Inter-Society Color Council *News*

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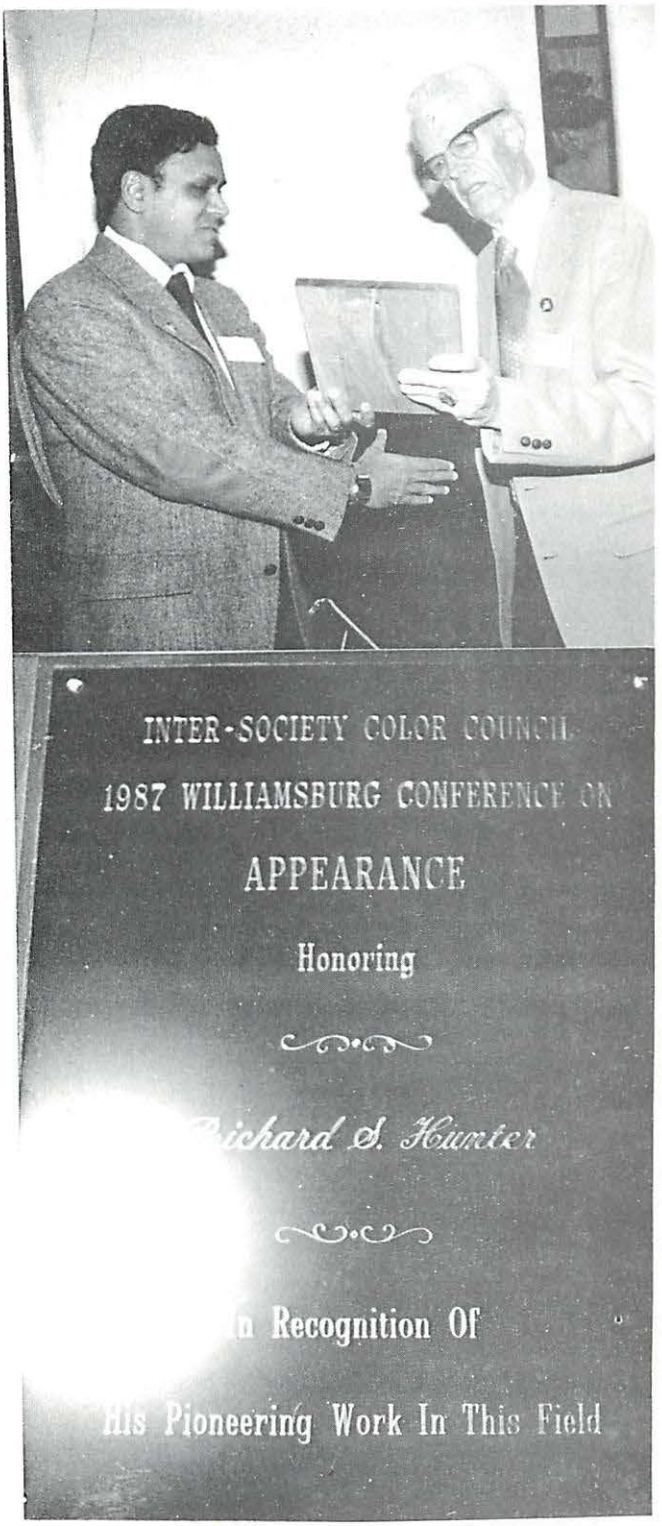

ISCC President Allan Rodrigues presents Richard Hunter with an engraved plaque at the opening of the 1987 Williamsburg Conference on Appearance, February 9, 1987. The conference was dedicated to Mr. Hunter in recognition of his pioneering work in the field of appearance measurement.

Photographs by Harry Hammond

RICHARD S. HUNTER

Contributions to Appearance Measurement

(Ed. Note: The following are the edited Introductory Remarks made by John S. Christie at the opening of the ISCC 1987 Williamsburg Conference honoring Mr. Hunter.)

First I wish to thank President Rodrigues and the conference organizers for inviting me to make these introductory remarks. I have known Richard Hunter for 38 years, and I have worked with him at Hunter Associates Laboratory for 25 years. Although there were rough periods in the evolution of HunterLab, I feel privileged to have been a participant during the years of its very successful growth.

Mr. Hunter, as most of you know, has been a pioneering leader in the field of appearance evaluation and measurement. During his 60 years of active work he has been a creative scientist, concentrating on describing, measuring and developing measurement procedures that correlate with visual assessments of appearance. He has concentrated on solving measurement problems practically and economically. Perhaps more than anyone else, he has appreciated the complex interrelations between appearance sensations ascribed to spectral characteristics and those generally classed as geometric.

In addition to founding Hunterlab and serving as the inspiring motivator of his staff, Mr. Hunter found time to be associated with many professional organizations, not merely as a member, but as an active participant in their technical deliberations. I emphasize the word *active,* because in every case he was a working member of a technical committee of the organization. Permit me to enumerate some of them.

ASTM – Nine materials committees of the American Society for Testing and Materials (ASTM), with his help, have developed dozens of appearance standards dealing with paints, plastics, metals, polishes, industrial chemicals, enamels, textiles, and the like. In addition, Committee E-12 on Appearance of Materials, which Hunter helped to found in 1950, develops appearance measurement methods applicable to the work of many materials committees. Hunter served as chairman of the committee for the maximum permissible period of six years, 1976-82.

TAPPI – Technical Association of the Pulp and Paper Industry.

AATCC – Americal Association of Textile Chemists and Colorists.

FSCT – Federation of Societies for Coatings Technology.

SPE – Society of Plastics Engineers.

OSA – Optical Society of America.

USNC/CIE – U.S. National Committee of the International Commission on Illumination.

Munsell Foundation.

In ISCC he has been active in a number of the technical project committees. He served as Vice-President (1970-72), President (1972-74) and as a Director (1974-76).

In addition to all the committee activity, Hunter found time to publish 110 papers and a book, *The Measurement of Appearance,* Wiley, 1975, a second edition of which will appear this year. The book grew out of the material he prepared for the many industrial seminars and workshops which began while he was with Gardner Laboratory and were greatly expanded as the need for them grew at Hunterlab. The educational effort of Mr. Hunter and his associates, especially the late Margaret Burns, may not be unique, but it has contributed measurably to helping people understand the capabilities and limitations of the science of appearance measurement, as well as to the understanding of the capabilities of Hunterlab instruments.

This tremendous educational effort has not gone unnoticed. Mr. Hunter has received ten awards, among them such prestigeous ones as the ISCC Macbeth Award (1976), and the ASTM Award of Merit (1961) which carries with it the title of Fellow of the Society. In 1981 he received ASTM's highest award, that of Honorary Member.

As impressive as his work effort and accomplishments are, Hunter's direct contacts with people have been even more important. In our conversations, it has been quite apparent that these relationships have been extensive and, in many cases, lifelong. Hunter appreciates acumen and scope of knowledge in individuals, and he has utilized these attributes of his friends and acquaintances when appropriate to assist him in developing appearance measurement solutions.

Let me identify some of the people who have had an important influence on the career of Richard Hunter.

Hunter began work at NBS at the age of 18 in the Colorimetry Section under its Chief, the energetic Irwin Priest. His job was designated *Minor Laboratory Apprentice,* which translates to "Gofor" or errand boy, going from one laboratory to another to borrow this or that. This put him in contact with other NBS scientists and their activities.

Hunter developed a visual reflectometer and Helen Kiley of the American Writing Paper Company, Holyoke, Maine, was sufficiently impressed with it that she arranged to have him present it, his first scientific paper, at a TAPPI meeting.

Henry Gardner, Sr., at the National Paint, Varnish and Lacquer Association was the first user of the reflectometer, but he indicated that what the paint industry really needed was a glossmeter. This statement provided the initial stimulus that directed Hunter's lifelong interest toward geometric attributes of appearance.

In 1934, after the depression furloughs, Hunter returned to NBS to work on aviation lighting under Frank Breckenridge and in Photometry under Dr. J. Franklin Meyer. Later he was able to transfer back to colorimetry under Dr. Kasson Gibson,

whom he described as a "quiet motivator." With Gibson's encouragement and that of Dr. Deane Judd, Hunter was stimulated to continue the development of his reflectometer and glossmeter. In 1938 he built the first Multipurpose Reflectometer at NBS and Gardner Laboratory over a period of two decades built over a thousand replicas.

