HINDSIGHT
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January, 2009
Volume 40, Number 1

Official Publication of the Optometric Historical Society

Hindsight: Journal of Optometry History publishes material on the history of optometry and related topics. As the official publication of the Optometric Historical Society, Hindsight: Journal of Optometry History supports the purposes and functions of the Optometric Historical Society.

The purposes of the Optometric Historical Society, according to its by-laws, are:
- to encourage the collection and preservation of materials relating to the history of optometry,
- to assist in securing and documenting the recollections of those who participated in the development of optometry,
- to encourage and assist in the care of archives of optometric interest,
- to identify and mark sites, landmarks, monuments, and structures of significance in optometric development, and
- to shed honor and recognition on persons, groups, and agencies making notable contributions toward the goals of the society.

The official publication of the Optometric Historical Society, published quarterly since its beginning, was previously titled:
Newsletter of the Optometric Historical Society, 1970-1991 (volumes 1-22), and
Hindsight: Newsletter of the Optometric Historical Society, 1992-2006 (volumes 23-37).
Hindsight: Journal of Optometry History began in 2007 with volume 38, number 1.

On the cover: The drawing represents OHS for Optometric Historical Society: the O an elementary schematic of an eye, the H three intersecting pairs of spectacles, and the S a representation of a light wave with the Greek letter lambda indicating one wavelength. The drawing artist was Diane Goss.

OHS website: www.opt.indiana.edu/ohs/opthohiso.html

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TABLE OF CONTENTS

Journal subscriptions are registered by joining the Optometric Historical Society. The cost of an institutional or library subscription is the same as for a regular personal membership.

Manuscripts submitted for publication should be sent to the Editor at the email address or postal address above. A Word document attached to an email message is the preferred means of submission. Paper copy submissions sent by postal service will also be considered.

OHS News

Officers and Board Members for 2009

Irving Bennett and Chuck Haine have been elected to four year terms on the OHS Board. Bridget Kowalczyk will complete the unexpired term of Walter Chase, who is ill. The Board members have completed election of officers among themselves. Listed below are the OHS Executive Board members and the officers for 2009. The year of expiration of each Board member's term is given in parentheses.

President....................... Irving Bennett (2012)
Vice-President................ Chuck Haine (2012)
Secretary-Treasurer......... Bridget Kowalczyk (2010)
Trustees......................... Jerry Abrams (2009)
Jay Enoch (2010)
Doug Penisten (2011)
Melvin Wolfberg (2009)

Nominations to fill Board Positions Expiring at the End of 2009

The terms of Board members Jerry Abrams and Melvin Wolfberg will expire at the end of this year. Melvin Wolfberg has asked to not be re-elected to the Board. Please submit your nominations for these two Board positions by June 15, 2009 to:

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OHS members who receive at least three nominations and agree to serve on the Board will have their names placed on an election ballot to be mailed later this year with a copy of Hindsight. Self nominations are welcome and encouraged.

Dues Notice

A dues notice has been enclosed with this issue of *Hindsight: Journal of Optometry History.*

75th Anniversary of the Stiles-Crawford Effect(s): A Celebratory Special Symposium, October 23, 2008; Rochester, New York

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Abstract

There are rather few articles which, so-to-speak, serve to change the landscape in a scientific field. One of those was the discovery of the "directional sensitivity of the retina" by Walter Stanley Stiles and Brian Hewson Crawford (first reported in 1933). Subsequently, their findings were subdivided by Hansen into two logical components, "the Stiles-Crawford Effects of the First and Second Kinds, (SCE-1 and SCE-2)." The former (SCE-1) dealt with aspects of their research which addressed alterations in perceived brightness of a visual stimulus; the second (SCE-2) was associated with the perceived hue and saturation of these visual stimuli.

These discoveries arose out of a failed attempt by W.S. Stiles and B.H. Crawford to measure properly the areas of the entrance pupils of their experimental subjects as part of a research program which addressed problems of glare, e.g., disability glare, in illuminating engineering. Their research was conducted at the National Physical Laboratory (NPL), which is located in Teddington, Middlesex, England. These two fine scientists properly deduced the reason for the failure of their experimental design, and they effectively described and defined a new feature of the visual system which was largely ascribed to the retina. In time, it was realized that this phenomenon was associated in large measure with the waveguide/fiber-optics properties of photoreceptors, and that this was a feature shared by virtually all vertebrate species.

