INTER-SOCIETY COLOR COUNCIL

NEWS LETTER

NUMBER 134 March, 1958

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BIBLIOGRAPHY ON COLOR FROM 1936-1954 ISCC NEWS LETTERS NOW INDEXED AND PUBLISHED

Each ISCC delegate and member will soon receive a copy of the 357 page BIBLIOGRAPHY ON COLOR assembled and arranged by Margaret N. Godlove from the bibliography on color that appeared in the ISCC News Letters during the period 1936-1954 when Dr. I. H. Godlove was editor. This has been a very large and highly cooperative undertaking that has taken several years to complete. Its purpose is to provide a permanent record of this bibliography from the News Letter in a collected and indexed form.

For some years before his death Dr. Godlove had planned to prepare a subject index for this bibliography, and had already worked out a tentative subject breakdown. After his death Mrs. Godlove suggested that if the Council wished to have the project completed, she would arrange and type the copy providing others in the Council would advise her regarding the subject index and would review for accuracy the placement of references according to subject. Deane Judd did a lion's share of the initial advisory work regarding the project, and he with Forrest Dimmick, Ralph Evans, Ed Stearns and others, reviewed the placement of references in their more particular fields of interest. Tiny Erikson and the Braden-Sutphin Ink Company arranged to handle the duplication of stencils provided by Mrs. Godlove and to supervise the assembly and mailing of the publication. Warren Rhodes arranged for the design and printing of the cover at the Graphic Arts Research Department of the Rochester Institute of Technology. The design is by H. J. Barschel, a staff member of the Art and Design Department of RIT. With such help the ISCC is able to provide each of its delegates and members with a copy, thus supplying him with a reference to the voluminous color literature, particularly the periodical literature, of the 1936-1954 period. With Richter's Bibliography on Color, published in

Germany, this Godlove Bibliography provides the most complete coverage of color literature of this period that is available.

The book belongs on the reference shelves of any library concerned with color technology. As noted on the inside cover page, copies are available for purchase at $3.75 each, prepaid. Checks should be made to the Inter-Society Color Council, and sent to G. L. Erikson, addressed as follows: ISCC-GODLOVE BIBLIOGRAPHY, c/o Braden-Sutphin Ink Company, Attn. Mr. G. L. Erikson, 3650 East 93rd Street, Cleveland 5, Ohio.

COLOR ASSOCIATION AND BELGIAN LINEN ASSOCIATION ANNOUNCE FASHION COLORS

"Balance Sheet for a More Human World" is the dramatic theme of the Brussels Universal and International Exposition which will be held in Brussels from April 17 to October 19, 1958.

Although Belgium is a small country it is famous for so many wonderful things. Cities full of marvels rich in art and architecture, the truly great Flemish paintings of Van Eyck and Rubens, and certainly one remembers that for generations it has been the flax center of the world, renowned for its skilled weavers -- its Belgian linen. With all this and the Exposition it would seem quite natural to find inspiration for new fashion colors.

The Color Association of the United States in cooperation with The Belgian Linen Association takes pleasure in presenting this collection of nine fashion colors in honor of the Brussels Universal and International Exposition 1958!

This animated summer palette consists of Belgian Blue, Ghent Rose, Van Eyck Green, African Orange, Courtrai Blue, Bruges Pink, Congo Yellow, Flemish Flax and Rubens Red.

In the news release, Estelle M. Tennis states that although these shades are available in Belgian linen they also have fashion and merchandising importance in other fabrics. World's Fair posters, brochures and other promotional material are available at the Belgian Linen Association, 280 Madison Avenue, New York City.

NEWS FROM THE AMERICAN CERAMIC SOCIETY

At the Dallas convention of the A.C.S., May 1957, the Design Division "Session on Color," moderated by T. G. Pett, was a panel discussion by members of the A.C.S. delegation to the I-S.C.C. The session gave an insight into the I-S.C.C. and the manner in which the A.C.S. and the ceramic industries may benefit from it. There was a discussion period regarding all phases of color problems in the ceramic industry.

The title of Dr. Balinkin's talk was "Color and Design in Ceramic Mosaic Tile Used on the Exterior of Buildings."

Papers pertaining to color presented at the Design Division meetings and reprinted in the Ceramic Bulletin in 1957, are:

Mrs. H. D. Taylor, "Timing of Colors in Merchandising with Special Reference to the Ceramic Industry." (Sept. 28, 1957)

Georgina Newman, Living for Young Homemakers, "Dynamic Color in Table Setting." (April 1957)

Guin Hall, N. Y. Herald-Tribune, "More Color for Modern Cities." (April 1957)

F. J. Von Tury, in his paper, "Design at the Crossroads," mentioned the influence of I-S.C.C. on design and production. (Ceramic Bulletin, Dec. 1957)

Other papers concerning color presented in A.C.S. meetings and reprinted in the Bulletin:

R. S. Hunter, "Instrumental Methods of Color and Color-Difference Measurement." (July 1957)

D. G. Sammarone and H. S. Saunders, "A Study of the Subsieve Particle Size Distribution of Milled Enamels and Color Oxides." (Sept. 1957)

Paul Henry, "Chemicals Used in the Manufacture of Ceramic Colors." (Nov. 1957)

The Technical session of the 42nd annual meeting of the Ceramic Association of New Jersey, held in Trenton, New Jersey, featured a symposium on "Plant Control for Uniform Colored Glazes." This symposium was devoted to plant problems related to producing uniform stains and colored glazes. The subjects discussed included control problems in color stain production and plant problems including the milling, application, firing and measurement involved in obtaining uniform colored glazes.

The Design Division is planning a session on color for the 1958 Pittsburgh meeting April 30th. We hope to have Herbert R. Spencer, Jr. repeat his talk "Color in Porcelain Enamel," which he will present at the I-S.C.C. Washington meeting.

At the same meeting, H. Creston Doner will give a talk on how color, light and glass can increase our enjoyment of living.

F. J. Von Tury

Philadelphia-Wilmington COLOR GROUP

"PhotoStress Technique, Development and Applications" was the topic discussed by Dr. Felix Zandman, Tatnall Measuring Systems Company at the group meeting February 25. According to the meeting announcement, Dr. Zandman answered the question "How Strong is Green?". Dr. Zandman was born in Grodno, Poland and completed his education in France. His background of research includes association with the Centre National de la Recherche Scientific, SNECMA (manufacturer of jet engines) PhotoStress, France and U. S. A., and Professor of Stress Analysis at the Aeronautical Academy of Engineering - Paris.

