthorne, New Jersey.

I wrote immediately to the man who writes for R-B-H Trends, Mr. R. L. Lynch, Sales Manager. He generously consented to provide enough samples to include with this issue of the Newsletter.

He asked me to emphasize that the bulletin is written for Interchemical's pigment dispersion customers (consequently, the stress on the importance of good pigment dispersion). He said that Interchemical's color expert, Dan Smith (also a member of ISCC), patiently and thoroughly reviewed the article before it was published.

Since the article on bronze phenomena was published in two installments and since there was not a sufficient number of both Part I and Part II for distribution to the Newsletter, we have decided to reprint the article in full for Newsletter readers.

Ed.

"BRONZE PHENOMENON IN PIGMENTS AND DYES

"Most of us are pretty fuzzy when it comes to understanding the phenomenon of surface bronzing in pigments and dyes. 'Bronzing' describes the metallic luster from certain colored surfaces in which the surface reflected light may be of quite different color than that transmitted by the pigment or dye itself. While not the frequent problem it was 15 to 20 years ago, we should still make it part of our business at least to know how to recognize and to cope with surface bronze. Why is it that some inks among the jet blues and violets show reddish metallic luster when others do not? Why do many dyes in dry powder form appear almost complementary in color to what they actually are in dilute solution? Methyl violet crystals, for example, appear a shiny yellow-green rather than violet; the brilliant purple dye fuchsin appears a lustrous bright green in the solid state. Among pigments iron blue can be a notorious 'bronzer'--remember fighting it in the old automotive enamels? Bright organic reds including lithols, paras and some BON's are often troublesome.

"Can bronzing be reduced or eliminated by clear overcoating? Does particle size have anything to do with it? Can the better pigment wetting of an R-B-H dispersion reduce the phenomenon of surface bronze? And why is such metallic luster called surface bronze in the first place? Is there a similarity to surface color of polished metals?

"Bronzing is much easier to demonstrate than to understand. Most text books hurriedly cover the subject in a short paragraph as 'examples of selective surface reflection from those bodies which show anomalous dispersion of light . . . as represented by Helmholtz's equation:

$$\mu^2 = 1 - P\lambda^2 + \frac{Q\lambda^4}{\lambda^2 - \lambda^2_1},$$

"This we will not attempt to explain here. Fortunately Interchemical has some well qualified (and patient) color experts* to help translate this jargon into terms we can understand.

"It All Starts with Refractive Index

"The refractive index of a material for any wavelength of light is the ratio of the speed of this light in a vacuum to its speed in the material. As a beam of light enters one medium from another at an angle, its change of speed is always accompanied by a change of direction at the interface. The amount of this change (refraction) provides a relatively easy means of measuring index of refraction.

"When a beam of white light is passed through a glass prism into air, it is dispersed into the familiar colors of the spectrum because index of refraction of the glass varies with wavelength--that is, the violet component of white light is bent (refracted) more than the longer wavelength red component.** In glass and the great majority of other transparent materials, index of refraction varies regularly with wavelength. This regularity provides what is called normal dispersion of light.

"Anomalous Dispersion

"In a few materials, however, index of refraction does not vary regularly with wavelength. If white light were passed through a prism of pure iron blue, for example, most of the yellow-red should be absorbed, with much of the blue, green and violet passing through. But some of the yellow-red would

*Of particular help, Daniel Smith, Director of Color Center, Interchamical Central Research Laboratories.

**For this reason index of refraction of a material is generally given for the Sodium D lines 589.3 millimicrons.

get through, and this part of the white light would be bent or refracted very much more than expected--perhaps beyond the shorter-wavelength violet--putting it far out of the normal sequence of spectrum colors. This is anomalous (meaning irregular, nonconformable) dispersion of light. Intensely colored materials, that is, materials with very pronounced absorption bands, frequently have abnormally high indices of refraction in the wavelength region of maximum absorption.* This is what happens in pigments and dyes that show surface bronze.

"Bronze is Purely a Surface Phenomenon

"A material normally appears colored because it selectively absorbs a part of the incident light (which is dissipated as heat) and reflects or transmits only the remainder to our eye. This kind of colored reflection is called body color.

"Whenever light passes from one medium into another of different refractive index, some of the incident light is reflected at the interface without being selectively absorbed. The amount of light reflected at the interface will be appreciably greater with increasing difference between the two indices of refraction.

"In a bronzy pigment the index of refraction becomes so high in the region of greatest absorption that very little light of such wavelength gets through the interface--it is strongly reflected in this region instead.

"This is in opposition to the mechanism by which we account for body color. Instead of being selectively absorbed, the incident light is selectively reflected at the surface--that is, certain wavelength components of the incident light are reflected more efficiently than others so that the reflected light is colored. For this reason the surface color of a bronzy material is frequently almost complementary to the body color. And because this reflection is often so pronounced, particularly at grazing angle, it appears bright and shiny, or 'glossy.' In fact, it could appropriately be called 'colored gloss.'

"You will recall that the interface of two transparent materials depends upon the magnitude of difference between their indices of refraction and that the index of refraction varies with the wavelength of the light considered. The phenomenon of surface bronze in intensely colored pigments and dyes was explained as the result of peculiarly high indices of refraction in the wavelength regions of maximum absorption. This causes a high proportion of the incident light which would normally be absorbed in this wavelength region to be selectively reflected at the interface instead. Because this reflection takes place selectively in a wavelength region where light normally is absorbed, the bronze surface color is sometimes complementary to the body color.

*In reality, refractive indices reach a maximum just on the high wavelength side of that where maximum absorption occurs.

"In the examples the bronze surface colors are particularly noticeable where the inks are printed over black. Since the colored inks are essentially transparent, we see their normal body colors reflected back through the ink film from the white paper substrate. While surface bronze is actually present over the entire colored area, it is so weak compared with the body color that it becomes readily apparent only where the body color is eliminated by absorption into the black substrate. Surface bronze in the colored area over white does reduce chroma somewhat in the body color as will be pointed out later.