This paper is divided into two parts. In the first part, Enoch describes, as best he can, the culture and working conditions at NPL during 1959/60 when he served as a post-doctoral fellow with W.S. Stiles. And in the second part of this paper, the authors describe the findings of W.S. Stiles and B.H. Crawford at the time of their discovery.

Today, we celebrate the 75th Anniversary of that research. The organizing committee for this program (alphabetically) is David Atchison, Jay M. Enoch, Vasudevan Lakshminarayanan, and Pieter Walraven. Our group of speakers today will follow with discussions of aspects of subsequent work which has evolved from the initial discoveries made by the late W.S. Stiles and B.H. Crawford.

Introduction

Today, we celebrate the 75th Anniversary of research conducted by Walter Stanley Stiles and Brian Hewson Crawford. The report of this research appeared in the Proceedings of the Royal Society of London in 1933.[1] Subsequently, their discovery became known as the Stiles-Crawford Effect of the first kind (SCE-1). Some years after this research had been reported, the speaker had opportunity to serve as a post-doctoral fellow (in 1959-1960) with Walter "Stanley" Stiles at the National Physical Laboratory (NPL). This fine institution is located in Teddington, Middlesex, U.K., and lies within "Bushy Park", the large Royal Preserve attached to Hampton Court Palace. Hampton Court Palace is located a bit upstream from the Teddington Locks on the Thames River. While at that laboratory, JME also had opportunity to get to know quite well Brian H. Crawford, James M. Burch, Frank J.J. Clarke, David A. Palmer, and quite a number of others at NPL. There, he also had opportunity to meet the then NPL Director G.B.B.M. Sutherland as well as John Guild. Guild was then quite elderly and retired. Guild's NPL colorimetric data coupled with contributions made by W.D. Wright played an important role in the development of the C.I.E. standard color matching data for V_λ.

While in England, Jay and Mrs. Enoch were invited by Stanley Stiles to attend a meeting at the Royal Institution in London and to hear Prof. F.Z. Young speak. He described and demonstrated the experiments of Thomas Young (that is, he used the original apparatuses of his forebear Thomas Young, who had been associated with the Royal Institution). Separately, several times, Enoch visited the laboratories and libraries at the Institute of Ophthalmology in London where he met Sir Stewart Duke-Elder, Robert Weale, Katherine Tansley, H. Dartnall, etc. He also had opportunity to visit with Profs. Arnold Sorsby and Hamilton Hartridge at the Royal College of Surgeons. Subsequently, and to his surprise, Hartridge kindly willed his card and reprint files to Enoch (these maintained and updated materials now reside in the library of the Elite School of Optometry, a unit of the Sankara Nethralaya, Chennai, Tamil Nadu, India). At City University in London, JME came to know Prof. Robert Fletcher, then Director, and a number of his faculty. During two extended visits to the Cambridge University Physiological Laboratories, he met and interacted with Sir Bryan H.C. Matthews, Alan L. Hodgkin, Fergus Campbell, Giles Brindley, Horace Barlow, etc. (Note, William Rushton was not in residence at the time). JME also visited with W.D. Wright at Imperial College, and R.W. Ditchburn and D.H. Fender at the University of Redding.

Clearly, this was a period of time when quite a number of physicists and visual scientists in Great Britain were active in colorimetry, lighting research, radiometry and photometry, as well as in other aspects of visual psychophysics and physiology. And there were quite a number of additional distinguished scholars active in studies of the physiology of vision. These individuals brought very special skills to their research, and this, in turn, enriched interdisciplinary, or what today might be termed translational research. In general, one might argue that this time period was "golden" for vision science in England! JME was very lucky to have had an opportunity to meet many members of this fine, active, and then dominant scientific group.

Thus, JME was in residence in Teddington roughly 26/27 years after the initial discovery of SCE-1. Sadly, few of the other students and scientists remain who had opportunity to work early on this and related topics with Stanley Stiles and/or Brian Crawford at Teddington. JME hopes some of them are here today!