TANNER'S COUNCIL RELEASES LEATHER COLORS FOR FALL AND WINTER 1958

The elegant eras of the past, and the disciplined costuming for the time, place, and event will be of increasing importance and interest in the fashion world.

Leather will continue to play an important role for this careful go together look - the uncluttered look where everything is in tune.

According to the news releases issued by The Color Bureau, Tanner's Council of America, these are the leather colors for women's footwear for the Fall and Winter of 1958: The Winter Neutral is called Oyster, and it is one of those rare tones which shifts its subtle color in correct harmony with each and everyone of the other leather colors, thus making it a pleasing coordinator for trim or accent.

The Deerskin Tans are represented by Vicuna, that medium neutral tan that is a campus favorite and looks young and correct with blacks, browns, grays or navies. Nut Brown is new and slightly browner and deeper than Vicuna.

Benedictine comes under the Copper Tan Category, and its traditional leather hue will have special interest in fine suede for town or country wear.

The two best Medium Browns will be Briarwood and Perfect Brown. Briarwood is the lighter of the two with its warm glowing color just right for the Winter Fabrics. Perfect Brown is that just right color with brown furs and it will be a volume brown in handbags.

The Blackened Browns will be represented with Golden Walnut, Java and Town Brown.

The color with great possibilities is the new Tartan Green which is dark and strong and very right for coordination with the newer fabrics. This really new leather color trims smartly with Oyster, Nut Brown or Benedictine and should prove to be irresistible to stylish customers.

For that most beautiful way to see red try Comanche, which is a bright, clear berry red and predominantly a kidskin color or Scarlet, a classic volume color or Basque Red which is bright and superlative in fine calfskin. Cherry Red is a basic deep red with a long success record and it is the red most often used for handbags. Damask Rose is a new leather tone. This is a top fashion color revival from the 1925 success and will be a Winter favorite in accessories and millinery. Beet Root is a Fashion red, engineered deep in the red scale, developed for calfskin and is smart with navies, grays and dark greens.

The classic dark blue for smooth and suede leathers is called Flight Blue. Navy which seems always good has added interest with an undulating grained texture.

The 1958 leather grays are true neutrals. They are down the scale into the medium and dark values, the right grays for the Fall and Winter fabrics. The new Winter Grays that "GO" with everything are: Gunmetal, Gray Seal, Chinchilla, Graphite and London Gray.

It is interesting to note that more and more care is going into the choice of leather and colors in regard to children's shoes. They are, after all, people too, with most distinct preferences and definite likes and dislikes. Shoes for children are trending steadily toward lighter constructions and more pliable soles.

The Leather Color Guide for Men's and Boys' Footwear for the Fall and Winter of 1958 will have "The Look of a Gentleman." Men's fashions are as important as women's and it is true that now more than ever these gentlemen are interested in what they wear, how it fits and seem to be glad that more color is brightening up their fashion world.

Leather will be an increasing style note in footwear for men, and the colors are all blue chips. There are three major groups covering the smooth and textured leathers in the three important fashion categories.

The Copper Beech Browns are vigorous volume colors, colors for males of all age brackets who prefer a classic American leather hue. Leading this list is a new tan called Ranger with a rich warm color in a small rather flat grain with a copper undertone. Beechwood is darker with a new texture that is visually a pattern within a pattern. The last two in this category are Vintage, a basic color certain to be a best seller, and Juniper with its brassy undertone that has a special luminous quality in fine smooth finished leathers.

Four colors which come under the Mahogany Browns are Meerschaum, Bruin, Mahogany and American Burgundy. Darkly rich in hue, these colors will increase in importance because of their coordination with the dark fabrics.

The newest Fashion color in men's footwear comes under the heading of The Forest Browns. These are the bronzed browns that wear so well with the brown-black fabrics and the many blends and mixtures that have this dark or medium bronzed tonality. They are Olivewood, Dark Oak and Hemlock.

The After Dark Colors not only will have style but comfort with the increased demand in pliable, graceful foot coverings for "at-home" or special event shoes. Midnight Blue and Black will vie for attention in this category.

The carefree, pliable leathers for sportswear, for leisure, for campus and country are The Brushed Leathers. Greige, Wheat, Vicuna, Peat Moss and London Grey are the colors to choose from in those wonderful brushed surfaces which require little or no upkeep, and actually improve with wear.

ISCC ANNUAL MEETING JOINED BY WASHINGTON-BALTIMORE COLORISTS

Members of the Washington-Baltimore Colorists joined ISCC delegates and members at the ISCC 27th Annual Meeting held at the Sheraton-Park Hotel in Washington, March 25-26, COLOR IN THE BUILDING INDUSTRY its theme. The secretary's report of this annual meeting, including committee reports and reports of Member Body delegations, will be circulated to delegates and individual members as soon as it is ready.

THE COLOUR COUNCIL OF TORONTO

There was an item in the November '57 Colour Comments concerning the officers and committees of the Colour Council. From this information, I conclude that our retired friend, Charles Conquergood, is as active as ever. He is listed as Honorary-President, chairman of the Constitution Committee and co-member of the Membership Committee. John Gilchrest is still the Secretary and 'Gene Butt remains the editor of the excellent Colour Comments. Past-President is Professor Carswell and the President is R. C. Allison.

Dr. Isay Balinkin was the speaker at the February 19th meeting at the Prince Arthur House. His topic was "Colour Mixtures with Lights, Filters and Pigments." According to the meeting announcement, the talk was illustrated with slides and demonstrations. I'm sure it was!

"Let's Come to Terms" was the topic of the panel discussion at the March 11th session. Moderator Wilfred Sinclair and his supporting panel; 'Gene Butt, W. E. Carswell, Charles Conquergood, and William A. Howard came to grips with such terms as "Colour," "Colour Harmony," "Primary Colours," "Deep," "Shade," "Flat," and "Dull." From the program announcement I quote, " . . . the fact is, that even the word 'colour' is difficult to define accurately."

PHYSICAL SOCIETY COLOUR GROUP

Eighty members were present at the 103rd Science Meeting to hear Mr. L. C. Jesty, Dr. W. S. Stiles and Professor W. D. Wright.

Mr. Jesty gave an account of the meeting on Physical Problems of Colour Television. He singled out praise for Professor Wright's survey of the whole field.

Dr. Stiles " . . . and a tape recorder" gave an account of the Symposium on Visual Problems of Color. (See Dr. Judd's account in this News Letter.) "They did not think the solutions given by Hunt, MacAdam, Fry and Hurvich and Jameson were going to be the last word. This was had by the tape recorder . . ."