Hunter received his BS degree in Psychology and Physics by attending evening classes at George Washington University for ten years while working days at NBS. During this period he also took a course in optics taught by A. H. Pfund at Johns Hopkins University in Baltimore. Professor Pfund must have been very good at teaching fundamental concepts of optical systems and photometry, because Hunter never lost sight of them in HunterLab designs.

The patterned or half-silvered mirror for visually comparing two fields of view became an important element in the design of Hunter's early instruments. The same concept was used many years later in the development of a Signalling Mirror to aid in the rescue of downed military and civilian air crews and passengers. The patterned mirror concept came from Hunter's contacts with the late H.P. Gage at Corning Glass Works.

At the suggestion of W. N. Harrison of the Enamelled Metals Section at NBS about 1939, Hunter replaced patterned mirrors and visual observers with the newly developed photoelectric cells in the designs of new instruments for measuring color and gloss.

Lawrence Wood of Cornell University suggested that the photocell circuit should use a current rather than a voltage balanced bridge, and this procedure led to a significant improvement in the linearity and stability of Hunter's instruments.

Research by E. Q. Adams at the General Electric Company, as far back as 1923, identified the fact that, in color vision, amber minus green and green minus blue were the outputs of the visual system. Hunter incorporated this opponent-color concept in his colorimeters by making use of a circuit developed by Wilson of Westinghouse, in which the differences were obtained directly from the electrical outputs of the photocells. This led to the direct readout of Hunter's original alpha-beta chromaticity coordinates and, later, to the a-b chromaticity dimensions. This is another example of Hunter's adaptation of techniques used elsewhere to provide more stable and precise instrument outputs.

There are other individuals whose expertise in identifying the color needs of industry led Hunter to develop new instruments. One of these was the late Dorothy Nickerson. Her work with the Department of Agriculture in the visual grading of raw cotton led to the development of the Nickerson-Hunter photoelectric colorimeter for grading cotton.

The list of people who have had a pronounced influence on the development of HunterLab would not be complete without making mention of his wife, Elizabeth. She worked with him in specific capacities from the inception of HunterLab until the present day. In addition her day-to-day enthusiasm and encouragement have had an immeasurable impact.

Hunter's personality is such that he has never failed to give credit to others for their inputs and, just as important, he has spent a good portion of his life helping others understand and gain knowledge in the field of appearance measurement. We who have worked with him and those who have attended the workshops and seminars through the years can attest to the success of his efforts.

In 1982 Mr. and Mrs. Hunter endowed a chair at Rochester Institute of Technology, the occupant of which is known as "The Richard S. Hunter Professor of Color Science, Appearance and Technology." The Hunters have thus planned to ensure that there will be a continuous flow of young people trained in color science to carry on the research necessary to improve the techniques of appearance measurement in forthcoming decades.

Permit me to conclude this biographical report with a personal anecdote that illustrates another admirable facet of Hunter's personality, namely his frankness. He and I often walked to lunch at the Reston Country Club not far away. One snowy, overcast day while walking across a broad expanse of the club grounds, Hunter remarked that years ago he and Deane Judd had been walking across the NBS grounds in a similar environment and the question arose: "With the snow as the reflector and the overcast sky as the light source, why does the snow look brighter than the sky?" I voiced some ideas about forward and backward scattering efficiencies and such, but came to the conslusion that none of these seemed to provide an explanation. So I asked: "Well, why is it?" and he simply replied, "I don't know."

John S. Christie, February 9, 1987

Mr. Hunter made a brief response, after which, Dave Alman introduced Norbert Johnson as moderator for the first session.

The report on the conference will continue in the next issue of the ISCC News. The authors have been asked to inform the Editor when and where their papers will be published. We shall include that information in the ISCC News when it is available.

A Message from the President

With this issue of ISCC News, our Interim Editor, Harry K. Hammond passes on the reins of editorship to Bonnie Swenholt. We owe Harry a debt of gratitude for filling in this past year and a half. With his characteristic zeal he brought a high level of energy to this task, spending many hours collecting news items and cajoling many of us to review journal articles or contribute to the News in one way or another. Many thanks to you, Harry!

Bonnie Swenholt is well known to most ISCC members. She has chaired various committees, served on the Board of Directors, and more recently been Arrangements Chairman. In ap-

pointing Bonnie Editor of ISCC News, the Board is quite confident she will maintain the high standards set by her predecessors. Best wishes to you Bonnie!

Allan Rodrigues
ISCC President

ELECTION OF DIRECTORS

The Secretary's memorandum of December 2, 1986, contained the list of six nominees proposed by the Nominating Committee for Directors for a three-year term, 1987-1990. (See ISCC News No. 304, November-December 1986.) No additional nominations were received by the deadline of December 22. Biographies of the three successful candidates are given below.

Roy S. Berns

Dr. Berns is an individual member of ISCC. He is active on four project committees, namely Indices of Metamerism, Image Technology, Materials for Instrument Calibration, and Color Education and Resources Materials. Berns is an Associate Professor in the School of Photographic Arts and Sciences at Rochester Institute of Technology. He is acting Chairman of the Department of Color Science and also serves as Interim Director of RIT's Munsell Color Science Laboratory. Berns received his BS and MS degrees from the University of California at Davis where he studied Textile Chemistry. After graduation, he worked as a laboratory manager for Custom Finishes, Inc. in their Printing Department. He attended Rensselaer Polytechnic Institute and studied Color Science under Professor Fred Billmeyer. After receiving his PhD from Rensselaer, he joined RIT staff in 1984, working under Dr. Frank Grum. Berns has been appointed to the Editorial Board of Color Research and Application. He is a member of the American Society of Testing and Materials, (ASTM), Council on Optical Radiation Measurement (CORM), the International Color Association (ICA), and the International Commission on Illumination (CIE).

James E. Grady

Mr. Grady is a delegate from the Detroit Color Council (DEC). He works for Ciba-Geigy as an Automotive and Industrial Specialist in the Pigments Department. He worked for DuPont for 23 years in the pigment color business prior to DuPont's sale of that area to Ciba-Geigy. He currently markets pigments and coordinates technical service and research and development on automotive pigments for coating and plastic suppliers. Grady is an immediate past President of DEC and is a member of its Board of Directors. He was in charge of logistics and meeting arrangements for the 1986 Symposium on Automotive Color Control.

Jacqueline (Jacqui) Welker

Ms. Welker has been a member of the ISCC for 16 years and has served with numerous committees. She currently Chairs at Committee 25P, Determination of the Tinting Strength of Pigments, and she is active in Project Committee 37, Artists' Materials. Welker also Chairs the Liaison Committee between ISCC and the Federation Societies for Coating Technology (FSC). She organized the third very successful symposium on Color and Appearance Instrumentation (SCAI III) held in Pittsburgh in 1985 in conjunction with the ISCC annual meeting for the first time. Welker has worked for PPG Industries for over 22 years, 20 in the field of color. She currently manages the color research on the Coatings and Resins Group. She is involved in international activity in coatings and in glass and chemicals as well.

ISCC ANNUAL MEETING

Industrial Applications of Color Science

The 56th Annual meeting will be held in Philadelphia, April 5 to 7, 1987, at the Barclay Hotel, Rittenhouse Square.

The theme of the meeting will be *Industrial Application of Color Science.* Papers will be presented during the general session each day. The invited papers are listed below, together with the names of the authors and their affiliations.

Uses of Spectrophotometry (Sunday afternoon, April 5)

Trouble Shooting Techniques in the Textile Industry – Roland Connelly, Burlington Industries.