"Notice that over black the bronze, or 'colored gloss,' is more pronounced when viewed from a low angle against illumination--in the same manner as we usually check gloss in any other surface.

"Spectrophotometric Curves Tell the Story

"Spectrophotometric curves of each ink were made by transmitted light for body color, and by surface reflected light for bronze color. Note the curves by transmitted light all have strong absorption bands indicating their intense color. When tristimulus values are calculated from these curves, they show the dominant wavelength of the surface bronzes to be quite different from that of the body color in each case.*

"The mixed blue and red ink is particularly interesting. A mixture of alkali blue and Red Lake C can produce a black which is the subtractive result of the roughly complementary blue-violet and orange-red body colors. But in the mixture the surface bronzes of alkali blue and Red Lake C add to give a low value yellow--identical to the result obtained by a proportionate average of the orange and yellow-green bronze curves of the separate pigments. Similar results (not shown) are had when PTA green and sodium lithol inks are combined. The purple bronze from the green ink adds to the green bronze from the orange ink to give colorless bronze. This ink combination therefore becomes a 'gloss' black. In surface bronzes we have the interesting phenomenon in which additive instead of subtractive results are obtained when mixing colored pigments!**

"Surface Bronze Should Not Be Confused
With Interference Color

"Surface bronze should not be confused with the often similar appearance of iridescence due to interference. The interference colors observed in an oil film on water, or in a soap bubble, or in the wings of a Japanese beetle, etc., can be distinguished from surface bronze by observing a change of color across the spectrum as the angle of view is changed. Surface bronze color does not change with point of view although intensity or brightness will vary.

*Where the dominant wavelengths contain the suffix C (for complementary) they indicate a color in the purple chromaticity area.

**First reported by Daniel Smith in a thesis at MIT, 1934.

"It is certainly possible for both bronze and interference phenomena to occur simultaneously as in the old iron blue automotive finishes. After short exposure to weather there was probably enough vehicle wear or pigment migration for some pigment-to-air interface, sufficient to give a 'plummy' bronze reflection. As weathering continued further deterioration took place at the surface in a way that produced some diffraction of the incident light with consequent interference colors. At that point the weathered iron blue finish was not only 'plummy' in appearance but would change with angle of view from red through yellow, green, blue and back to red.

"Color of Polished Metals
Also Due to Selective Reflection

"Most surfaces do not reflect selectively because variation of refractive index with wavelength is too small to be influential. Normally, most incident light passes through the interface and is selectively absorbed, the remainder being transmitted or reflected back through the surface as color due to the selective absorption. Metals, however, have extremely high 'optical constants' (index of refraction multiplied by absorption coefficient) so that polished metals reflect a great proportion of incident light at the surface; furthermore, reflection differences with wavelength are sometimes quite large so that the resulting selective reflection accounts for distinct color in such metals as copper, brass and gold.

"Factors to Reduce Bronze

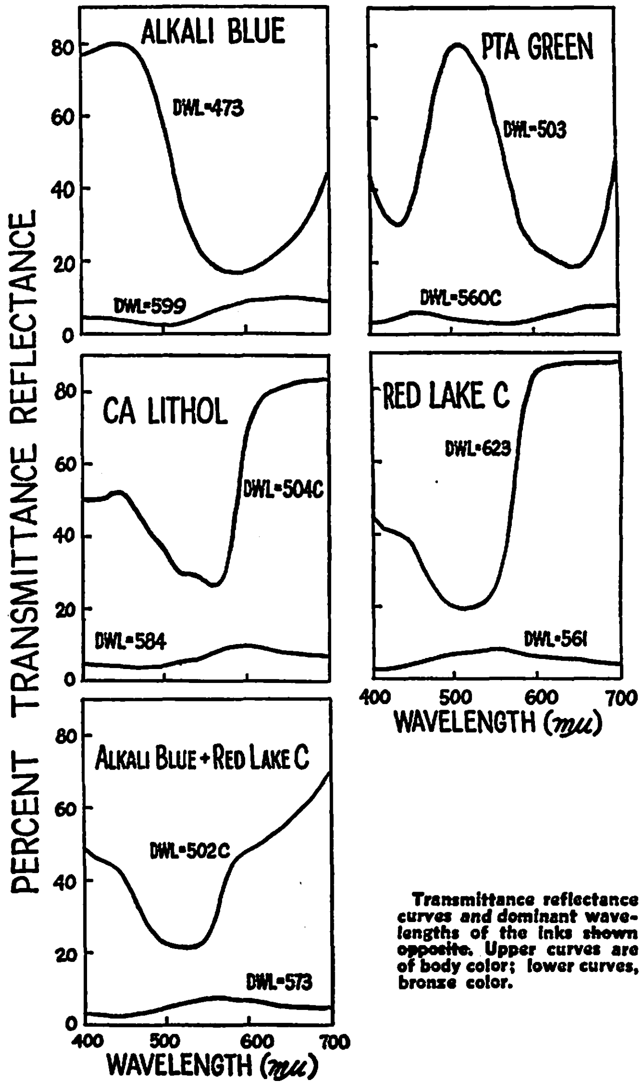
"The most obvious approach to reduce or overcome bronze is to reduce the amount of difference between indices or refraction at the interface, thereby reducing the amount of surface reflection. A maximum index difference would be at a straight pigment-air interface. Interposing a transparent film of any vehicle between the pigment and air eliminates the pigment-air interface and replaces it with a pigment-vehicle interface of smaller index difference.