"After tea Professor Wright gave an amusing description of the C.I.E. Working Party held after the Symposium at Teddington. He regretted the use of wave-numbers and thought that two systems - one each for 2° and 10° - would be a handicap."

According to the agenda of the 104th Science Meeting the topic of Dr. F. H. C. Marriott, Physiological Laboratory, Oxford, was "The Photochromatic Interval and Quantum Theories of the Visual Threshold."

The following abstract of this presentation is taken from the meeting announcement:

"When the eye is exposed to short light flashes, colour may be unrecognized or incorrectly named. The chromatic interval between the thresholds for vision and for correct colour naming is present for such flashes even for deep red light. Frequency-of-seeing curves have been obtained for the two thresholds, and their significance is discussed. Bouman and Walraven (1957) have carried out much more extensive experiments on the subject. Their interpretation of the results obtained is, however, open to criticism.

"Tea."

A short report of the Sub-Committee on Colour Systems was sent to members. 200 reprints of this report are available for distribution. The Honorable Secretary, Colour Group, Institute of Ophthalmology, Judd Street, London, W.C.1, will be pleased to forward them to those interested, on receipt of a stamped addressed envelope.

REPORT ON THE NPL SYMPOSIUM ON VISUAL PROBLEMS OF COLOR

The symposium took place at the National Physical Laboratory in Teddington, September 23 through 25. The 150 people who attended had preprints, coffee breaks, receptions, and bus trips. It showed that the enigma of color vision is being studied in diverse ways all over the world and that the researches have made exciting progress.

From this continent there were contributions from Wald, Hubbard, MacAdam, Sperling, Graham, Judd, Wyszecki, Farnsworth, and Fry. Contributors from England were Pirenne, Rushton, Morton, Pitt, Dartnall, Denton, Stiles, Wright, Crawford, Weale, Brindley, and Hunt. From Western Europe: Baumgardt, Plaza, Fiorentini, Lucia Ronchi, Richter, Bouman, Granit, Donner, and Le Grand. From Russia: Federov, Yustova, Yurov, and a charming translater (blond).

I have to summarize 40 papers in a few pages, and if I leave you a little confused, that is the way I was after three days of the Symposium.

At the first session tributes were dedicated to the memory of Selig Hecht, by Hartridge, Pirenne, and Ballard. The principal lecture was presented by George Wald, "Retinal Chemistry and the Physiology of Vision." The known facts of rhodopsin, porphyropsin, and iodopsin and their precursors, variants, and decomposition products were brilliantly reviewed. The recent findings were fitted into the gradually unfolding picture. In discussing the great increase in sensitivity due to rod vision in man during dark adaptation, Wald emphasized the parallelism between the time course of dark adaptation and the formation time of rhodopsin in a test tube shielded from light.

In his discussion of Wald's paper, Baumgardt pointed out the fact that as dark adaptation proceeds, responses from increasing numbers of rods may feed into a single optic-nerve fiber. He stated his opinion that the retinal cones and rods are equally sensitive. Wald conceded that the functional organization of the retinal neurons has an important bearing on dark adaptation and said that he was about ready to admit that individual rods are only 7 or 8 times as sensitive as individual cones.

The second session dealt with visual pigments, particularly in relation to color vision. For me the most interesting of the papers was that by Rushton, "The Cone Pigments of the Human Fovea in Colour-blind and Normal." Using the technique he described at the Philadelphia meeting of the OSA, Rushton measured the spectral reflectance of the living retina both with and without previous exposure to light. From the difference in the two curves he found the absorption spectrum of the pigment that had been bleached. From the spectral reflectance of the extra-foveal retina, Rushton had already succeeded in finding the absorption spectrum of rhodopsin, and in the present work he

measured the spectral reflectance of the foveas of a living protanope, deuteranope, and normal trichromat. By these measurements he determined the absorption spectra of two visual pigments, one with a maximum absorption at 540 mμ, the other at 590 mμ. He suggested that the normal fovea has two classes of cone, one with pigment 540 only, the other with a three-to-one mixture of 590 with 540. The protanope has only the first type; the deuteranope, only the second.

Graham reported spectral luminous-efficiency curves for 5 protanopes, 5 deuteranopes, and 7 normals. The protanopes showed the classic sharp decline in luminous-efficiency curve in the longwave end of the spectrum compared to the normal curve; the deuteranopes showed a slight but consistent decline in the blue and green compared to normal. This finding was dramatically confirmed by studies of the luminous-efficiency functions of a young woman found to have normal vision in her right eye and nearly classic deuteranopia in her left eye. These results are contrary to the Hering and Müller theories of deuteranopia, but they support the form of three-components theory suggested by Rushton's studies of the bleaching of the living human fovea.

Morton and Pitt summarized work on visual pigments by giving a list of 18 pigments isolated by difference spectra from various animals (frog, shrimp, tench, guinea pig, conger eel, trout, carp, squirrel, man, cat, and so on). These pigments have maximum absorptions at such wavelengths as 430, 465, 480, 500, 510, 525, 535, 540, 550, 560, 570, 605, and 620 mμ. The title of the paper, "The Multiplicity of Visual Pigments," is amply justified.

Dartnall studied the bleaching of visual pigments extracted from the frog, carp, tench, conger eel, and gurnard as a function of the wavelength of the bleaching energy. By comparing the various bleaching rates with the extinction coefficients at the same wavelength, he found the very satisfying result that the quantum efficiencies of the bleaching processes are independent of the wavelength. In discussion it was brought out that the whole body chemistry of such fish as have both a salt-water and a fresh-water history changes in advance of the transition. This change involves a change from a rhodopsin-type visual pigment to a porphyropsin type. Similar changes have been noted as the tadpole changes into a frog.

The third session dealt with brightness matching and color matching with emphasis on the Helmholtz-Kohlrausch effect. Yurov, Stiles, and Sperling presented data showing that, for example, amounts of red and green energy both judged to be equally bright as a given yellow comparison field produced on being added together a luminance significantly less by as much as 25% than double that of the original yellow comparison field. This effect is also known sometimes as "Farbenglut," and is in the direction that corresponds to setting too low an energy of red and green to match the yellow as if the observer had mistakenly estimated some of the high saturation of these fields as brightness. Anyway it all means that a strictly additive quantity like luminance cannot possibly correlate satisfactorily with brightness, as has been shown already in this country by MacAdam, Chapanis and Halsey, and Wyszecki and Sanders. Sperling pointed out in his paper that if the heterochromatic settings are made by flicker photometry, the Helmholtz-Kohlrausch effect is much reduced and usually not significant.