Spectroradiometry of Self-Luminous Displays: A Progress Report – Justin Rennilson, Advanced Retro-Tech

Forum for Conservation and Art Sunday afternoon, April 5)

Introduction to ISCC – Allan Rodrigues, President

Metamerism in Art Conservation – Roy Berns, Rochester Institute of Technology

Applied Microphotometry in the Analysis and Characterization of Historic Paints – Richard Wolbers

Review of the Role of Textile Conservation in the Reproduction Program at Winterthur, Margaret Fikioris, Textile Conservator, Winterthur Museum

Historic Restoration (Sunday afternoon, April 5)

Restoration of the United States Capitol Building Rotunda – Bernie Rabin, Norton Simon Museum

Uses of Colorimetry (Monday morning, April 6)

Color Difference: A Progress Report – Alan Robertson, National Research Council of Canada

Industrial On-Line Color Control – William Nichols, Cone Mills

Pearlescent Pigments: Color and Appearance Characteristics – Harold Miller, Mearl Corporation

Metamerism (Tuesday morning, April 7)

Observer Metamerism and Video Displays – Danny Rich, Applied Color Systems

Metamerism in the Automotive Industry – William Longley, Ford Motor Company

Instrument Metamerism – Henry Hemmendinger, Hemmendinger Color Laboratory

Workshop Sessions – Conducted by experts in their fields. (Monday and Tuesday afternoons)

Offpress Color Proofing – Phillip Solow, Graphic Arts Technical Foundation

Recommended Practices for Color Difference Measurement – SAE J 1545 – Thomas Keane, Pacific Scientific

Project Committee Meetings

There will be project committee meetings on Monday, April 6, and Tuesday, April 7, working on projects in color science, art, education, lighting, and colorants. The meetings will be scheduled in sequence, not necessarily numerical. The time may conflict with another event on the program but not with another project committee. The committees are listed below in numerical sequence with the names of the chairpersons and brief statements of scopes.

22. *Materials for Instrument Calibration.* Danny Rich. Study and Recommendation of Reference materials and procedures for the calibration of color measuring instruments.

25. *Determination of the Strength of Colorants.*

25F. (Fibers), George Sonn. Strength test evaluation; correlation of non-fiber test with the developed strength in the fiber.

25P (Pigments), Jacqueline Welker. Evaluation of repeatability and credibility of various tinting strength methods.

27. *Indices of Metamerism,* Hugh Fairman. Experiments to characterize metamerism, color constancy and related phenomena.

32. *Image Technology,* Paula Alessi. Discussion of color problems common to the photographic, printing and television industries.

33. *Human Response to Color,* Walter Granville. Guidelines for the application of color in buildings and commercial products.

34. *Color Difference Problems,* Sy Commandy. Experiments to gain a better understanding of the mathematical description of color difference.

35. *Color of Living Tissues,* Stephen Bergen. Research in color science related to living tissue such as skin and teeth.

36. *Examples of Industrial Color Difference Acceptability,* William (Rick) Mathew and Anthony Pentz. Development of visual examples of industrial color acceptability tolerances.

37. *Artists' Materials,* Hilton Brown. Develop and disseminate information on art materials related to color.

40. *Color Education Resources & Materials,* Evelyn Stephens. Identification of resources for education in color; organization of a speakers' bureau, slide collection and other materials.

41. *Special Education,* Richard Ingalls. Identification and production of graphic materials for color education.

New Project Committee (organizational meeting) – *Museum Conservation.*

New Project Committee (organizational meeting) – *Color Terminology.*

Other Events

Sunday Evening, 6:00 to 8:00 p.m. *Wine and Cheese Reception.*

Monday noon. *Buffet Luncheon.*

Monday evening. *A Night Out on the City,* consisting of a bus tour of the historic area ending at the City Tavern with cash bar and subscription dinner, followed by a talk by Marigene Butler, Philadelphia Museum of Art, Conservation Department, on Historic Restoration in Philadelphia

Tuesday noon, *Awards and Business Luncheon.* Presentation of the Godlove Award and Nickerson Service Award

Business meeting conducted by Allan Rodrigues.

ANNOTATED BIBLIOGRAPHY

Color Order Systems

An *Annotated Bibliography on Color Order Systems,* commissioned by the International Colour Association (AIC), was completed in 1985 by the AIC Study Group on Color Order Systems, under the chairmanship of Dr. Fred W. Billmeyer, Jr. A preliminary distribution of the Bibliography early in 1986 by ASTM Committee E-12 on Appearance was limited to physical appearance due to cost restrictions for both production and distribution.

Through the generosity of Mr. Faber Birren, a member of the Study Group, a new edition has been prepared by reprinting in new typeface on quality paper, with cover and plastic binding. This 90-page booklet, 8½ x 11 inches in size, contains the full original report of over 400 entries, updated to November, 1986. Among the color order systems covered are the Munsell, Natural Color, OSA-UCS, Ostwald, DIN, and Coloroid systems.

Until the edition of 200 copies is exhausted, copies will be sent to individuals at no charge except for the following for postage and handling:

First-class mail within the U.S., $3.10
First-class mail within Canada, $3.20
Air mail to all overseas locations, $6.50

All payments must be made by International Money Order or in U.S. dollars drawn on a U.S. bank. Funds drawn on foreign banks (including Canadian) not having a U.S. office will not be honored and payment will be returned to sender. Copies should be requested from:

Mimeoform Service, Inc.
Rear, 4805 Prince George's Avenue
Beltsville, Maryland 20705, U.S.A.

FROM THE DETROIT COLOUR COUNCIL

The Canadian Society for Colour and the Detroit Colour Council have announced a joint symposium on Automotive Color Design to be held on May 28, 1987 in Windsor, Ontario. The symposium will be the feature session of the annual CSC meeting held May 27-29 at the Cleary Auditorium in Windsor, Ontario, just across the river from Detroit.

Speakers from the auto companies and from the coatings and pigment industries will describe the complexities of building automotive color programs. Input to these programs and limitations will be featured. Comparison between American, European and Japanese approaches will be highlighted.

For registration information contact Bob Schneider at 800-521-9094 or Bill Longley at 313-337-5234.

RIT OFFERS INDUSTRIAL SHORT COURSE IN COLOR SCIENCE

Rochester (N.Y.) Institute of Technology's Munsell Color Science Laboratory, the nation's preeminent academic laboratory devoted to the science and technology of color, will present its acclaimed industrial short course on the quantitative measurement and specification of color.

The program, "Colorimetry: An Intensive Short Course for Scientists and Engineers," will be offered twice, May 11-14 and Aug. 24-27. It will be directed by Dr. Roy S. Berns, interim director of the Munsell Laboratory.

Early enrollment is suggested since attendance will be limited to provide a maximum of hands-on experience. The Munsell Laboratory is the most well-equipped academic laboratory in the country for color measurement and houses most commercial instruments.

The in-depth short course provides the fundamental information about color science and engineering required to understand and make effective use of colorimetric instrumentation, theory and practice.

Topics will include: a detailed derivation of the CIE system of colorimetry; physics of objects and light sources; accurate methods of spectrophotometry; standardization and specification; and color mixing principles for additive and subtractive coloration systems, including an overview of computer colorant formulation.

The course is highly beneficial to persons involved in industries that include coatings, textiles, polymers, reprographics and electronic imaging.

For further information contact: Christine Kester, Munsell Color Science Laboratory, Rochester Institute of Technology, One Lomb Memorial Drive, P.O. Box 9887, Rochester, New York, 14623-0887; (716) 475-5842.

COLOR AND VISION NETWORK

A new service has been established for people working in color who also use modern computer technology for communication.

A relatively new buzz word is E-mail. E-mail is to be contrasted with snail mail; the kind with which we are used to communicating. Snail mail requires one to find some sort of writing implement, paper, envelope and postage stamp. After setting down on paper what one has to say, sealing it in the envelope and putting on the proper postage, the communication is dropped into a box with the hope and prayer that it will arrive at its destination during this millenium.

E-mail, on the other hand, only requires one to have telephone communication with one's computer. By using the proper software, telling the software the proper things, a message, long or short can be sent great distances and it frequently will arrive at its destination in a matter of seconds.

The Color and Vision Network is a collection of E-mail addresses of people working in the fields of color and/or vision. To have one's E-mail address listed on the Network, all that is required is to contact the coordinator (see below). In addition to these addresses, a Key word file is under development which will associate activity descriptors in color and/or vision with people working in the respective area. Anyone wishing to distribute announcements, bulletins etc. to those listed in the Network can do so by sending the material via E-mail to the coordinator.

Dr. Reeves, Northeastern University, has proposed to create a bibliography of work by people in the Network. Once established this facility will be distributed to all members and should be of great assistance in their work.

At present there are about 90 people listed on the network from Australia, Canada, Germany, Japan, Netherlands, Sweden, UK, and the U.S. The list is growing daily.