"Each of the following factors contributes toward this end in an ink or coating:

A clear topcoat over the bronzy film.
Maximum wetting of the bronzy pigment by the vehicle.
Increased ratio of vehicle to pigment.
Extend the bronzy pigment with a transparent white, as in a resinated or laked pigment.
Prime coat where necessary to obtain non-absorbing base in order to maintain maximum ratio of vehicle to pigment in the film.
Formulate for fast drying to help minimize absorption of vehicle in substrate.

"The effectiveness of clear topcoating can be readily demonstrated on page six where even an oil smudge or fingerprint will kill the bronze over black. Also, topcoating the colored portion will increase the chroma of the ink body color by eliminating unapparent bronze in this area.

"Does reduced particle size in a bronzy pigment give less metallic reflection in a dry film? Theoretically no, but in practice there is some advantage in pigment of small and uniform particle size. As the pigmented film shrinks or contracts upon drying, oversized pigment particles will more likely protrude through the surface with more opportunity for straight pigment-air interfaces. Even more important is another R-B-H plus value--good wetting of the pigment by vehicle is an important step toward reducing bronze."



Transmittance reflectance curves and dominant wavelengths of the inks shown opposite. Upper curves are of body color; lower curves, bronze color.

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METAMERISM AND COLOR STABILITY

An historical essay by Walter C. Granville.

At the March 1962 meeting of the Inter-Society Color Council in New York City, illustrations demonstrating metamerism were distributed to those in attendance. They included a pair of printing ink matches supplied by G. L. Erikson, a pair of paint matches by Ralph E. Pike, a pair of textile samples by Roland H. Derby, Jr., and three gray paint swatches by Walter C. Granville in connection with his talk.[1]

At the suggestion of Warren L. Rhodes, Editor of the Newsletter, and through the cooperation of the above persons, duplicates of these demonstrations* accompany this historical essay which discusses experiments on surface color metamerism with which I am familiar. Theoretical work including the papers by

*A two-page folder containing the Granville grays and an explanation was prematurely distributed with Newsletter 161. If you cannot locate your copy, Walter C. Granville, P. O. Box 188, Libertyville, Illinois, will send a duplicate on receipt of a stamped self-addressed envelope.

Wyszecki[2] and Stiles[3] is beyond the scope of this essay (and perhaps the writer too) but because of its importance should not go unmentioned.

Metamerism was the word adopted by Wilhelm Ostwald[4,5] to designate the phenomenon exhibited by two or more surface colors which appear to be alike under one color of illumination such as daylight, but mismatches under another color of illumination such as an incandescent lamp. Now the term is in common trade use.

Although the term metamerism was first used some 40 years ago, the phenomenon was by no means then unknown. Studies of extremely metameric pairs in which mixtures of two parts of the spectrum are set up to color match other two-part spectrum mixtures have yielded our most valuable knowledge regarding the properties of the average normal eye.[6-11]

Why is it that a phenomenon now so well known to color workers was so obscure as to have gone unrecorded until a century ago? It is probable that conditions for observing this behavior of colors were seldom present. One must have two sources of illumination that differ in spectral quality (but not necessarily in color) and few were available prior to the fluorescent and incandescent lamps. Artificial sources such as the candle or oil lamp were too similar and their intensity too low to reveal these color differences. However, natural sources like the sky or setting sun and their modification by stained glass windows or colored surfaces undoubtedly produced metameric situations.

With the advent of electric light sources, the phenomenon was readily perceived, and with the development of the G. E. (Hardy) spectrophotometer, curves of metameric pairs dramatically showed how the phenomenon occurred. Yet it is probable that this characteristic of colors was recognized long before the advent of modern colorimetry by artists and craftsmen who were faced with the problem of matching the same color in two different media such as ceramic tile with paint or a textile.

The printing industry has unwittingly produced enormous quantities of metameric matches. All three and four-color reproductions are metameric to the original subjects! Even single color matches, i.e., matches made by one printing impression from a solid plate are usually metameric to the original color. This situation still undoubtedly causes many disagreements on the accuracy of an ink match. Yet the first demonstration, printed by intent, appears to have been the pair of metameric blues in Color as Light,[12] the second of Three Monographs on Color published by Interchemical Corporation in 1935. These matches were designed by Arthur C. Hardy, consultant to the publisher, translated into ink formulas by Carl E. Foss and printed under the supervision of the writer, which was my first contact with the phenomenon.

The development of the recording spectrophotometer by Hardy was a great stimulant to the preparation of visual demonstrations. James J. Glenn while at the Research Laboratories of Sidney Blumenthal & Co. developed the Glenn Colorule[13] and showed it at the 1941 ISCC annual meeting. It contained two series of textile swatches, one a combination of orange and blue dyes and the other a combination of yellow and violet dyes. Each series was spectrally consistent within itself but metameric to the other series. In addition to testing of color vision and the quality of light sources, it illustrated in a dramatic way the disagreements among observers in viewing the same set of metameric matches. About this same time, E. I. Stearns, former ISCC President, produced a pair of olive drab swatches of cloth that were spectacularly metameric. A decade later Frederick T. Simon[14] emphasized the wide occurrence of metameric matches in the textile industry and that combinations of different synthetic fibers added another factor with which to contend.

The relation of metamerism to camouflage and theatrical effects was discussed by Charles Bittinger at the October 1924 meeting of the OSA. The paper was not published but the title and abstract which follow show that Captain Bittinger, an artist and former art editor of this Newsletter, had the subject well in hand.

> Applications of Colors of Similar Appearances but Different in Spectral Composition.
> "The principles governing the selection of pigments and dyes which shall appear similar under one illumination and different under another. Application of such colors to changeable pictures to theatrical effects and to camouflage in time of war."

Permanent green paints were metameric to natural foliage and could be detected easily with a red filter; the foliage would look much lighter than the paint. Efforts to improve these paints were partially successful using chromium oxide which gave a fair spectral match. In 1942, a new pigment, dianisidine blue, was developed[15] with adequate permanence and improved spectral characteristics which could be combined with yellow to give a usefully non-metameric match to foliage.