Stiles' paper, "The Average Colour Matching Functions for a Large Matching Field," was the most important in this session because it will probably be the chief basis for a new standard observer to supplement for fields of large angular subtense the 1931 CIE standard observer. Field tests so far reported (Judd, Kelly, Cruz, MacAdam, Burnham) indicate that the standard observer agrees with actual observers for fields of less than 4° subtense. The new Stiles data imply a luminous-efficiency function considerably broader than the 1924 CIE standard function, and they also seem to establish a slight but significant breakdown of Grassmann's law that equal colors added to equal colors produce equal color sums. Stiles' data also confirm the so-called Brindley effect that the color of the spectrum at say 820 mμ is yellower than that at 730 mμ, actually matching closely that at 645 mμ. It seems that we cannot anymore say the "red extreme of the visible spectrum" because the extreme of the visible spectrum is not as red as the somewhat less extreme. Another interesting feature of the Stiles data is a pronounced bend of the spectrum locus at the short-wave extreme, the final direction being toward the yellow part of the spectrum locus. Stray energy is ruled out as an explanation by the careful precautions taken by Stiles and Burch, his collaborator, to eliminate it. But fluorescence of the extrafoveal retina or participation of the retinal rods remain as possible explanations. Stiles applied a correction for rod intrusion at the long-wave end of the spectrum because his prior work with Aguilar indicated that the two halves of the photometric field in this spectral region stimulated the rods unequally; but the same work indicated for the short-wave region that the retinal rods were responding maximally in both halves of the photometric field and so could have no net effect on the adjustment for color match.

Wyszecki described a method of deriving the color-mixture functions based upon finding 32 filters whose spectral transmittances are linearly independent to a high degree. The observer determines the tristimulus values of these filters on a large-field Donaldson three-primary colorimeter, and by inverting a matrix of order 31 (which is hard even for an electronic computer) the color-mixture functions required to produce a least-squares fit to the observed tristimulus values may be found from the known spectral transmittances of the 32 filters. If the color-mixture functions so found fail to agree sufficiently well with the observed tristimulus values this may indicate inconsistencies in the experimental settings due to poor precision, but it may also indicate a failure of Grassmann's laws. The method thus automatically produces a check of the practical importance of any failure of those laws.

Since we are in process of formulating a standard observer for the 10°-field, and have to worry about corrections for the unwanted intrusion of rod vision, some mention should be made of a Russian paper (Bongard, Smirnov, and Friedrick) available in preprint form but not read, "The Four-Dimensional Colour Space of the Extra-Foveal Retinal Area of the Human Eye." It was reported that matches set up in the 10°-field by means of three primaries were found not to be stable. They could be upset (by as much as 15%) by varying all radiances by a constant factor, or by changing adaptation. On the other hand, color matches set up by four primaries (460, 485, 520 and 640 mμ) were found to be quite as stable for a 10°-field as matches by three primaries are for a 1.5°-field. The instability of three-primary matches is ascribed to rod intrusion into the color matches for the 10°-field.

The fourth session dealth with Subjective Colour Measurement and Temporal Effects. Wright pointed to the increasing attention being paid to color appearance as distinguished from color measurement based on color matching alone (problems of design, chromatic adaptation, contrast, after-images, retinal position, Maxwell's spot, color rendition, and color reproduction). The basic technique is to adjust the color seen by a retinal area maintained in a standard state of adaptation so that the perception of the color in that area is the same as that of another area differently stimulated and held in a non-standard state of chromatic adaptation. The adjusted color is an indication of color perceived by the latter retinal area. The precision of setting, though much inferior to that obtainable in color matching, is still very respectable. Wright urged formal adoption of a definition of the standard adaptive state and suggested: 4° observing field, 15° white surround illuminated by CIE source A with observer adapted to the surround.

Ditchburn presented his paper, "Eye Movements in Relation to Perception of Colour," which consisted of reports by observers of their color perceptions from one eye stimulated by various chromatic patterns which are caused to affect precisely the same retinal areas regardless of eye movements by being reflected to a screen in front of the observer from a small mirror attached to a contact lens placed over that eye. He reported a progressive desaturation of all colors regardless of hue, the field finally becoming structure-free, first gray, and then dark.

Fry commented that he would expect a uniform gray but not black, and asked if the black was anything more than the domination of the unstimulated eye by retinal rivalry. Ditchburn said that they had tried identical stabilized retinal images for both eyes and sometimes got both eyes to see black at the same time. These results suggest that all vision is contour vision. Destroy the contours and you destroy vision itself.

Fiorentini reported studies of "Space Versus Time Distributions of Chromatic Stimuli." In critical fusion-frequency measurements she found that slow variations of the stimulus are more effective than rapid. She confirmed the well-known result that discontinuity in the luminance gradient can cause by contrast the perception of a light area bordered by dark areas in a strip across which luminance increases monotonically, but similar discontinuities in chromatic gradient failed to produce an analogous contrast effect.

Farnsworth repeated the paper presented at the March, 1957, meeting of the OSA in which he showed that the Munsell, Wright, and MacAdam data on chromaticity spacing differ essentially only in the relative degrees of violet-greenyellow discrimination compared to red-green. He suggested that the time interval allowed for observation to obtain the three sets of data account for essentially all of the differences, red-green discrimination being favored by longer observing times. We know that insufficient field size and insufficient luminance favors red-green discrimination; now we have the puzzling suggestion that insufficient time handicaps it.

The favoring of red-green discrimination by insufficient luminance was shown again by Plaza's report on "Colour Thresholds with Monochromatic Stimuli Through the Spectrum" (530 to 630 mμ). At the chromatic threshold only a

narrow wavelength region was seen as yellow, but at 10 and 100 times threshold, yellow components were reported over much wider wavelength ranges.

The fifth session was to deal with the connection between normal and anomalous trichromats, but of the three papers scheduled (Richter, Rautian, Nyuberg) only that by Richter was given. Richter reported on a determination of the color-mixture functions for his own deuteranomalous vision carried out in Wright's laboratory. He found that these functions could be expressed so that two of them are linear, homogeneous transformations of the 1931 CIE standard observer. The third function, peaking at about 590 mμ could not be so expressed. He suggested that deuteranomaly is based on two visual pigments of normal vision combined with one pigment not present in the normal eye.