For further information on this service contact Peter K. Kaiser, coordinator at:

cvnet@yorkvm1.bitnet or
cvnet%yorkvm1.bitnet@wiscvm.wisc.edu

BOOK REVIEW

Colorimetry

Colorimetry, Second Edition, Publication CIE No. 15.2 (1986), A-1033 Vienna, P.O. Box 169 – Austria, paper cover, photo-offset from typewritten text, pp. 74.

Price: $28 (Price to members of USNC/CIE $22.)

This long-awaited, authoritative document has now been published by the International Commission on Illumination (CIE). The summary states:

"The recommendations of the CIE Colorimetry Committee are given for standard illuminants; for the standard of reflectance factor; for illuminating and viewing conditions; for the standard colorimetric observers; for the calculation of tristimulus values, chromaticity coordinates, and colour differences; and for various other colorimetric practices and formulae."

The text, in English, contains a seven-page introduction describing in general terms and in chronological order the important recommendations of the Committee. This is followed by 36 pages of text on the five catgeories of recommendations of the Committee under the following enumerated headings:

1. Recommendations concerning standard physical data,
2. Recommendations concerning standard observer data,
3. Recommendations concerning the calculation of tristimulus values and chromaticity coordinates.
4. Recommendations concerning uniform colour spacing.
5. Recommendations concerning miscellaneous colorimetric practices and formulae.

Most important, however, are the 26 pages of tables of spectral data from 300 to 830 nm at 5 nm intervals for Illuminants A, C, D50, D55, D65, D75; color matching functions for the two standard colorimetric observers, 1931 (2 degree) and 1964 (10 degree), for 380 to 780 nm at 5 nm intervals, as well as the relative spectral power distribution (SPDs) of twelve illuminants representing typical fluorescent lamps. There are also 36 references to original documents, the two most important of which are CIE Publication No. S1 (1986), *CIE Standard Colorimetric Illuminants,* and CIE Publication No. S2, *CIE Standard Colorimetric Observers.* These two publications contain spectral distributions of the titled material from 300 to 830 nm at one nanometer intervals; however, they have not yet been printed. Published CIE documents can be obtained in USA from:

Dr. Klaus D. Mielenz
Secretary, USNC/CIE
B-306 Metrology Bldg.
National Bureau of Standards
Gaithersburg, MD 20899

Payment with order is desired but not required. Make checks payable to: *U.S. National Committee, CIE.*

SYMPOSIUM ON COLOR VISION MODELS

A Memorial to Wyszecki and Stiles

A memorial symposium will be held under the joint auspices of the International Commission on Illumination (CIE) and the International Color Association (AIC), June 10-13, 1987, in Florence, Italy. It is being presented as an AIC Interim Meeting. The CIE Technical Committee on Models of Heterochromatic Brightness (TC 1-04) is responsible for the technical program. All other arrangements are being handled by AIC President Prof. Dr. Heinz Terstiege.

The symposium will start with memoirs presented in honor of Dr. W. S. Stiles and in honor of Dr. Gunter Wyszecki. Dr. Mathew Alpern, U. of Michigan, will present the memoir for Dr. Stiles and Mr. Wolfgang Budde, CIE, will present the memoir in honor of Dr. Wyszecki.

The following people have accepted invitations to make presentations at this symposium:

Dr. Peter Gouras, Columbia U., U.S.A.
Dr. Steven Shevell, U. of Chicago, U.S.A.
Dr. John Krauskopf, N.Y.U., U.S.A.
Dr. Hirohisa Yaguchi, Chiba U., Japan
Dr. Donald Hood, N.Y.U., U.S.A.
Dr. Adam Reeves, Northeastern U., U.S.A.
Dr. Ken-ichi Naka, Nat. Instit. of Biology, Japan
Dr. Jan Walraven, TNO Instit. of Perception, Netherlands
Dr. Robert Hunt, Great Britain
Dr. Gershon Buchsbaum, U. of Pennsylvania, U.S.A.
Dr. Carol Cicerone, U. of Denver, U.S.A.
Dr. Thomas Frumkes, Queens College CUNY, U.S.A.
Dr. Munehira Akita, Kyoto Inst. of Tech., Japan
Dr. Akimichi Kaneko, Nat. Instit. of Physiology, Japan
Dr. Pat Trezona, N.P.L., Great Britain
Mr. John McCann, Polaroid Corp., U.S.A.
Dr. Joel Pokorny, U. Chicago, U.S.A.
Dr. Vivianne Smith, U. Chicago, U.S.A.
Dr. Eberhart Zrenneer, Max Planck Inst., Munich, Germany
Dr. Charles Stromeyer, Harvard U., U.S.A.
Dr. Robert Massof, Johns Hopkins U., U.S.A.
Dr. Arne Valberg, Inst. of Physics, Norway
Dr. J.J. Vos, TNO Inst. for Perception, Netherlands
Dr. Lucia Ronchi, Inst. of Optics, Italy
Dr. Francoise Vienot, Museum of Natural History, France
Dr. Mitsuo Ikeda, Tokyo Inst. Tech., Japan
Dr. Taro Indow, U. of Calif., Irvine, U.S.A.
Dr. Barry Lee, Max Planck Inst. Goettingen, Germany
Dr. Y. Nayatani, Electro-communication U., Osaka, Japan
Dr. K. DeValois, School of Optometry, U. of Cal., Berkeley, USA

Dr. Veijo Verisu, Dept. of Psych., U. of Helsinki, Finland

The persons listed above are expected to speak on a variety of topics and from many perspectives. All presentations will be related to our understanding of how the visual system operates with direct significance to the modelling of color vision.

Dr. John Mollon, U. of Cambridge, will present the opening lecture outlining the current state of the art of color vision models. Dr. Oscar Estevez, U. of Amsterdam, will present the closing lecture outlining the state of the art of color vision models now that we are at the end of the symposium.

Because meeting space in Florence is limited, there can be no more than 60 active participants. Therefore the organizing committee reserves the right of admission for further specialists in color vision.

Peter Kaiser, February 12, 1987.

INTERIM EDITOR RETIRES

Well, not exactly. His year of voluntary servitude has ended, much to the joy of his wife, Pauline. And Hammond will worry less about where to obtain newsworthy material to fill an issue every two months. However, he plans to send material to editor Swenholt whenever he finds it.

Each of you readers can help make this aspect of the editor's job easier, if you will. There are all kinds of articles on color that appear from time to time in newspapers, magazines and technical journals. When you see one you could clip it and send it to the editor. You could also do better than that. You could write a short paragraph about how and where you found it, what seemed most interesting, and where further information can be obtained.

You could write about a personal experience, ideally color related. You could also drop a note to the Editor and tell him or her what you like or do not like about the *News.* Is there too much material or not enough on the subjects you like to read? Do you like or dislike certain types of items? If you cannot write, you could pick up the phone, make a survey, and phone it to the Editor. (Doubled spaced typewritten copy is preferred.) We may soon have a new ISCC Directory. Unfortunately it will not contain phone numbers; so you will still have to look up the locals and pay information for the numbers of distant members.

In summary, there are a number of things that each of you could do. Why not do one this month and make a contribution to the editor for the next issue? I cannot guarantee that it will be published. But there is a good likelihood that it will be – and with your by-line, unless you request anonymity.

Harry K. Hammond III, February 19, 1987

COLOR RESEARCH AND APPLICATION

Articles in Jan-Feb, 1987 Issue

We suspect that all of us concerned with color have, at one time or another, wondered how the many color effects we deal with came to be: What causes color, anyway? In his article, *The Fifteen Causes of Color,* Kurt Nassau provides not just one but fifteen answers to this question, for that is how many different origins of color phenomena he finds necessary to cover it all. His subtitle, *The Physics and Chemistry of Color,* gives fair warning that a full understanding of the text will be easier for those educated in these subjects, but we encourage all our readers to at least browse the article and enjoy the 17 color illustrations that provide vivid examples of the wide variety of color phenomena around us.

The CIE proposed the use of tristimulus values to describe color in terms of measured spectral quantities in 1931. At the time, the precision of the instruments available was limited and there was no need for the CIE to specify in detail such variables as wavelength range and interval that could have small effects on the calculated values. Fifty years later the picture had changed. A new generation of color-measuring instruments could produce highly precise spectral data, but using identical data in the calculations on various instruments led to differences in the tristimulus values that were large compared to the repeatability of the instruments. This is the point at which a CIE working group, chaired by Fred W. Billmeyer, Jr., and with his coauthor Hugh S. Fairman as a member, began to prepare a new *CIE Method for Calculating Tristimulus Values* that will correct the problem. Their article provides the logic, the evidence, and the results. They hope that instrument manufactorers and users will adopt the new recommendations. It is ironic, however, that internal reorganization of the CIE and resulting political debates have led to long delay in the publication of the recommendations by the CIE – the April, 1983, "final draft" still not having been issued as this is written in December, 1986.