The present attitude on metamerism by industry is negative--it causes nothing but hardship and the problem has been how to minimize or live with the effect. But there have been some useful applications. Color changes in theatrical costumes and scenery sometimes seem to occur like magic. Perhaps the most consistently startling ones for several decades have been the stage shows at Radio City Music Hall where metameric light sources and fluorescent paints are used with great effectiveness.

In 1943 at the Research Laboratories of Interchemical Corporation, while developing a lecture demonstration based on a metameric ink match* to Camel cigarette carton brown, I noticed the accuracy of the match depended on the distance at which it was viewed and thought at first I had come upon a previously unknown effect. Of course, distance was not the primary cause. It was a matter of whether or not the samples were viewed through the macula, the central 5° or so, of the retina which contains a yellowish pigmented layer, or by the extra-macular area. The effect was well known to workers practicing visual colorimetry who avoided it by restricting the field of view, usually to 2°, but in the case of surface color matches, I have since come across few prior references but those I have seen are brilliantly clear, emphasizing that most if not all visual phenomenon have already been discovered.

*later incorporated in a folder distributed by the Macbeth Corporation.

J. Scott Taylor in his preface to Part II of Ostwald's Color Science[5] has the following interesting comment: "Here the whole question of complementary colors appears to be somewhat confused, few persons being aware of the fact that the complementary condition is largely a relative matter and that unless the illumination and visual angle are accurately defined, specifications about complementary colors are really valueless. This is largely the fault of the textbooks which fail to inform the seeker after truth that two colors which are complementary in one kind of daylight are not complementary in another kind of daylight, nor do they deign to supply the additional information that two colors which are complementary at ordinary reading distance, are no longer complementary when the distance is increased, although this would appear to be a necessary consequence of the fact that the areas of the color sensitive regions of the retina are different for different hues."

An earlier reference to the effect of distance was described in the Tyndall Lectures delivered by W. D. W. Abney[16] in 1894 at the Royal Institution where patches made by projection of lights matched to the experimenter (lecturer) close up, but not to the audience. He further suggested there is no absolute color match because of variations in the density and shape of the macula. Today this is still a valid view, where the media are not identical, but from the frequent disagreements in the visual appraisal of color matches, one would think it had little support! There are very likely earlier references and I hope the reader will call them and other omissions to my attention.

This "distance" phenomenon should be better known as it can have serious practical consequences. For example, in color matching with printing inks, sometimes the color to be matched is a very small area and the matcher has to use a linen glass to enlarge the field of view. This is still practiced today for how else can one get a good look at an extremely small color area, yet in doing so, the basis for disagreement is laid.

For some years I had pondered if metamerism might be the basis for the artist's distinction between lively and dead grays. A dead gray would have a flat spectral reflectance curve, while a lively gray would have a complex curve. In 1947 to test this hypothesis, I matched a non-selective gray paint with a mixture of titanium dioxide white toned with pthalocyanine green, rhodamine B and hansa yellow 10G. I was delighted with this misbehavior at different viewing distances under the same illuminant as well as under different illuminants. Unfortunately, no observer was able to distinguish one gray from the other without prior training to look for the after image of the macula on the complex gray. Nevertheless, and with the help of Deane B. Judd, results of these experiments and a computational basis for wide field (extra macular) tristimulus values were given in a joint paper[17] at the OSA meeting in March 1949. These same grays were used by Kenneth L. Kelly[18] to study observer differences in color mixture functions.

I was never quite willing to give up the idea that there was a perceivable difference between a simple and a complex gray and that metamerism was the basis. A few years ago, it occurred to me that the effect artists had been claiming for a dead gray was that it was illuminant stable, i.e., it remained gray under all illuminants and conditions of viewing. On the other hand, the lively gray was illuminant unstable; it acquired or changed in hue and saturation when the illumination was changed. Thus, metamerism might be considered as a form of appearance stability of individual colors. The three grays contained in the card "Stable and Unstable Colors" distributed at the 1962 annual meeting of the ISCC illustrate this point of view. At the meeting, I found that Roland H. Derby, Jr., also had adopted these terms in describing color changes in members of a metameric pair.

The application to paint formulation for interior decoration seems obvious since, for example, a gray paint could be formulated to either remain gray all of the time or to look gray in daylight and pink at night, or to look greenish in daylight and neutral at night. But this raises the question of intent which is something that must be decided by people.

Dorothy Nickerson's IES Committee on Color Rendering of Light Sources has laid the groundwork for this type of evaluation. Thus, it seems possible that metamerism or color stability which up until now has been considered an unfortunate characteristic may some day provide a refinement in controlling the appearance of our environment.

(Post-manuscript note by the author) Judging from the pre-publication reaction to this essay from the persons whose samples are exhibited there must be many references that have been omitted through oversight or ignorance. For example Ralph Pike has called my attention to patents 2,642,404 and 2,604,414 issued to him covering methods for making durable "lively grays." Also his laboratory has prepared but not published a report on colorimetric measurements of all metamers accompanying this essay, for variable light sources and 2° and 10° field calculations. Roland Derby, Jr. mentions a book on color by D. Paterson[19] published in 1900 which contains an illustration of metamerism. He considers it to be a remarkable little book and the only copy he knows about is at the Lowell Textile Institute. He also mentions a recent paper by Commerford[20] on textile metamers. Still another recent paper which concerns the definition and proposed unit of metamerism was published by Bruning.[21]