The fifth session dealt with electro-physiological aspects of vision, particularly colour vision. Brindley reviewed work on the Electroretinogram (ERG) and Donner that by the microelectrode technique. This technique is to anaesthetize the animal, perhaps remove either the brain, the eye, or the lens and cornea, irradiate the retina, and pick up electrical signals of retinal response by touching some point on the retina with a micro-electrode. The signals are in the form of "spikes" following one another more or less rapidly, and are taken to be the responses of large ganglion cells. By finding the energy required to produce a constant frequency of spikes as a function of wavelength, the spectral sensitivity of the receptors serving a single ganglion cell can be determined. Broad sensitivity curves, said to refer to dominators, are found, both for scotopic and photopic conditions. The scotopic dominators agree with known rod pigments. By using the directional sensitivity of the cones (Stiles-Crawford effect) the cone and rod contributions can be separated. The cone dominators represent the summed effect of at least two cone sensitivities. Narrow sensitivity curves (modulators) are also found.

The final session dealt with color theories. Le Grand in his paper, "Colour Theories and their Implications in Colour Vision," made clearly the difficult point that the color-mixture functions are determined solely by the spectral properties of the visual pigments and have nothing to do with their distribution among the receptors or with the nerve connections by which the signals reach the cortex.

Hunt in his paper, "Adaptation and the Trichromatic Theory," pointed out that the tridimensionality of color matching and the stability of metameric matches regardless of chromatic adaptation proves that only three independent visual pigments are involved in human photopic vision, and that these pigments are present in the cones only in low concentrations. Luminance discrimination requires for its explanation a non-linear connection between stimulus and frequency of nerve response, and Hunt pointed out that a power relation:

$$R = R_o + S^p$$

works better than the usual assumption of a logarithmic relation:

$$R = \log S$$

He said that the three-components theory is the foundation of color vision, but can no longer claim to be the whole edifice.

Fry in his paper, "Chromatic Adaptation with Special Reference to the Blue-Green Region of the Colour-Mixture Diagram," reported he had run into difficulty in his attempts to locate the three primaries of the three-components theory (v. Kries) of chromatic adaptation. He proposed a four-primary theory: red, green, cyan, and violet. The primary cyan and the primary violet of this theory lie on the straight line tangent to the spectrum locus at 450 mμ, but have not yet been precisely located. One of the reasons is that at least a close approach to dichromasy exists in the violet corner of the mixture diagram. Stiles commented that many of his observers showed the same characteristics; that is, for a given ratio of violet to green primary to match a spectrum blue, the amount of desaturating red was set with good precision; but a quite different ratio of green to violet primary could also produce a match with a different amount of desaturating red.

For me, the outstanding paper of this session was that by MacAdam, "Beat Frequency Hypothesis of Colour Perception." This hypothesis leads to a strikingly successful Müller, second-stage formulation with a nonlinear connection to the first stage; the connection being a second degree power series rather than logarithmic. The hypothesis, itself, has been abandoned by MacAdam after correspondence with Hartline who said he thought neurones simply do not respond according to beat frequencies among input signals, but rather with their own characteristic frequency when they respond at all. Thus the hyposthesis is gone, but the mathematical structure remains. By adjustment of a relatively small number of constants MacAdam was able to predict (1) the constant hue and constant chroma loci of the Munsell renotations, (2) a good approximation to the "MacAdam ellipses," (3) the type of failure of the v. Kries coefficient law of chromatic adaptation which had previously led MacAdam to suggest a 5-component theory of chromatic adaptation, and (4) a close fit to the constant-saturation ovoid found by the OSA Committee on Uniform Color Scales.

The similarity of the theoretical studies presented (Fry, Hunt, MacAdam) and those given in preprint form only (Jameson and Hurvich, Shklover) impressed me more than the differences between them. All are multiple-stage theories. Shklover's theory given in his preprint, "The Problem of the Equi-Contrast Colorimetric System," is so close to MacAdam's that when the paper was called for, Yurov read instead from a 12-page letter by Shklover comparing the MacAdam formulation with his own. Maybe the fact that color theorists independently find similar formulations means we are approaching the correct solution.

Deane B. Judd

(Presented at the Columbus meeting of the Optical Society of America, October 18, 1957.)

LIGHT AND VISION - A SHORT COURSE OFFERED AT THE UNIVERSITY OF MICHIGAN

On March 19, 20, and 21 the University and the Illumination Engineering Society offered a short course on "Light and Vision," designed to serve industrial hygienists, public health personnel, school administrators, architects and engineers. On the first two days basic information was offered. School lighting and plant and office lighting were covered on the third day.

"Ophthalmological Aspects," "Illuminating Engineering Aspects," "Light and its Measurement," "Light and Visual Performance," "Light and Ocular Psychology," and "Light and Comfort" were on the agenda the first day. On Thursday, March 20 "Coordination of Daylight and Electric Light," "Daylighting," "Impact of Lighting on Architectural Design," "Electric Lighting Sources," "Control and Fundamentals of Design," "Light and Color," "Maintenance," and "Lighting Survey" were the subjects. In the School Lighting session "School Lighting from an Architect's Viewpoint," "School Lighting from an Educator's Viewpoint," "School Lighting from an Engineer's Viewpoint" were covered. "Applications of the Four Factors of Seeing to a Variety of Industrial Applications," "Proper Lighting of Hazardous Areas (Combined with Outdoor Lighting," "Maintaining Lighting Levels in the Plant," and "Visual Comfort in the Plant," constituted the Industrial Lighting session. The Office Lighting session included "Visual Comfort in the Office," "Maintaining Lighting Levels in the Office," "Lighting in Corridors, Conference Rooms, Cafeterias, Lobbies, Rest Rooms," and "Lighting Layout Design."

The enrollment fee of $10 included the published proceedings. Inquiries should be addressed to the Continued Education Service, School of Public Health, 109 South Observatory Street, Ann Arbor, Michigan.

AGE CHANGES IN COLOR MATCHING, BY JEANNE GILBERT, PH.D. - A SHORT REVIEW

Several workers have studied the effect of age, sex, and acuity on color discrimination. In this paper, Dr. Gilbert presents a study of 355 unselected subjects (160 male and 195 female) between the ages of 10 and 93 years who were given the Color Aptitude Test designed by Dimmick and Foss for the Inter-Society Color Council. The results as reported by the Journal of Gerontology (see News Letter bibliography) are summarized in Figure 2, Analysis of Variance and Figure 1, Age Changes in Color Matching Scores.