Experience has shown that artists often show what many feel to be too little concern for the lightfastness of their works. It is bad enough to look at a medieval masterpiece and wonder what its colors were like when the artist created it, but much worse to feel the need to do the same with a modern piece. The situation has been exacerbated by the proliferation of new colorants and media in recent years. Papermakers are not exempt from the problem, and artists have increasingly gone to hand papermaking to insure adequate lightfastness of the colored papers. Henry W. Levison and coauthors Francisca Sutil (a hand papermaker) and E. Tom Vonderbrink describe extensive tests of the *Lightfastness of Pigmented Handmade Papers,* and provide lightfastness ratings of a wide variety of old and new pigments for this application. With this information, ade-

quate lightfastness of pigmented papers can be assured with confidence.

Among the many as-yet-unresolved puzzles in color vision are the relations of color perceptions to changes in the image observed in time and space, as for example those occurring all the time on television screens. Ann Elsner, with coauthor Burns and mentor Pokorny, describes *Changes in Constant-Hue Loci with Spectral Frequency.* But despite their best efforts the detective story of the causes leading to the phenomena they observed has not yet been told to the end.

It was just a few issues ago, Summer 1986 to be precise, that we read the latest articles by W. A. Thornton describing the wavelengths of peak response that he attributes to the human visual system. One of the admittedly controversial pieces of evidence supporting Thornton's proposals is the wavelengths at which, on average, the spectral curves of pairs of metamers cross. The use of Wyszecki's metameric-black concept makes these crossover wavelengths equivalent to the points where the hypothetical spectral curves of metameric blacks cross zero. In this issue, Michael Brill provides a *Statistical Confirmation of Thornton's Zero-Crossing Conjecture for Metameric Blacks,* based on the statistically most significant principal component of the spectrum of natural daylight.

Fred W. Billmeyer, Jr.

W.D. WRIGHT SYMPOSIUM – 19TH NOVEMBER 1986 – IMPERIAL COLLEGE – LONDON

Over 80 people came to Imperial College to help celebrate the 80th Birthday of a remarkable man. At the lunch Prof. Wright was presented with a book of commendations that had been gathered from more than 70 of his friends and colleagues from all over the world.

The aims of the Symposium are best revealed in the Foreword by John Hutchings in the booklet on the meeting.

FOREWORD TO SYMPOSIUM
by John Hutchings

This conference is in celebration of the 80th birthday of a man who, as we all know, has made many contributions to our knowledge of the fundamentals of vision and colour science, and has achieved a real and valuable extension of that science into the world of art and education. W. David Wright was Professor of Applied Optics at Imperial College from 1951 to 1973, author of five books, including the bible of most colorimetrists "The Measurement of Colour," first published in 1944, and "The Rays are not Coloured." Coupled with this, he had contributed in a large measure to the progress of the Commission Internationale d' Eclairage; to the foundation and advancement of the International Colour Association, of which he was the first President; and to The Colour Group (Great Britain), being the founder Chairman. This life-long dedication has been acknowledged by his receipt of the Colour Group Newton Medal in 1963, the International Colour Association Deane B. Judd Award in 1973, the 1980 Inter-Society Color Council Macbeth Award and, since retirement, visiting Professorships at the University of Waterloo, Canada, and the Rochester Institute of Technology, USA. In addition, The Colour Group (GB) has instituted the W.D. Wright Award which assists promising students to attend conferences.

As he would be the first to acknowledge, he did not do everything by himself; many others have been involved in all these activities. However, as a figurehead, "W.D. Wright has provided breadth and continuity of achievement over such a long period that The Colour Group Committee found it highly appropriate to sieze upon this occasion for celebration."

It was decided that the day would not be confined to looking back, David has always looked forward to the expansion of the influence of colour science and understanding into everyday life. Hence, only the morning will be devoted to "the past." The rest of the proceedings will be given over to a review of the present state-of-the-art in specified areas and we shall end with a look into "the future." One of his most far reaching contributions to colour was the founding of a lively and productive research school and it is particularly significant that all our formal speakers today were post-graduate students of the Wright school.

COLORIMETRY UP TO 1960
by R.W.G. Hunt, The City University, London

An understanding of the trichromacy of colour vision was well established by the middle of the nineteenth century as a result of the pioneer work of Young (1802-1807) and Helmholtz (1852-1866). With very little delay, the basis of trichromatic colorimetry was laid by the theoretical work of Grassman (1853) and the experimental work by Maxwell (1856-1860). Grassman propounded the basis on which colorimetric calcuations rest; a basis that is used today for the countless computations of tristimulus values by summating weighted spectral power data at successive wavelengths throughout the visible spectrum. Maxwell provided the first set of functions that bear an obvious similarity to what we now call colour-matching functions.

This pioneer work was followed by spectral colour-matching data obtained by later workers, notably by Konig (1903) and by Abney (1913). However, in the context of modern requirements all of these early investigations suffered from some rather severe limitations, such as low light levels in the matching fields, and the use of undefined white stimuli.

So it came about in the 1920s that the now famous parallel investigations by Guild at the National Physical Laboratory (NPL), and by Wright at Imperial College, provided data of much superior reliability, which was to provide the basis for modern colorimetry of quite astonishing permanence.

In Guild's apparatus the colours to be mixed were presented to the observer in rapid succession by means of a prism rotating across sectors of the three primary colours, the length of the sectors being adjusted by means of shutters to vary the amounts of the primaries in the mixture; the three primaries were provided by coloured filters illuminated with white light. In Wright's apparatus, the three primaries consisted of small bands of light isolated from three different regions of the spectrum formed by a system of prisms, the three beams being ingeniously recombined by reflecting them back through the same prism system; variation of the amounts of the three primaries was in this case achieved by moving light-absorbing wedges across each of the three beams. Guild used 7 observers, and Wright 10, for the spectral colour-matching data. Although Guild and Wright clearly used apparatus that was quite different, when their results were transformed to a common set of reference primaries, using Grassman's laws, remarkably close agreement was obtained. It was this agreement that encouraged the CIE at its meeting in Cambridge in 1931 to adopt an averaged set of colour-matching data to represent the results of the total of 17 observers who had been involved.

The straightforward story so far was then complicated by the fact that the CIE, in 1924, had already standardized one wavelength-dependent function, known now as the spectral luminous efficiency function, V(λ), and it was decided to con strain the experimentally-determined colour-matching data so that the V (λ) function could be generated by adding together suitable proportions of the three colour-matching functions. This procedure would probably have been entirely satisfactory had the 1924 V (λ) function been of high accuracy. However, it has now been clearly established that at the violet end of the spectrum the V (λ) curve is too low, some values being as little as a tenth of those currently considered to be more correct. Hence, the 1931 CIE Standard Colorimetric Observer, as the final colour-matching functions are officially referred to, may be regarded as an imperfect child of one incorrect and one correct parent.

In spite of these problems introduced by the use of the 1924 V(λ) function, the CIE 1931 Observer has been used ever since, and must surely now be one of the longest living international standards in metrology. The reason for its success is undoubtedly the high standard of the original work by Guild and by Wright. The discrepancies introduced by the V(λ) function are, fortunately, in a part of the spectrum where the amount of light present is usually very low, so that the effect of the errors on the final result is usually small enough to be negligible.

The unsatisfactory position regarding the V(λ) function, and interest in field sizes larger than the 2° used for the data obtained by Guild and Wright, led the CIE to call for a new determination of colour-matching functions, and this was carried out by Stiles and his co-workers at the NPL in the 1950s. Colour-matching functions were redetermined for 2° fields; but it was decided not to make any changes to the CIE 1931 Observer, because the new colour-matching data confirmed the Guild-Wright data very closely, and the effects of the incorporation of the erroneous V(λ) function had not been shown to be significant in practical colorimetry. The new investigation therefore concentrated on the use of a 10° field, and this work culminated in the CIE 1964 Supplementary Standard Colorimetric Observer, recommended for use when the field size is greater than 4°.