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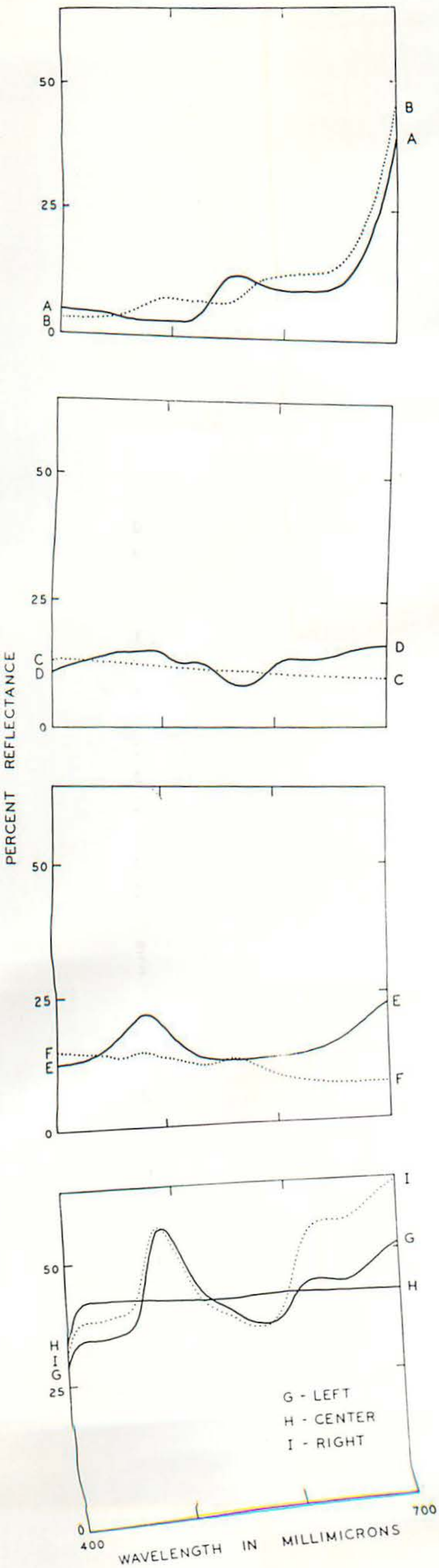
2. Günter Wyszecki, "Evaluation of Metameric Colors," J. Opt. Soc. Amer., 48, p. 451 (1958).

3. W. S. Stiles and Günter Wyszecki, "Counting Metameric Object Colors," J. Opt. Soc. Amer., 52, p. 313 (1962).

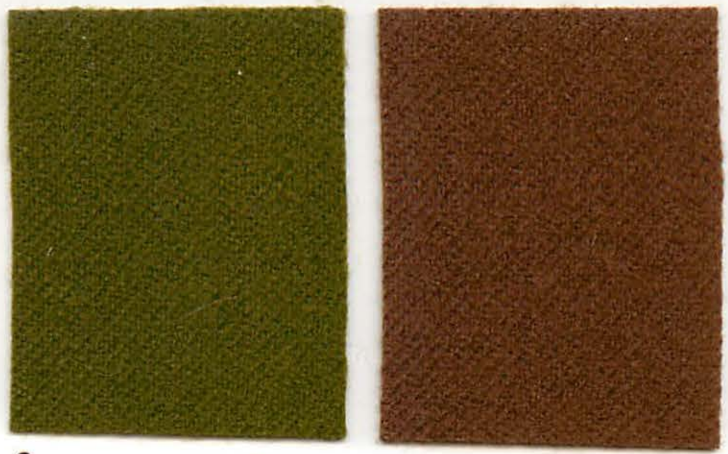
4. Wilhelm Ostwald, "Farbkunde," S. Hirsel, Leipzig (1923).

5. Wilhelm Ostwald, "Color Science," Part II, pp. 35-46 (translated by J. Scott Taylor), Windsor & Newton, London (1933).

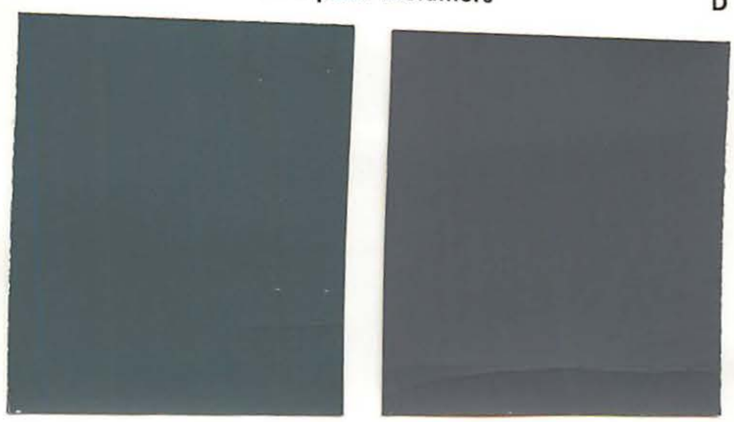
Illustrations accompanying essay on Metamerism and Color Stability



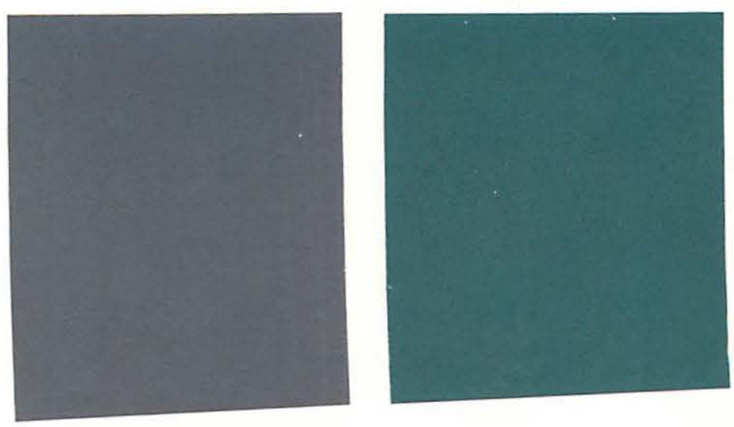
A **Derby textile metamers** ***B***



C **Pike paint metamers** **D**



E **Erikson ink metamers** **F**



Granville stable and unstable grays

A two-page folder containing three "gray" chips and a description of their appearance behavior under different viewing distances and illuminants, intended to accompany this essay, was prematurely distributed with ISCC News Letter No. 161. The curves, left, are for these chips.