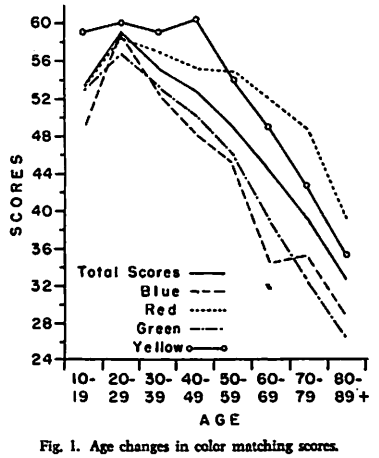

Fig. 1. Age changes in color matching scores.

TABLE 2. ANALYSIS OF VARIANCE.

Source of Variance	Sum of Squares	Degrees of Freedom	Estimate of Variance	F Ratio	Level of Significance
Age.....	95,451	7	13,637	65.56	.01
Sex.....	1,302	1	1,302	6.25	.05
Tests.....	39,283	3	13,094	62.95	.01
Age × Sex....	26,048	7	3,721	17.89	.01
Age × Tests..	22,977	21	1,094	5.26	.01
Sex × Tests..	4,712	3	1,571	7.55	.01
	189,773	42			
Total.....	476,694	1,419			
Residual.....	286,921	1,377	208		

According to Dr. Gilbert, no statistically reliable sex differences in variability are found. Discrimination ability increases between age 10 and 20 and thereafter decreases continuously. The tendency for the blue and green discrimination to deteriorate more rapidly than red and yellow, may be due to

the yellowing of lens with advancing years. At all ages wide individual differences were found in ability to match colors.

References:

Boice, M. L. Tinker, M. A., and Paterson, D. G.: Color Vision and Age. Am. J. Psychol., 61: 520-526, 1948.

Chapanis, A.: Relationships Between Age, Visual Acuity and Color Vision. Human Biol. 22: 1-33, 1950.

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Dimmick, F. L., and Foss, C. E.: Factors in the Application of the Color Aptitude Test. Official Digest, 26: December, 1954.

Ouellette, L. A.: Age Differences in Color Discrimination. Unpubl. Masters Thesis, Fordham Univ., 1955.

Pickford, R. W.: Individual Differences in Colour Vision. Macmillan Co., New York, 1951.

Smith, H. C.: Age Differences in Color Discrimination. J. Gen. Psychol., 29: 191-226, 1943.

Tiffin, J., and Kuhn, N. S.: Color Discrimination in Industry. Arch. Ophth., 28: 951-959, 1942.

COLOR ASSOCIATION'S ESTELLE TENNIS RETIRES

On January 24, 1958, John M. Hughlett, president of the Color Association of the United States, Inc. announced that Miss Estelle M. Tennis had decided to retire to private life on February 1 after 29 years with the Association. In 1954 Miss Tennis was appointed Executive Director, having succeeded Mrs. Margaret Hayden Rorke in that office after 25 years as Mrs. Rorke's assistant. Miss Tennis is a native of Oakland, California and has wanted for some time to return there to live. This she now plans to do.

We are sorry to lose Miss Tennis, especially before she could serve the term on the ISCC Board of Directors to which she was so recently elected, but we join heartily with her associates at the Color Association in wishing her every happiness in the step she has decided to take.

She will be succeeded as Executive Director of the C.A. by Miss Midge Wilson who formerly served as assistant to the Executive Director. Prior to her association with the Color Association Miss Wilson was connected with Seventeen Magazine, and before that was fashion coordinator with B. Blumenthal & Company. She is a member of the Board and Treasurer of The Fashion Group, Inc. While we shall miss Estelle, we look forward to meeting Miss Wilson who will now serve as chairman of the Color Association's delegates to the Inter-Society Color Council.

Good luck, Estelle! And for your many friends in the ISCC we give them your new address: 6100 Margarido Drive, Oakland 18, California.

SHORT COURSE ON COLOR ITS SPECIFICATION AND MEASUREMENT

The National Research Council of Canada conducted a short course on color, January 22, 23, and 24, 1958 in Ottawa. Dr. D. B. Judd covered the first day and one-half of the course. Dr. G. W. Wyszecki completed the last day and one-half.

PROGRAMME

Wednesday, 22 January:

10:00 a.m.
Opening by Dr. L. E. Howlett, Director of the Division of Applied Physics

10:15 a.m.
Dr. D. B. Judd, National Bureau of Standards, Washington

Introductory lecture I:

1. Contributions of Newton, Young, Maxwell, Helmholtz, and Hering

2. What is color - in demonstrations
   a) No light, no color
   b) Color does not belong to an object
   c) Color belongs to the combination of object and illuminant or to light leaving object toward observer
   d) Color perception belongs to perceived object, not to real object

1:30 p.m. Dr. D. B. Judd

Introductory lecture II:

1. Physics of color
   a) Spectrum
   b) Absorption by filters
   c) Spectrophotometer

2. Physiology of color
   a) Metamerism
   b) Tricolor matching
   c) Maxwell's spot
   d) Chromatic adaptation
   e) After-image

3. Psychology of color
   a) Brightness
   b) Hue
   c) Saturation
   d) Color spacing

Thursday, 23rd January:

9:00 a.m. Dr. G. W. Wyszecki, Division of Applied Physics

The C.I.E. system of specifying colors

1. Additive and subtractive color mixtures (Maxwell disk, Tricolor projection, Screen-plate printing; Filter combination)

2. Grassmann's laws of additive color mixture
   a) Any color may be described by a linear combination of three primary colors
   b) Lights of the same color produce identical effects in mixtures regardless of their spectral composition
   c) If, of a two-or-more-component mixture, one or more components are steadily changed, while the others remain constant, the color of the mixture steadily changes

3. Color space - vector space

4. Chromaticity diagram

5. Color-mixture functions

6. Evaluation of tristimulus values and chromaticity coordinates by using spectrophotometric measurements

7. The C.I.E. system of specifying colors
   a) Standard observer
   b) Standard light sources
   c) Weighted- and selected-ordinate method of computing C.I.E. tristimulus values

1:30 p.m. Dr. G. W. Wyszecki:
Visual and photoelectric colorimetry

1. Visual colorimetry
   a) Three and six primary Donaldson Colorimeter
   b) Conversion of a real primary system into the C.I.E. primary system

2. Photoelectric colorimetry
   a) Light source - filter - photocell combination to approximate C.I.E. color-mixture functions
   b) Hunter color and color difference meter
   c) Colormaster

3. Precision and accuracy of colorimetric measurements at present

Friday, 24th January:

9:00 a.m. Dr. G. W. Wyszecki:
Color order systems

1. Basic characteristics of color order systems
   a) Additive color-mixture systems (Ostwald)
   b) Colorant-mixture systems (Plochere)
   c) Screen-plate printing color systems (Hickethier)
   d) Color-appearance systems (Munsell, Rhombohedral lattice)