The period under review (up to 1960) closed with two interesting signs of things to come. In 1959, the CIE adopted the u,v approximately uniform chromaticity diagram; from this first attempt to move from representing only colour matches to representing colour differences, have stemmed the current CIELUV and CIELAB systems. And at the symposium on Visual Problems in Colorimetry held at the NPL in 1957, David Wright called for colorimetry to be extended further still, so as to define colour appearance; today we see the growth in this subject that has sprung from the seed he then sowed.

ADVANCES IN COLOUR SCIENCE FROM 1960 TO THE PRESENT

by A.R. Robertson, National Research Council of Canada, Ottawa

Introduction

So much has happened in colour science in the last 26 years that any attempt to review it in 45 minutes can be no more than a personal selection of advances that have interested me. W.D. Wright himself has said that "there has been an explosion in the output of visual research in the last two or three decades and he would be a bold man who claimed to be able to keep abreast of it all" (Wright, 1977).

Colour-Matching Functions

The first of Professor Wright's many notable contributions to colour science was one of two sets of colour-matching data that formed the basis of the CIE 1931 standard colorimetric observer. In 1951 he commented that it "appears to have stood the test of twenty years remarkably well" (Wright, 1951). Now, 35 years later, it is even more firmly entrenched, having survived some questioning in the early 1960s. After a major investigation at the NPL (Stiles and Burch, 1955) the CIE decided in 1964 to leave the 1931 observer unchanged for small fields (2°) but to supplement it with a second observer which was more suitable for large fields (10°). A later study by Estevez (1979) showed that any differences that do exist between the Wright/CIE data and the newer NPL data for 2° fields are due to the V(λ) curve that was built into the CIE ob-

server and not to Wright's actual data.

Recent work (Wyszecki and Stiles, 1980) has shown that the predictions of the standard observer break down at very high levels of retinal illuminance ($>10^3$ to 10^6 td). The importance of this to practical colorimetry is not yet clear but it undoubtedly has significance in efforts to determine how the visual system works. Wright, in his colorimeter, could not make matches at such high levels but he was able to adapt the eye to high levels and to demonstrate a breakdown of low-level matches immediately following such adaptation (Wright, 1936).

While it is clear that the CIE 1931 observer will continue to be used indefinitely as a standard to facilitate the exchange of information about colour and to predict metameric matches particularly in industry, Technical Committee 1-04 of the CIE recently has been studying possible additional ways to help vision researchers. The first is an attempt to obtain a complete set of data on the visual functions of a single observer against which mathematical models of vision can be tested. Wright had anticipated this many years ago (Wright and Pitt, 1935 and 1937) and it will be interesting to see how well the new CIE data compare.

Colour Vision

The second project of CIE TC 1-04 is to recommend a physiologically based system of colorimetry derived from estimates of the action spectra of the cone mechanisms. This is possible because so much more is known now about what these action spectra are. The new knowledge is based both on microspectrophotometry (e.g. Dartnall et al., 1983) and on psychophysical techniques (e.g. Smith and Pokorny, 1975). It has always seemed likely that the CIE colour matching functions were the result of the action spectra of three types of photoreceptors although not all vision scientists accepted this explanation. Now it is virtually beyond dispute and the new physiologically based system will have to have a simple relationship to the 1931 standard observer.

In the last two or three decades there has also been a significant increase in what we know about later stages of the visual system. In particular the so-called "opponent channels" have been studied in great detail both psychophysically and by electrophysiology (see Mollon, 1982 for a good review). It is now widely accepted that signals from the cones feed in some way into opponent mechanisms and that the Young-Helmholtz and Hering theories of colour vision are compatible with each other. This was not obvious to everyone twenty years ago although Wright (1964) had written "I doubt whether there is any fundamental conflict, although there are clearly some misconceptions on both sides that have to be removed."

The period under review has also seen a proliferation of mathematical models of colour-vision. While these models are often useful in providing some structure to our ideas about the processes involved, the details can be no more than speculation at present. To quote Wright again: "I am constantly amazed at the confidence with which grossly simplified writing diagrams of the retina are put forward as representing what is actually happening to the signals as they traverse the retina from cones to ganglion cells" (Wright 1977). Failure to recognize the oversimplification of these models sometimes leads their proponents to suggest elaborate correction factors rather than to reject the model. The "farm-gate contraction" quoted by Wyszecki and Stiles (1982) is relevant here.

Applied Colour Science

These advances in colour vision research are not of direct interest to practical industrial colorimetrists although their influence will surely be beneficial eventually as they lead to better ways of predicting the complicated phenomena of colour perception. Of more immediate interest are many significant international agreements, mainly in the form of CIE recomendations, that have been made since 1960. These involve the supplementary standard observer (mentioned above), new standard illuminants, a new reference standard and geometries for reflectance factor measurements, new uniform colour spaces and colour difference formulae, indices to describe colour rendering, metamerism and whiteness, a method for assessing the quality of daylight simulators, a proposal for predicting corresponding colours with a change of chromatic adaptation, and an empirical equation for predicting heterochromatic brightness matches.

Wright (1946) pointed out that "the application of the results of academic studies of vision to the solution of practical problems of seeing is not always so obvious and direct as could be wished." Uniform colour spaces are an excellent example of this. No-one should claim that the CIELAB colour space has anything very much to do with how colour vision works. The axes of the system were chosen more for mathematical simplicity than anything else and do not come close to reflecting the complex processes that take place in the retina and cortex. Nevertheless the space has proved to be an exceedingly useful tool for colorimetrists and is slowly but surely becoming a standard way to communicate about colour and colour differences.

An important factor that has aided the acceptance of CIELAB has been the realization that in different industrial situations, different weights may have to be given to the hue, chroma and lightness components. These developments can hardly be a surprize to the man whose birthday we are honouring today, for 45 years ago he wrote: "It is true that even a uniform-chromaticity sacle will not always give a true picture of the subjective importance of colour errors; thus in some cases hue errors may be more serious than errors of saturation

or vice-versa. Nor can it take into account the vital part that manufacturing considerations must play in the specification of colour tolerances. Nevertheless, in many problems the uniform scale could be applied directly and it seems reasonably certain that in all those cases in which special considerations arose, the significance of the tolerances would be more accurately appreciated with a uniform scale as the basic system than with a non-uniform scale." (Wright, 1941)

Colour Measurement

Another significant advance since 1960 has been the great increase in the speed, accuracy and precision of colour-measuring instruments such as spectrophotometers. Wright (1959) wrote that "for the highest class of colorimetric work, three particular developments seem to be desirable; first, the development of a spectrophotometer with the highest possible accuracy and sensitivity. Second, the preparation of a set of surface colours distributed more or less uniformly through the colour solid to be used as master standards for first order reference. Ceramic tiles would probably be the most stable for this purpose, but they would need to be very uniform over their area and very flat over their surface. The third development would be the design of a highly sensitive differential spectrophotometer by means of which working master standards could be calibrated by comparison with the reference master standards." All these developments have occurred, the first by the building of reference spectrophotometers at the National Physical Laboratory and the National Bureau of Standards, the second by the production of the Ceramic Colour Standards by British Ceramic Research Ltd., and the third by the introduction of several high-speed, high-precision commercial spectrophotometers.

Conclusion

In the first Newton Lecture to the Colour Group, Wright (1963) wrote that "one of the advantages of writing about some great figure of the past is that you feel under an obligation to make a proper study of his works. Certainly, for this occasion, I have read Newton's *Opticks* with greater care than ever before, and I have found it a very revealing experience." For my part, I have read David Wright's works with greater care than ever before and I too have found it a revealing and indeed stimulating experience.

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DAVID WRIGHT AND THE AIC

by Heinz Terstiege, President, Association Internationale de la Couleur

Many discussions had already been held at the yearly organised "Journees internationales de la coluleur" in Europe which had taken place since 1957 but it was only during the XVth CIE Congress in Vienna at an informal meeting of people interested in colour on the 21st of June 1963 that an international Action Committee consisting of delegates of national organisations within each country was formed. However at the International Colour Meeting in Lucerne in June 1965, the Action Committee could not yet agree on the statutes of an International Organisation to be chartered.