In early September, 1959, as Enoch left Washington University in St. Louis to travel to Teddington to start his Post-Doctoral Fellowship at the National Physical Laboratory, he was handed his just-delivered work permit. In that document, he had been appointed a "Consultant to Her Majesty's Government". When he arrived with his family in Southampton, as is appropriate, he presented their passports and documents to the Immigration Officer. This Officer took one look at JME's work permit as a "Consultant to Her Majesty's Government", and said to him, "Cor! Blimey! What God-dammed fool is coming here to work for this God-dammed Government!" Thus, properly-chastened, JME, his wife, and their then two children, aged 2 and 4, arrived in England.

With his family settled-into a residence on Cambridge Street in Teddington, JME remembers walking daily through this still shrapnel-scarred town (this was about 15 years after WWII) to report for work at the National Physical Laboratory. On his first day at work, Stanley Stiles graciously received him into his office (which he was to share), but indicated he had to submit an urgent report that day, and asked JME to introduce himself to the several individuals working at the Light Division of NPL. He did so, and at one point came to the laboratory of a gentleman with short-cropped white hair who was seated at his desk. Before JME could introduce himself, he turned to JME and said, "How is it that you didn't come to work with me?" Enoch said, "Sir, may I ask, who you are?" He responded, "I am Crawford." Enoch replied, "Am I not to work with you?" Thus, Enoch learned (sadly) that Stiles and Crawford were not the close partners they had been in earlier years. So-saying, both of these gentlemen were extremely kind to him (and his family) - in fact, they could not have been nicer! He learned a great deal from them both, and became close friends with them and their families.

Walter Stanley Stiles was one of a number of individuals named Walter Stiles in his family (5 are cited). Hence, family and friends came to call him by his middle name, "Stanley". Mathew Alpern wrote the Biographical Memoir of Stiles for the Royal Society of London.[2,3] There he discusses Stiles' family and their history. His older sister, Grace Etheridge, stated to Mat, "they were of yeoman stock, and had qualities of honesty of purpose which people of the times seemed to possess."

Stiles' dad retired at age 54 after a career spent in the Metropolitan Police. He died at the age of 101! JME met Stiles' dad on 2 or 3 occasions when he visited Stanley Stiles at his office. His dad was then well into his 90's (had JME known that then, he would not have believed it!). His dad was taller than Stanley, and was well-built, with ample white hair. He remembers that he had very large and very strong hands, and seemed quite athletic. Enoch could readily appreciate the reference to "yeoman stock" mentioned by Stiles' sister.

The NPL experience was quite incredible. In his introductory Memorial to Walter Stanley Stiles presented at the Stiles-Wyszecki Memorial Symposium on Color Vision Models, held in 1987, Mathew Alpern[3] commented upon first seeing Stiles' NPL Trichromator, "My first impression of this elegant instrument was so memorable, that 25 years later I devoted a sabbatical year to experiments on its Canadian off-spring".[3] Westheimer called it the "cyclotron of vision research".[3] JME was equally impressed and overwhelmed, and he *truly valued* the extraordinary opportunity given to him which allowed him to reassemble a good bit of the instrument (2 tiers), to align, and to recalibrate this remarkable three-tier instrument while he was in residence at the National Physical Laboratory Figs. 1,2. Skills learned in these highly demanding activities benefited the writer throughout his entire research career. When this task was completed, he was to work both at length as experimenter and subject on this remarkable device in joint studies with Stiles.[5] This device had been used for color matches for 2° and 10° field diameter standard observer measurements, for determination of Stiles' two color increment threshold "π" functions, for SCE-1 measurements (of white light, and monochromatic light stimuli, and SCE-2 hue and saturation data). Fig. 1 is a schematic of the optical plan for the three tiers of the NPL Trichromator.[4] Fig. 2 shows the optical changes made to two tiers of this instrument for Stiles' and Enoch's research on the Stiles-Crawford effects SCE-1 and SCE-2 (see below).[5]

Enoch had never even heard of a near-two-story-high, enclosed optical device for vision testing. The only other self-enclosed stand-alone equipment or test rooms JME had encountered were the chambers used for dark adaptation and other studies in Selig Hecht's laboratory at Columbia University, and they were of modest size. Although quite different in complexity and application, he suspects one might place "leaf-rooms" designed by Adelbert Ames and co-workers at the Dartmouth Eye Institute (and the distorted rooms employed there as well) in the same general category. The latter were used for testing and correcting aniseikonia and for educating individuals as to the spatial distortions encountered in aniseikonia.