Note: All curves on this page were made on representative samples of the production runs of the chips shown.

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8. W. de W. Abney, "Modified Apparatus for the Measurement of Colours and Its Application to the Determination of Colour Sensations," Phil. Trans. Roy. Soc. (1900); Researches in Colour Vision, pp. 223-254, Longmans-Green, London (1913).

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10. J. Guild, "The Colorimetric Properties of the Spectrum," Phil. Trans. Roy. Soc. London, A 230, 149 (1931).

11. OSA Colorimetry Committee, "Science of Color," pp. 114-115, Crowell Co., New York (1953).

12. "Color as Light," No. 2 of a series of monographs on color, p. 20, Research Laboratories of the International Printing Ink Corp., New York (1935).

13. James J. Glenn, "Glenn Colorule," ISCC Newsletter 43 (September 1942).

14. Private communication from Frederick T. Simon on metameric textile samples (February 1951).

15. Walter C. Granville, Camouflage, U. S. Patent 2,361,473.

16. W. de W. Abney, "Color Vision," pp. 28-30, Sampson Low, Marston & Co., London (1895).

17. Walter C. Granville and Deane B. Judd, "Metameric Colors and the Macular Pigment," J. Opt. Soc. Amer., 39, p. 632A (1949).

18. Kenneth L. Kelly, "Observer Differences in Color-Mixture Functions Studied by Means of a Pair of Metameric Grays," J. Res. Natl. Bur. Std., 60, No. 2 (February 1958), research paper 2825.

19. D. Paterson, "The Science of Colour Mixing," Scott, Greenwood and Co. London (1900).

20. Therese R. Commerford, "Some Metameric Pairs," Lab Notes 4, 2, The Derby Company (1963).

21. Armin J. Brunung, "A Study of Metamerism in Colored Paints," Off. Digest, p. 437 (April 1962).

ACTA CHROMATICA

Volume 1, Number 2, of Acta Chromatica has been published by the Color Science Association of Japan. A report of the inauguration of this annual periodical appeared in Newsletter 158-159, March-June 1962. Subscriptions are $2.00. Order from:

Shidisai Kaguku Kyokai
% Department of Engineering
Tokyo University
Bunkyo-Ku, Tokyo, Japan

COLOR ENGINEERING
VOLUME I, NUMBER 2

Subscribers have received their second copy of Color Engineering magazine. The four lead articles were written by well-known members of the Council.

They are:

"Color Quote: 'Color Makes People Hungry to Buy'" by Howard Ketcham
"Those Other Aspects of Appearance" by Richard S. Hunter
"Color Trends: Color Goes Natural" by Egmont Arens
"Fundamentals of Color Measurement" by Hugh Davidson and Henry Hemmendinger
(The second of a series on color specification and control.)

The reader will also find the sections of Color Literature and Materials and Equipment interesting and useful. I was pleased to find that the Reader Service Department cards were colored (blue).

The ISCC also played a prominent role in other sections of the magazine. "Color Goes Natural" is Egmont Arens' report for the American Society of Industrial Designers to the Annual Meeting of the Council. George Ingle's report on Page 28 was also taken from the ASTM report to the Annual Meeting.

VISION AT LEVELS OF
NIGHT ROAD ILLUMINATION

The Newsletter has received "Vision at Levels of Night Road Illumination" (Number V, VI, and VII) from the author, Oscar W. Richards, American Optical Company Research Center. These articles are detailed reviews of the literature on the title subject for the years 1959, 1960, and 1961. Each contains an extensive bibliography. They are reprinted from the Bulletin of the Highway Research Board.

One section of the review is concerned with color. The following are selected from these sections:

(1959) The Council of Industrial Health, American Medical Association, has again opposed tinted glasses and windshields for night driving. "The use of any 'night-driving' lens or windshields, whether tinted, reflecting, or polarizing, reduces the light transmitted to the eye, and renders the task of seeing at night more difficult. The source of glare in night driving is the contrast between the headlights of oncoming cars and the darker surroundings. The use of tinted lenses or windshields does not reduce the contrast but reduces the intensity of illumination from both the headlights and the surroundings, thereby impairing vision. There is no scientific evidence to support any claim that the use of tinted lenses or windshields improves night vision." Yellow glasses reduce recovery time after glare by about 12 percent and the seeing time in the presence of glare about 29 percent according to Davey.

Recent proposals for tinting highways with various colors and for use of fluorescent color markings for night driving suggest careful study as to the effect these will have in seeing after dark. Heath and Schmidt have examined color recognition by those with defective color vision. The recognition of colors is improved when both white and red are seen in the same field of view. They report that bluish-green tends to be called green, and yellowish-green tends to be called red. In general, the limits for signals proposed by Judd were approved. Breckenridge has given a check list of the conditions affecting the probability that a signal light will be recognized, and discusses color signal standards. An international report on colors of light signals is available.

From a study of low contrast, Ronchi proposes that for perception of low contrast, it is essential that one should eliminate with suitable filters either the blue or the green, as the presence of both blue and green impairs the perception of contrast at low luminances. This may be another factor contributing to the difficulty of seeing at dusk. Noise, according to Grognot and Perdriel of 100 decibels decreases the size of visual fields and color perception, although not reducing visual acuity.

With regard to Land's recent contributions to color vision, Wolfson indicates that Land's observations are explainable by color constancy and gives computations to show compatability with the Young-Helmholtz theory. Brown calls attention to the Fechner colors obtained from black and white pictures.