10:30 a.m. Dr. G. W. Wyszecki:
Uniform chromaticity diagrams

1. Definition of a U.C.S. diagram

2. Judd's U.C.S. diagram

3. MacAdam's U.C.S. diagram

4. Breckenridge-Schaub R.U.C.S. diagram

5. Hunter U.C.S. diagram

6. Farnsworth U.C.S. diagram

7. Uniform chromaticness scales

1.30 p.m. Dr. G. W. Wyszecki:
Color differences, color tolerances and their specification

1. Color difference formulas; the N.B.S. unit and other units of color difference

2. Specification of color tolerances by computed color difference quantities or by special color standards

Other ISCC members who attended the course are:

W. E. Carswell, School of Architecture University of Toronto
C. R. Conquergood, Canada Printing Ink Company Limited
J. Lane, Color Consultant, Edmonton, Alberta, Canada
B. Ross, British Chrome & Chemical (Canada) Ltd.

JAPANESE RESEARCH REPORTS ON COLOR BLINDNESS TESTS

Since Dr. Ishihara's retirement, Prof. Kakachi Umazume, and his associates and students, have continued an active program of research in color vision in Japan. Prof. Umazume supplied reports regularly to the Human Engineering Branch of the Naval Medical Research Laboratory at New London, but several years passed before a translator could be found in this specialized field. Mr. Toshio Yamaka, of the Biological Laboratories at Harvard, has now completed excellent translations of several of the articles and the first of these, "Color Sense Testing by Serial Arrangement of Hue," by Sakae Obi, is now available on request from the Secretary's office. If sufficient interest is shown, the other translations will be made available to members of the I-S.C.C.

(Requests for copies should be addressed to Mr. Ralph M. Evans, Secretary I-S.C.C., Color Technology Division, Eastman Kodak Company, Rochester 4, New York.)

Mr. Obi's experiment is the first to study the correlation between anomaloscope results and the scores on color blindness tests of chromaticity discrimination. Part I describes a test he made up of two series of pigments -- one along a confusion line for deuteranopes according to Pitt (or Judd) and one along an intersecting confusion line for protanopes. It was found, with some exceptions, that type and degree of red and green defectiveness could be determined by the number of errors made on each of the two confusion lines. (This was also accepted by the author as a confirmation of the accuracy of Pitt's (or Judd's) lines, but the critical reader will ask if the exceptions, and residual lack of correlation, might not be taken as an indication of the degree of the inaccuracy.) He found positive correlation coefficients between the number of errors on the serial arrangement for deuteranopes and the range ($r = 0.66$) and extreme settings ($r = 0.71$) on the Nagel anamaloscope. (The use of Willis' combination score, Medical Research Lab. Report No. 190, would have yielded a still higher correlation.)

Probably, for one of the first times in print, Mr. Obi has furnished evidence, and recognized it, that the confusion lines for deuteranopia and protanopia are the same as for various degrees of anomalous trichomacy of each type.

In Part II, Mr. Obi describes the construction of a circular test series modeled on the Farnsworth-Munsell 100-hue Test. The results are similar to those reported for the 100-hue Test except for one feature: classification of type is reliable for moderately defective cases but not positive for dichromats! (This may be explained because Obi used somewhat smaller chromatic intervals than are found in the 100-hue series. Population tests with his series might yield data which, combined with the 100-hue data, would indicate the optimal design for most-diagnostic serial tests.)

Obi's circular test confirmed the findings of Pitt and Farnsworth that the discrimination of color defectives in the yellow-to-blue chromaticity gamut is as good as for normals.

Dean Farnsworth

LIGHT, COLOUR AND VISION BY LE GRAND REVIEWED

This excellent book is an English translation of a French work which appeared in 1948 as the second volume of a three volume text on physiological optics. When the book originally appeared in French it seemed to the present reviewer to be the most complete and the most logically arranged book which had yet appeared on the subject of colour vision, and if one amends this statement to refer only to the scientific aspects of the subject, this impression still remains. Since its first publication we have had the report of the O.S.A. Colorimetry Committee and we have had Dr. Judd's excellent book. These two books deal with certain subjects which Le Grand's book does not treat, particularly subjects of industrial interest; but as a general review of the scientific basis of colorimetry, and in particular of the theories of colour vision, the book is still required reading for all researchers and is now available to a wide group of readers who do not read French. The translation, I might say, is a remarkably smooth and readable one.

The first two-thirds of the book, 340 pages in all, deals with what the author calls "Experimental Facts," beginning with a definition of radiant energy, a discussion of sources of radiation and a description of the eye, "The Visual Receptor," which is the real subject of the book. There follows a chapter entitled, "The Photometric Quantities." The reviewer's only criticism of this chapter is that the extremely conventional nature of photometry is not properly brought out, although it is quite clear that the author realizes it. There follows a chapter on "Retinal Illumination" in which various phenomena such as the Stiles-Crawford effect are discussed. After a chapter on the luminous efficiency curves, or luminosity curves as they are more generally called in North America, for real observers, there is a long chapter called "The Trivariance of Vision," which leads gradually and logically to a discussion of the basic principles of colorimetry and, in particular, to a discussion of the C.I.E. system. Next comes a chapter on the experimental facts of colour vision; another on "The Absolute Threshold"; one on "Luminance Difference Thresholds" and one on the thresholds of colour difference. These are followed by a chapter on flashing and flickering lights and similar time effects; and then a chapter on "Spatial Interactions" between various parts of the retina. The last chapter of the experimental part of the book is devoted to the "Anomalies of Colour Vision."

The second part of the book on the "Theories of Vision" affords a remarkably concise summary of the state of the subject in 1948. The anatomy, photochemistry and electro-physiology of the retina are dealt with in turn, the historical development of the subject not being forgotten; and finally there are about fifty pages on theories of colour vision and of the thresholds. It must be admitted that these two chapters are difficult reading, but it is undoubtedly valuable to have the considered opinions of an author such as Professor Le Grand on these matters.

The book closes with appendices covering nearly fifty pages, including the necessary numerical tables for computations in the C.I.E. system, an excellent set of exercises for the student, and finally, two bibliographies and a good index. The double bibliography consists of 162 numbered entries which are presumably the papers and books which Professor Le Grand feels to be particularly important, and several hundred other entries which are referred to here and there in the text. Altogether there is no lack of direction for students who wish to read further in the subject. The bibliography is greatly improved from that of the French edition, which was annoying because papers were referred to in the text which were not given in the bibliography.