The basement of the building housing the Light Division at NPL contained an enormous assembly of large wet-cell batteries forever being recharged and maintained by a team of scurrying technicians. Each research laboratory in the Light Division was assigned a private bank of batteries to power test lamps employed. On the main floor, there was a giant switch-board (really a switch-wall) which each morning could be reached by available tall rolling step-ladders. Into an assigned porthole, one inserted a large cone-shaped solid metal connecter with an insulated knob handle. This served to open one's designated circuit (and this circuit was closed again at night by removing same). After making this connection, one went upstairs to one's laboratory to close a private, giant knife-switch which would then deliver the desired power to one's lamps in the laboratory. The stability and accuracy of these circuits was just extraordinary!

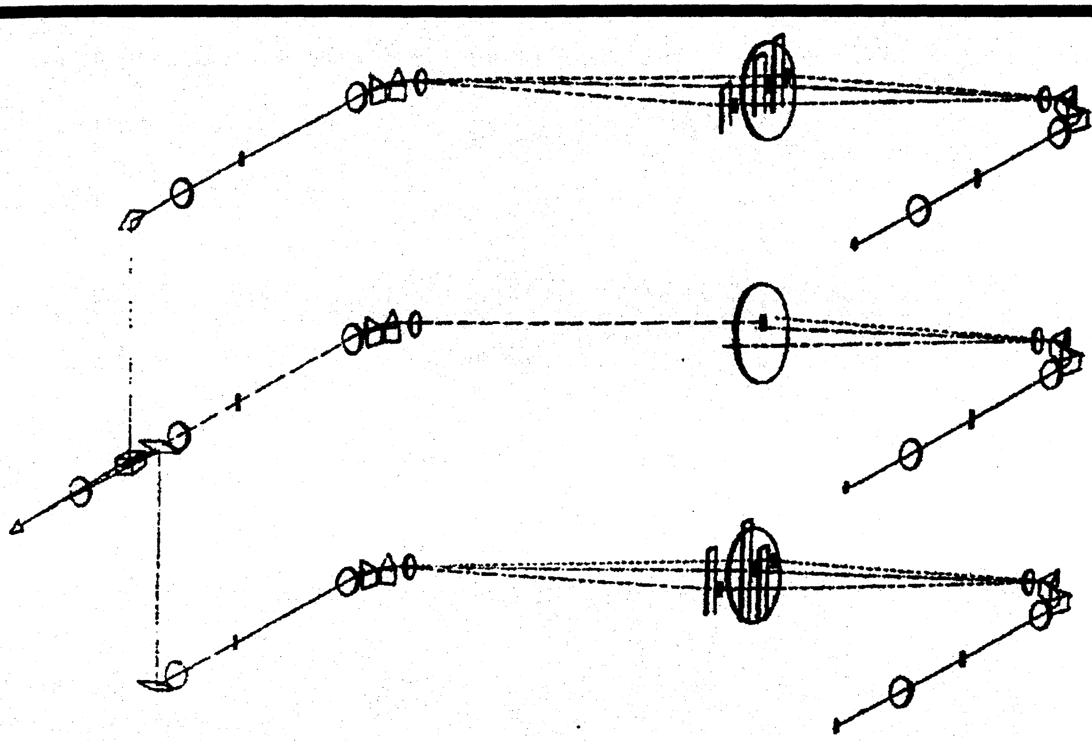

Figure 1. Isometric sketch of NPL trichromator.