(1960) Decreasing the illumination by a sixth gives normal subjects some idea of the reduced clarity of color as would be seen by those with a mild deficiency. To keep discrimination errors below 1 percent, Gustafson shows that the contrast must be at least 75 percent. Changes in the photochromatic interval with dark adaptation are reported by Lie and Luria and Schwartz are measuring preadaption effects from colored light. Baglien mentions among other factors of vision that yellow is first identified and seen most clearly. On the contrary with poor light, yellow turns gray and is less visible than other colors. Another paper states: "...yellow tinted lenses are a particular handicap to colour-deficient drivers." A more thorough test of tinted windshields by Wolfe et al. confirms the fact that seeing is reduced proportionately to the loss of light from absorption by tinted windshields and McFarland et al. show that this loss is of greater consequence for the older driver. Brightness can be scaled with both white and colored stimuli.

Color vision is reviewed by Hurvich and Jameson. Schroeder explains color vision based on three different sensitive regions on one cone receptor in the retina. Boynton's theory involves three types of photopigments among five kinds of cones, opponent color processes to the lateral geniculate body, and coding in terms of the four psychologically unique colors from there to the cerebral cortex, to quantify color vision and explain color vision deficiencies. Vos explains why some people see blue in front of red, and others red in front of blue.

(1961) Wilmer discusses the unique problems of seeing blue, and Birch and Wright discuss normal and deficient color vision.

Birmingham, England is reported to be experimenting with colored roads, using green, red and white mixes. They also propose to make the beltways brown in color. It will be interesting to see whether the color-deficient persons can tell the difference between the red, green, and brown after the roads become dirty. From a study of driver responses to amber traffic signals, Olson and Rothery recommend a constant amber phase of about 5.5 sec as practical for a wide range of speed zones, with variation when needed to allow for extra wide cross-streets. Color discriminations for yellow and red were reported to be reduced considerably in workers on diesel engine trains after 12 hr. of work. An examination of color-deficient individuals in Germany showed that there was little evidence that the present traffic lights were hazardous. The main difficulty is the shortening of the red end of the spectrum for protans. It is suggested that the only satisfactory solution of the problem would be to use an equal area shape rather than a color for the signal.

Thresholds were measured in the periphery of the retina for 2.6 min arc-subtence red, green, and white signals. The thresholds for red were above those for white and the thresholds for white were slightly greater than for green. Bishop and Crook report that for targets of greater luminance than the backgrounds about 9 hues, 3 luminance levels, and 2 purity levels are useful for operational coding, providing no more than 30 of the possible combinations are included in the set. Under optimal conditions the maximum size of an identifiable set is 60 when trained observers are used.

Crain and Siegel using 0.32° targets of red, yellow, orange, and blue fluorescent colors and matching nonfluorescent paints found that the ordinary paints were seen at lower thresholds than the fluorescents, but that the color thresholds were lower for the fluorescent colors. Tachistoscopic thresholds were determined for shape, color, perimeter, area, and organization of pattern for ordinary and fluorescent paints. Dichromatic stimuli were more effective than a single color, squarish were more effective than rectangular stimuli, and increasing the area of the stimulus increased effectiveness only until an optimal size was reached.

Refractive errors, Wienke discovered, are related to the red/green ratio which matches yellow (Raleigh equation), and myopes use more green and hyperopes more red to match yellow than do emetropes. This was not due to the size differences in the images.

ACCURACY STANDARDS

Hunterlab has designed and is preparing to market a set of nine panels to test the photometric scales, spectral characteristics, and geometry of tristimulus (45°0°) reflectometers and colorimeters.

The present test series checks only green and blue reflectance which are widely used for white and near-white materials. Spectral differences between blue filters have recently assumed importance because of disparities they introduce into the whiteness measurements of optical brighteners and titanium pigments.

For photometric accuracy, white and dark gray panels are measured against light gray. The white and light gray plaques span the reference area of interest for white and near-white materials. The darker gray tile is helpful in detecting stray light, grid leakage and other errors most readily found at the bottom of the reflectance scale.

For spectral accuracy, tan and ivory panels are measured against gray. Spectrophotometric curves for the panels are provided to check the accuracy of Y_c and Z_c filters. One panel is a gray with a nearly uniform spectral reflectance of about 50%, while another panel is a tan with nearly the same luminous (green) reflectance. A third panel is an ivory with nearly the same blue reflectance as the gray panel. Comparison of green reflectances of the gray and tan panels and of blue reflectances of the gray and ivory panels show whether the green and blue filters are to the red or violet side of the CIE Y_c and Z_c functions.

For geometric differences, an aluminum panel with a diffuse surface, but with more near-specular reflectance than the gray panel. Thus, if there is departure from parallelism in either the illuminating or viewing beams, the aluminum panel will read high relative to the gray one. A translucent white glass helps predict the loss of light with translucent specimens. When the diameter of the specimen window and the diameter of the light beam (or lighted area) are approximately the same, light striking near the edge can travel laterally within the sample and be trapped behind the edge of the window. Measurement differences due to specimen translucency arise frequently in color measurements of foods.

An additional pair of metameric panels is designed for use with color-difference meters which have b scales to measure yellowness-blueness. One of the pairs is a green porcelain enamel with low reflectance at the violet end of the spectrum. The other is a green glass of similar color with high reflectance at the violet end of the spectrum. Only with a metameric pair is it feasible to test the spectral accuracy of the chromatic scales of a color difference meter. With panels like gray and ivory it is not possible to separate spectral errors from those due to incorrect scale expansion. The green metameric pair has, in practice, proved very effective for identifying spectral differences responsible for disparities in the whiteness measurement of materials containing fluorescent brighteners and titanium pigments. Both of these materials are characterized by strong absorption in the near-ultraviolet.