When on the 21st of June 1967 during the XVIth CIE Session in Washington the Chariman and the Secretary of the

Action Committee called the delegates and interested observers of National Colour Organisations to a meeting, W.D. Wright was one of the 25 participants from 15 countries who had gathered in the Diplomat Room of the Sheraton Hotel in Washington DC and after some discussions chartered the International Colour Association (AIC).

Since it was intended to have the AIC Congresses every four years alternating with CIE Congresses it was decided to have the first congress together with the next meeting of AIC delegates in 1969. For this first term Professor W.D. Wright was unanimously elected the first AIC President and he also served the next term until 1973 as Past President of the AIC.

In recognition of his extensive contributions to the science and technology of colour Professor William David Wright was honoured by the International Colour Association with the 1977 Deane B. Judd-AIC Award.

On the occasion of his 80th birghday the AIC wishes David Wright all the very best and I personally, who have had the privilege of spending 6 weeks with him at the Imperial College in London, want to thank him for everything that he has done for the world of colour.

Wavelength and Colour Processing in Human Vision
by K.H. Ruddock, Imperial College, London

The measurement and analysis of colour matching and related attributes of human vision occupied much of Professor Wright's academic career, and provided the basis for the research carried out by a succession of distinguished students. Professor Wright's book 'Research on Normal and Defective Colour Vision' reviews this work up to 1946, and subsequently significant contributions have been made by Dr. F.J.J. Clarke, Dr. D.H. Foster, Prof. J.D. Moreland and Dr. D.A. Palmer, amongst others. The tradition of colour vision research has been maintained at Imperial College since Professor Wright's retirement, and those engaged in the various studies include Dr. V.A. Barbur (nee Waterfield), Dr. B.G. Bender, Dr. I.M. Blythe (nee Hendricks), J.M. Bromley, Dr. S. Naghshineh and the late Dr. G.J. Burton. It is impossible, in the short time available, to do justice to the many fascinating and important findings which have emerged from this work, and consequently, I have chosen for discussion a few topics which I consider to be of particular interest.

The trivariant nature of human colour vision is determined by the spectral absorption characteristics of cone photoreceptors, and one consequence is the relatively simple framework of tristimulus colorimetry, to which much of today's proceedings are devoted. Conversely, the dominant influence of the photoreceptors on colour vision renders more difficult the examination of post-receptoral spectral responses in man. The desaturating effects of rod signals, described by both Clarke and Moreland, provide an example of post-receptoral spectral organisation, and I examine two others. For small ($\leqslant 20'$) fields, colour matching is divariant (Konig, 1894; Willmer and Wright, 1945), but such tritanopic matches can be disturbed by adaptation of the surrounding retina (Burton and Ruddock 1972; Ruddock and Burton, 1972) and I discuss the implications of this observation.

The demonstration of 'opponent' spectral responses in man has proved difficult, despite the clear evidence of such activity in the earliest electrophysiological recordings from retinal stimuli (Svaetichin, 1956). The discovery of shape-sensitive adaption effects opened new avenues of psychophysical study, and I describe the way in which these can be exploited for the determination of 'opponent' spectral response characteristics, generated in the cortical pathways (Hendricks, Ruddock and Waterfield, 1982).

The study of defective vision formed an integral part of Professor Wright's research programme and in recent years, we have had the opportunity at Imperial College to examine a number of unusual subjects. I examine three types of colour vision deficiency, each associated with a different abnormality of the central pathways. Two of these involve complete absence of colour discrimination, in one case associated with residual vision in the 'blind' hemifield of a subject suffering cortical damage (Barbur, Ruddock and Waterfield, 1980) and in the other, with loss of pattern recognition (Bromley et al. 1986). The third subject displays disturbance of all visual functions in coloured, and particularly red lights (Hendricks, Holiday and Ruddock, 1981), but his black and white vision is entirely normal. This last subject provides clear evidence that at cortical level, colour is processed separately from other stimulus attributes, as has been demonstrated in the monkey by Zeki (1978).

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CONTRIBUTIONS SOLICITED

Stiles Lectureship Fund

(Ed. Note: – W. S. Stiles died December 15, 1985. His obituary was published in ISCC News No. 303, Sep-Oct 1986, p. 23.)

On the initiative of Professor Jay Enoch, a small international committee has been formed to try to establish a permanent annual lectureship in memory of the late W. S. Stiles. It is proposed to establish the lectureship at University College, London – Stiles' alma mater. The proposal has been welcomed by the Provost of University College. A sum of ten thousand pounds is needed.

Stiles was one of the most distinguished visual scientists of the twentieth century, although he did not attract a great deal of public recognition in his lifetime. His concept of a mechanism or channel, independent in detection and adaptation, has been extended from colour vision to many other sensory dimensions. He will be remembered for his discovery, with Crawford, of the directional sensitivity of the retina; his line-element analysis of discrimination; his concept of the equivalent background; his 10-deg colour-matching functions, which were the basis for an international standard; and his monumental 'Color Science,' jointly written with G. Wyszecki. He was a former Chairman of the Colour Group and an honorary member.

At the present, the donations received amount to about half the sum needed to establish the lectureship, anyone who values the contributions of Stiles to visual science and feels able to make a donation to the fund, is wramly invited to send a cheque either to Professor J. M. Enoch, School of Optometry, University of California, Berkeley, California 94720, USA; or to The W. S. Stiles Lectureship Fund, The Finance Division, University College London, Gower St., London WC1E 6BT, United Kingdom.

John Mollon

NEWS OF MEMBERS

William A. (Bill) Thornton

Ed. Note: – Bill Thornton is one of our most interesting members. For one thing, as President of Prime-Color, Inc. (PCI), he does not have to ask anyone for permission to talk about what he is doing. Last December he sent out an epistle that interested our then Interim Editor Hammond who asked permission to publish it. It also occurred to Hammond that everyone may not be well acquainted with Thornton, his background and achievements; so we present first a short *Thornton Biography* edited by Hammond. If you know Thornton you can skip the biography and go right to the *December Epistle.*

THORNTON BIOGRAPHY

Thornton has had an intersting career. After serving as captain in the Air Force, forecasting weather in Europe, Thornton returned to civilian life, earned a BS in physics at University of Buffalo (1948) and then went to Yale University where he continued his studies in physics, obtaining an MS (1949) and a PhD (1951). He then joined the General Electric Research Laboratory at Schenectady, NY. In 1956 he went to Westinghouse in Bloomfield, N.J. He worked first in electrolumni electroluminescence, then with lamp phosphors, becoming manager of the Phosphor Research Section. There followed 18 years as a Research-Engineering Consultant, including consulting and research in lamp design, luminescence, color, color-vision, and color-rendering.

For many years, his work centered around design of spectral compositon of lamplight for difficult visual tasks, a logical evolution of which was the discovery of the 'primecolors' of human vision. This led to invention and patenting of the prime-color (three-component) fluorescent lamp, one of his 35 U.S. patents.

In 1978 Thornton received Westinghouse's highest honor, the *Order of Merit,* for his development of the prime-color principle. In 1979 he was selcted U.S. National *Inventor of the Year.* He is a Fellow of the Illuminating Engineering Society of North America and has chaired the delegation from this Member Body for some years. He has also served as Director of ISCC (1980-83).

Thornton is now president of Prime-Color, Inc. (PCI) of Cranford, New Jersey, dedicated to bringing the benefits of pure-prime-color lighting to the user. PCI's Illumination Quality™ meter assesses twenty characteristics of lamplight as the trained human observer would evaluate them, but in addition it provides a numerical rating for each one.

What else does PCI do? It provides spectroradiometric measurements of lamps and filters in the visible and ultraviolet portions of the spectrum; lectures and workshops; consultation and research on all aspects of lamps and lighting. Thornton's *December Epistle* that follows contains more information.

Harry K. Hammond III, February 24, 1987

DECEMBER EPISTLE

December, 1986	Cranford, New Jersey
from Bill Thornton	at Prime-Color, Inc.

It's 6 AM, and I'm looking out over the CRT, from the warm, light computer room, onto dawning Harvard Road and our first snow. It's about time. Having grown up in western New

York, I still couldn't bear a winter without some good snows. This morning the trees and shrubs are covered, and the wintriness looks very proper. I and Prime-Color, Inc. (PCI) are now back in the family home, where the children grew up and the place still echoes with their shouts and play. It's much quieter now, largely redone, and all business; 80% of it is in good use for PCI. It's bright and warm, and stuffed full of technical apparatus of a hundred kinds.