Figure 1. The NPL Trichromator: This drawing provides the reader with some idea of the optical layout of the three tiers of this remarkable instrument. The double monochromators are readily visible on each tier. The beams are bought together for viewing at the level of the middle tier. Each tier has associated with it a separate well controlled lamp, and an independent balanced glass neutral density wedge was provided for *each selected portion of the spectrum* on each tier. The scales are read and adjusted to the desired calibrated value. Note, lamps were replaced on a regular schedule, that is, they were replaced before they exhibited even modest instability. All data were readily read out by the technician who sets up the experiment for the subject. The head/eye location of the subject is held at the appropriate location by a bite bar/head-rest assembly. Observer position, pupil size, etc. were monitored/adjusted and recorded repeatedly. (This figure is reproduced with the permission of The Physical Society of London. It is taken from W.S. Stiles' Thomas Young Oration.[4])

Many, but not all, optical units used at NPL were designed and built in-house. In the case of the "NPL Trichromator",[4,5] this included the double monochromators in each of three tiers. The Light Division had their own stock of glass from various batches/melts, each with defined features (index, dispersion, etc.). A team of design personnel would come in to aid scientists design lenses, prisms, lens/component holders, attachments, etc., as requested. These designs then were fabricated in-house. These fine products provided excellent control of aberrations and image quality. One could not help but be impressed!

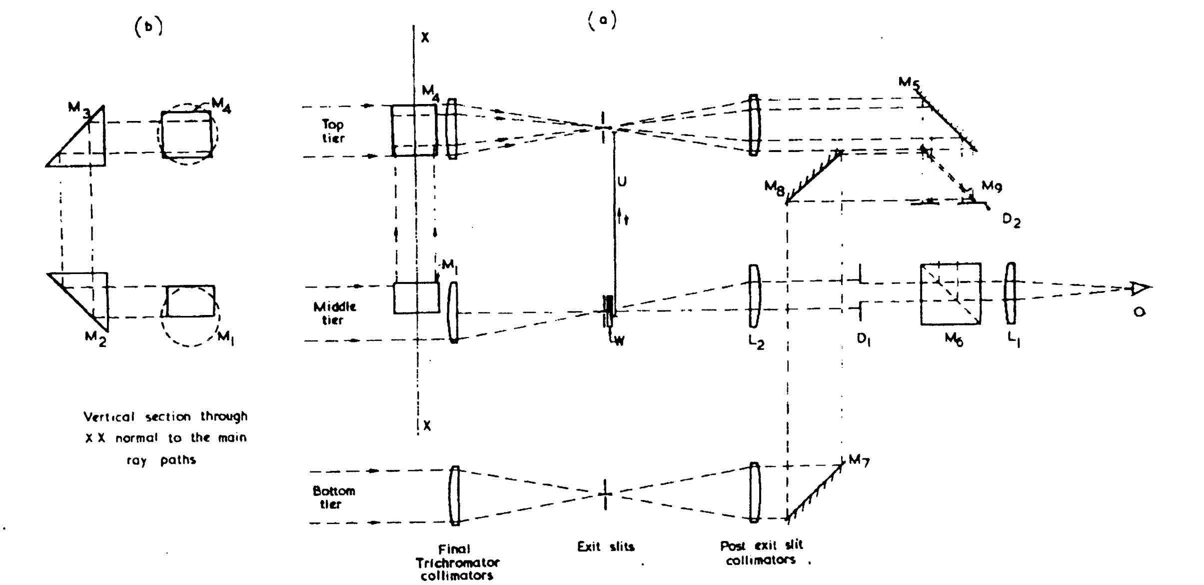

Figure 3. Diagrams showing adaptation of trichromator for directional colour-change measurements.

Figure 2. The NPL Trichromator: Specific optical modifications made to the NPL Trichromator for the purposes of measuring the SCE-1 and SCE-2 in 1959 for the research of W.S. Stiles and J.M. Enoch.[5] Also see Fig. 8, below. (This figure is reproduced with the permisson of the surviving author, and the publishers of Optica Acta.[5])