COLORED AND WHITE PAPER CRITERIA

Although numerous color printing guides are available, the designer may find their use limited. Most sample prints which are used as guides suffer two deficiencies--the papers do not match those which will be used by the printer or the inks are different in color (or gloss).

The duPont Color Council has tried to alleviate the first of these by providing sample prints. "...--solid and screen tones of the four process colors, duotones, typography, etc.--printed by offset on white, red, orange, yellow, green, blue and violet sheets." The same plates and inks were printed on two types of white papers--one group fluorescent, the other non-fluorescent.

Sets of the "criteria" may be purchased from duPont Color Council, Nemours 8421, Wilmington 98, Delaware.

duPont's recent "Design and Colored Paper" production of examples (experiments) illustrates the importance of the tactile sensation as well as color and design. The examples ranging from waxed paper to velvet, make this point effectively and imaginatively. The text points out that such responses are important in merchandising.

MEASUREMENT OF APPEARANCE

Although we all attach great importance to the specification of color, we all realize that color is only one and sometimes not the most important appearance attribute of an item. Many of us do fail to realize that the "other" attributes can have a significant effect on color.

Dick Hunter (Hunter Associates, McLean, Va.) has published a number of articles on this subject. One of his recent ones is "Measurement of Appearance of Paint Finishes," Official Digest, Federation of Societies for Paint Technology, Vol. 35, No. 459, April 1963, pp. 350-60, 361-5; "Those Other Aspects of Appearance," Color Engineering, Vol. 1, No. 2, pp. 8-14, June 1963.

In addition to color (hue, value, chroma) Mr. Hunter recommends specification of gloss (six varieties depending on nature of surface of item), texture, and transparency. White is a special case in color specification. Mr. Hunter discusses this topic, discussing some whiteness equations for paint, paper, textiles, plastics, and ceramics.

Reprints are available from Hunter Associates.

BIOASTRONAUTICS REPORT

Information on vision in color often comes to us from very unusual sources. For example, the Newsletter received the November 26th issue of Bioastronautics Report. From this report we learned that Goodyear Aircraft Corporation has indeed a substantial life sciences program. What first caught our eye was a question concerning their research philosophy of this organization--"How do we discriminate colour?" Arthur Kranish, publisher, generously consented to let us reproduce part of the report.

"Electro-Physiology Laboratory, Director: Dr. Eugene L. Pautler

"Principal Studies - The major program at this laboratory is an attempt to identify the 'code' which is used by the visual mechanism for identifying and discriminating color. A neural net color theory has been developed, and models have been synthesized and evaluated by use of electronic computers. The next step is to verify the model through laboratory research using the vertebrate retina itself.

"According to Dr. Cacioppo: 'What we are doing, in general, is developing a theory of color vision making maximum use of advanced and unique simulation and mathematical techniques. This theory shows good promise of integrating at a receptor-neural level theories with such phenomena as Land's observations and subject color perception.'

"A paper reporting the research has been submitted for publication and there is a possibility that results of these fundamental studies will be reported at a Bionics conference next spring. Such studies are said to have many potential applications, other than a significant contribution to sensory psychology. A new theory on color discrimination could have profound effects on color television, displays, graphics, color matching and many other industrial developments. Dr. Cacioppo states: 'Results to date have been very encouraging and a major research effort will be maintained in this field of electrophysiology.'

"Perception Laboratory, Director: Mr. R. H. Kause

"Principal Studies - This laboratory is chiefly concerned with determining the information requirements for identifying particular objects within their environment and with predicting potential operator performance in connection with 2-dimensional displays. Mathematical models defining the physical characteristics of 2-dimensional displays are being developed. Psychophysical studies will determine the amount of information an operator can extract from such displays.
11/26/62"

Reprinted from Bioastronautics Report, Vol. 1, No. 22, November 26, 1963, page 169, National Press Building, Washington 4, D. C.

IBMERISM "We can now observe the erosion which has befallen the styling world because of what we shall describe as 'IBMerism'".

So spoke Midge Wilson, executive director, the Color Association of the U. S., Inc., in her report at the Association's 48th Annual Meeting last month. Noting that "a new factor in the color picture is the electric computer, which gained importance with the growth of volume production and distribution," Miss Wilson feels that this growing practice of large businesses turning to the computer to keep their records, plot their buying and even dictate styling has resulted in more limited color ranges and very basic shades.

"The Computer has become the arbiter and final word. Many fail to see the data processing machine for what it is...an automatic brain which can ONLY process the facts it receives. It cannot report the business which is lost because of a too limited or too basic color line."

She further explains that our reactions to colors are emotional and psychological, purely human traits and quite foreign to the electric brain, and that the machines are saying, "Don't feature mauve, it is a borderline color and therefore you can't afford to carry it," when they should be saying, "by all means have mauve, even though it won't be your top selling color--it is new, it is gaining in importance and it will mean additional business."

In conclusion, she pointed out that the upcoming color trends are the answer to the machines and the mass-look of color. "The break-away is here, as indicated by the vitality in boutique and separates items which feature the free use of color and offer the consumer unlimited opportunities for expressing individual tastes. Color news centers around the variety of colors and diversity in the way in which they are combined. Data processing machines have definitely met their match with color...and on this score they are BLIND!"

Color Association officials have noted with regret that, due to mergers and consolidations in the fashion field, there are fewer and fewer creative people and therefore it has become a less and less creative market. In the face of a growing Common Market in Europe, this further complicates the problems of our own textile market.

Reprinted from American Dyestuff Reporter, July 22, 1963.

SOCONY MOBIL ACQUIRES AMERICAN-MARIETTA

(Last minute notice) Walter Granville has notified the Newsletter that American-Marietta Paints has been purchased by Socony Mobil Oil Co. The organization is now called Mobil Finishes Co., Inc. American-Marietta provided Color Planning for Hospitals and Schools. (See Page 15, this Newsletter.)

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