As mentioned above, the industrial problems of colorimetry are scarcely touched upon, and the book offers no competition to Judd's well-known work in this regard. With this exception the book can be recommended as a beautifully logical description of the state of the subject in 1948. Even though the preface promises "some additions to include recent developments," the work is not quite up-to-date. For example, the important papers of Jameson and Hurvich are given only a few lines. Nevertheless the book will be valuable to all workers in the field not only as a textbook but also for frequent reference.

W. E. K. Middleton

"COULEURS" - DOCUMENTARY KODACHROME FILM

A twenty-minute documentary Kodachrome film, "Couleurs", has been produced and offered for sale at cost by Le Centre d'Information de la Couleurs, 23, rue Notre-Dame des Victoires - Paris (2°), for 85,000 francs (about $170.00), which also includes a year's subscription ot their interesting and colorful publication, "Couleurs." According to their announcement, the film synthesizes knowledge of color and light with applications of color in human activities. The film was aimed at showing the evolution from a world of black and white to a world of color. The film demonstrates the increase in value of many manufactured products brought about by the shift to color. It is said the film should find a place of honor in the movie collections of educational institutions and of organizations whose activities are oriented toward the improvement of living conditions, both at home and at work.

Robert W. Burnham

E. TAYLOR DUNCAN SEEKS POSITION

Dear Mr. Rhodes:

I would like to inform Newsletter readers that I will be available this fall for a teaching position and/or other work relating to color. I have had some teaching experience as the enclosed folder indicates and will be happy to provide further information to anyone wishing to write me at 409 Marret Avenue, Louisville 8, Kentucky.

E. Taylor Duncan

Ed. Note: The folder referred to in Mr. Duncan's letter is an announcement from the University College at the University of Louisville, "Color in Your Life." It covers: history of color, color names and descriptions, color

order systems, color science, color psychology, planning the color scheme, and selling with color. The course covered seven sessions beginning Wednesday evening, November 6, 1957.

MISCELLANY "Evidence in Color," Canterbury, England--For the first time in the criminal courts, colored photographs were produced in evidence here. They were taken by Detective Inspector Harry England, to show color markings on thirteen stolen lambs.

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Post Office is having a happy experience with its red, white and blue trucks. A test covering 42 cities and 10 million miles of driving shows that they were involved in 622 accidents compared with 849 by the olive drab vehicles.

The olive trucks were in 50 rear-end accidents; the red, white and blue in only 24.

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In Grecian drama queens wore purple and white; other ladies were allowed to wear only saffron or frog green.

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"Sack Dresses, '57 hats Worn in 8000 B.C.," Paris, Dec. 2--A mural found under Sahara sands and said to date from 8,000 B.C. is on display here today. It shows two young girls wearing "sack" dresses and hats in the latest 1957 fashion.

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"Plates to Go Collegiate If Colors Are Suitable," Lansing, Oct. 30--Secretary of State James M. Hare plans to test the colors of state colleges and universities to determine if they are suitable for auto license plates.

"They will be studied for contrast and visibility," he said, "and also road tested to make sure they hold up and are readable at night."

The 1958 plates will be black and gray, honoring nothing in particular.

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Consumers need to learn how to pick oranges for quality. The appearance of the fruit has little or no relation to its flavor. In fact, a greenish or brownish orange may be more palatable and sweeter to the taste than one that is brightly colored. Apparently an attractive color is what many people look for in buying oranges, for the trade has taken legal action to block enforcement of the federal government's ban on the potentially dangerous coal-tar dye Red No. 32. The U. S. Fifth Circuit Court of Appeals ruled in July that since the dye became harmful only when consumed and in large quantity, the dye might be used for coloring oranges meeting minimum standards of maturity in the states of Florida and Texas. California packers are also asking to be allowed to dye Valencia oranges. Women who make orange marmalade at home will need to

look for the "color added" label and avoid all such artificially prettied-up oranges.

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Yellow is easier to see than red. Hunting clothing of the future is expected to be yellow instead of the traditional red. Tests made by various professional organizations in cooperation with the U. S. Army have indicated that yellow was four to five times more easily seen in a rain forest near Fort Lewis, Washington. At great distances, yellow tended to become white and would not be suitable as a survival color in snow country, but for the hunter at 50 yards or less it is considered far and away the safest.

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From the Detroit Times supplement, "Pictorial Living" comes a colorful note on schools. The entire article "Color Goes to School" is illustrated with attractive color photographs. According to the author, Ethel Smilick, "Detroit's city schools are following the trend toward brighter color in both study and play areas. . . .Many of us now believe there is a greater incentive for work . . . both teacher and student when colorful surroundings replace dreary ones.

"It costs little more to use color. . . . it costs our taxpayers not more than 80 cents a year, for the next ten years, for all the extra beauty color creates."

(All miscellany courtesy Helen Taylor.)

LIST OF ARTICLES ON COLOR RECEIVED BY NEWS LETTER

"Age Changes in Color Matching," Jeanne G. Gilbert, Journ. of Gerontology, 12:210-215, No. 2, Sec. B (April 1957)

"Aspects of Colorimetry Applied to the Colour Gamut of Pigments," E. Atherton and D. Tough, Journ. Oil and Colour Chemists' Assoc., 40:115-128, No. 2, (Feb. 1957)

"Assessment of Lightfastness," J. G. Gillan, Journ. Oil and Colour Chemists' Assoc., 40:129-135, No. 2, (Feb. 1957)

"Colorimetry in the Paint Industry," A. J. Seavell, Journ. Oil and Colour Chemists' Assoc., 40:87-114, No. 2, (Feb. 1957)

"Color Sense Test by Arrangement of Hue (or, Serial Arrangement Test of the Hue Order)," Sakae Obi (Translation by Toshio Yamaki), Part I: Nippon Ganka-Gakkai Zasshi (Journ. Japan Ophthalmological Soc.), Vol. 56:463-468, No. 7, (1952) Part II: Rinsho Ganka (Clinical Ophthalmology), Vol. 7:100-104, No. 2, (1952).

"Fundamental Aspects of Lighting," Henry L. Logan, Electrical Engineering, January 1957.

"Personal Experience with the I.-S.C.C. Colour-Aptitude Test," M. Hess, Journ. Oil and Colour Chemists' Assoc., 40:136-142, No. 2, (Feb. 1957)

"X Y Z in the Realm of Colors," Hans Joachim Höfert, Zeiss Werkzeitschrift, No. 24, pp. 37-44, June 1957