The garage should see development of lamp-making equipment. The basement is, for those queer people who like that sort of thing, relatively spectacular. In it are a shiny new lathe and milling-machine, not to mention grinders, a circular saw and two band saws, drill-press, and small stuff; and lots of shelves and work-areas. The new colorimeter is taking shape down there. One sits in front of it, and mixes colored lights of different kinds, in two side-by-side boxes, so that finally the mixed light in one box exactly matches that in the other box – even though they can be composed very differently; then the light from each box is piped out into the spectroradiometer to be precisely measured. This is the main method by which human vision is studied. In the machine shop, parts for Illumination Quality (IQ) meters are being made.

The recreation room is now the display room, where 20 fixtures allow comparison of 100 lamplights; projectors and screens are also there. Next to that is the secretary-technician's office, with its own computer, and a ton of files. Up another level is the main workroom where I am sitting; it has two more computers, the spectroradiometer, and a little electronic workshop. Up another level are two more work-rooms for the IQ meter. Up another level are bedrooms and a sitting-room – the only space most of you would call habitable. (And perhaps not even that, come to think of it. The whole place is, and looks like, bachelor's quarters: hardly any curtains or drapes, and unrelievedly functional – and dull?)

Business is, after the slow start everyone warned of, very busy. New and far better lamplight for the U.S. Department of Agriculture meat-inspectors is progressing rapidly (on a two year Small Business Innovative Research contract with the USDA). Much-improved surgical lighting has been demonstrated to the surgeons (who see it as we biased persons do). At very long last, the supply of IQ meters is close to realization; they are hand-held, and carried around to sample various illuminations. A punch of a button, and its eight eyes measure the light; then its electronic innards instantaneously compute some 20 characteristics of that light, including many characteristics that would otherwise require a group of expert human observers to assess. Two Prime-Color research papers appeared in 1986, and another will be published in 1987. And somehow the surface remains only scratched.

Access to something like PCI's spectroradiometer is apparently rare in the commercial world, so we have been measuring many sorts of things for others: ultraviolet from sunlamps, transmission of filters, reflectance of cloths and papers, and of course characteristics of lamplights of other manufacturers.

Early in 1986, we built a large instrument for a lamp factory on mainland China. In August, I went over to see that it was working well, and to lecture a bit – a warm, friendly experience (see ISCC News No. 304, November-December 1986).

A little knot of mathematically-inclined friends and I, who am not mathematically inclined, have been trying to clear up what role the prime-colors play in seeing, as well as in color-science. Unfortunately, seeing and color-science are not the same, so, like Sherlock Holmes, we piece together shreds of evidence from each approach. There seems to be no hurry – people have been at it for a century, and they will surely be at it for another 100 years.

NATIONAL RESEARCH COUNCIL OF CANADA

Spectrophotometry and Colorimetry

Most of the work at the National Research Council of Canada that is of interest to members of the Inter-Society Color Council takes place in the Photometry and Radiometry Section which is part of the Laboratory for Basic Standards. The Section Head is Dr. Ronald Bedford who succeeded Dr. Alan Robertson on 1 January 1987.

Within the Section, a group led by Dr. William Cowan is engaged in research in vision, particularly color vision. Current projects include examining the effect of spatial and temporal stimulus variation on bichromatic thresholds, the development of procedures for calibrating video monitors, and studies of color image reproduction. One results of this last item was the production, from digital originals, of the color separations for the special edition of Color Research and Application on "Color in Computer Generated Displays" (Vol. II Supplement, 1986).

The primary responsibility of the Laboratory for Basic Standards is to develop and maintain primary standards for the Canadian national system of physical measurement units. In line with this, another group in the Section maintains and develops standards and measurement techniques for photometry, colorimetry and radiometry. The scientific staff involved in this task are Dr. Philippe Boivin (absolute radiometry and detectors), Dr. Arnold Gaertner (spectroradiometry and photometry), Dr. Alan Robertson (spectrophotometry and colorimetry), Dr. Nelson Rowell (infrared radiometry) and Dr. Joanne Zwinkels (spectrophotometry). Current projects include the following:

1. Measurements of luminous intensity have been made according to the new (1979) definition of the candela. As a result the luminous intensity values attributed to NRC standard lamps will be adjusted slightly in 1987, as will those of most other countries.

2. Work is proceeding on the establishment of a spectral irradiance scale from 250 to 2500nm based on the NRC absolute radiometer which is an electrically calibrated thermal detector. In the next year or two, effort will be concentrated on the 700 to 1600nm range.

3. A Perkin-Elmer Lambda-9 spectrophotometer is being modified and used for a wide variety of reflectance and transmittance calibrations. In addition a reference spectrophotmeter is being developed for high-accuracy transmittance measurements from 200 to 3000 nm.

4. Color discrimination ellipsoids determined in various countries on behalf of CIE Technical Committee 1-08 are being analysed.

5. An analysis of the principles of color order systems is being prepared for ISO Technical Committee 187. It is hoped that this will lead to a better appreciation of the similarities of and differences between existing systems.

6. The Section operates the NRC trichromator, a sophisticated large-field visual colorimeter capable of application to a variety of color-vision experiments and to the measurement of most of the standard colorimetric characteristics of human observers such as 2° and 10° color-matching functions, luminous-efficiency functions by flicker photometry and by heterochromatic brightness matching, opponent-color response functions by hue-cancellation, wavelength discrimination, Stiles' π-mechanisms, color-matching ellipsoids, and the Stiles-Crawford effect. Currently no staff scientist is working on the trichromator but NRC welcomes and can give technical support to scientists from other institutions who wish to use this unique facility.

Alan Robertson, February 1987

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CALENDAR

1987

ISCC ANNUAL MEETING
"Industrial Problems in Color Science," The Barclay Hotel 18th & Rittenhouse Square, Philadelphia, PA 19103, April 5-7

AMERICAN CERAMIC SOCIETY
89th Annual Meeting and Exposition, April 27-30, Pittsburgh, Pennsylvania, Contact Delegation Chairman, F. Joseph von Tury, 11 Colonial Court, Metuchen, NJ 08840

ASTM
Subcommittee D01.57, Artists' Materials, May 12-13, Hyatt Regency Hotel, Atlanta, Georgia, Joy Turner Luke, Chairman (See address of Pres.-Elect). Meeting precedes that of National Art Material Trade Assn., May 14-16

Committee E-12 on Appearance of Materials, May 26-27, National Bureau of Standards, Gaithersburg, Maryland, Norbert L. Johnson, Secretary, 582-1-16 3M Center, St. Paul, MN 55144

CORM
Annual Meeting, May 28-29, National Bureau of Standards, Gaithersburg, Maryland, Norbert L. Johnson, Secretary, 582-1-16 3M Center, St. Paul, MN 55144

RIT
Munsell Color Science Laboratory, Colorimetry Short Courses for Scientists & Engineers (2 dates), May 11-14, Aug. 24-27, Registrar: Ms. Chris Kester, RIT, P.O. Box 9887, Rochester, NY 14623

GROUPO ARGENTINO DEL COLOR (GAC)
Color Science Courses (3), Introduction, May 12-19, Advanced Techniques, May 20-21, Formulation, May 22-23, Lic. Roberto Daniel Lozano, President, C. de Correo 157, 1650-San Martin (Bs. As.), Republic Argentina

DETROIT COLOR COUNCIL
Canadian Society for Color, Joint Symposium, Automotive Color Design, Cleary Auditorium, Windsor, Canada, May 27-29, Registration Information, Bob Schneider 800-521-9094, Bill Longley 313-337-5234

CIE, 21st SESSION
San Giorgio Maggiore, Venice, Italy, June 17-25

OPTICAL SOCIETY OF AMERICA
Topical Meeting on Color Appearance, Annapolis, Maryland, June 29-30

ILLUMINATING ENGINEERING SOCIETY
Annual Conference, Marriott Camelback Inn, Scottsdale, Arizona, August 2-6

FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY
65th Annual Meeting and 52nd Paint Industries' Show, Convention Center, Dallas TX, October 5-7

OPTICAL SOCIETY OF AMERICA
Annual Meeting, Riverside Convention Center, Rochester, New York, October 18-23

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