Separately, the superb spectrometer, microscope, camera, and precision turntable with which JME was provided at NPL were commercial products. He used these to study the then remarkable single and double fiber optics elements with cladding which were provided to him by Drs. Elias Snitzer and Harold Osterberg of the then American Optical Corporation in Southbridge, Massachusetts. The ratio of the index of refraction of these optical fibers and the index of their cladding was similar to the index ratio values encountered in vertebrate photoreceptors relative to their interstial matrix. The diameters (not lengths) of these fibers were also similar to those encountered in vertebrate photoreceptors.[6,7] Based upon these detailed studies, Enoch knew exactly what to examine when he returned to St. Louis and applied similar techniques to the study of vertebrate retinal receptors as fiber optics elements and waveguides (including study of human retinas).[7-12]

Some years ago, one of our vision scientists (well-intentioned no doubt!) claimed in a paper that he had built the finest-ever Stiles-Crawford device! JME has never have known how to respond to this statement. *None (few?) of us has had available such* *resources as existed at NPL*, and our NIH budgets did not let us build comparable devices. I and others (including this gentleman) have tried to do our very best, but the services offered, and the quality of products provided at NPL was just of a different class than that which has been available to most all of the rest of us. So saying, JME was particularly blessed to have been associated with first class instrument-makers/machinists and electronics engineers at each of his posts.

At NPL Enoch learned that fine optical-system-alignment is both a true art as well as a science, and it required great patience, perseverance, and dedication. The standards to which we were held in alignment and precision at NPL were such that, at times, JME found that he had to excuse himself, in order to relieve tension, so that he might continue to function properly.

One rather interesting feature of Stiles' laboratory was the bite-bar-file-drawer in the laboratory where the "NPL Trichromator" was located. Each bite bar of each subject was retained, it was "carefully filed away", properly labeled, and cleaned regularly with great care. Stiles deliberated as to placement of these individual bite bars within his collection. It was a veritable "Who's Who of Vision Science". As a relatively young scientist (then age 31), JME was most proud of his bite bar being located between George Wald's and Deane B. Judd's.

One assigned task was drilling a precise x-y grid of screw holes in a two inch thick sheet of steel. These plates had origin as spares for one of Britain's battleships during WWII. Today, almost everyone uses this sort of optical benches, but they are not two inches thick, and they are not made of case-hardened steel. So saying, the job was done, and JME's shoulders ached for weeks. This was his first exposure to this sort of optical bench, and difficult as it was, he must admit, he was much impressed by this form of base upon which to build optical instruments (in comparison to the rods or triangular structures widely used at that time).

In stark contrast to all of the above, some of the support services provided at NPL were, at best, rudimentary. There was no stapler, rather we were each given a common tailor's pin to make a hole, and short pieces of thread or yarn were provided to pass though (or be pushed through) the pinhole in order to join/tie two (or more) pieces of paper together. Pencils were sharpened with a razor blade. And one used ink wells and pens with disposable pen-points. Paper provided to most of us was unlined, yellowed with age, and rather brittle...only the most senior people received lined paper! Etc.

Walter Stanley Stiles and Brian Hewson Crawford; The Directional Sensitivity of the Retina

Walter Stanley Stiles, June 15, 1901- December 15, 1985: Stanley was London born, and he was the youngest of two children. His dad worked for the Metropolitan Police. Clearly, there were only limited resources for Stanley's education.

When one reads Alpern's biographical sketch(es) of W.S. Stiles for the Royal Society,[2,3] one senses that Stiles was searching to find the right path for his future career. Stiles had great mathematical facility. Mat Alpern made a key point in his writings, "...without the advantage of education at one of the great English Public Schools which nurtured his country's scientific and intellectual elite, and largely not recognized throughout his working life, he nonetheless changed the face of color science as only a few of his predecessors managed."[2,3] Stiles' contributions were broad, and he received a number of honors, and justly so! Figure 3 is a fine portrait of W.S. Stiles.[2]

Figure 3. Walter Stanley Stiles, Ph.D., F.R.S., O.B.E. June 15, 1901 - Dec. 15, 1985. (Photograph of Walter Stanley Stiles taken by photographer Walter Bird, 1960. This photograph is reproduced with permisson of the Royal Society. It appeared in the Memoirs of Fellows of the Royal Society 34: 816-885, 1988.)

Giles Brindley, in his book on the retina,[13] selected Stiles as his model for a Class A scientist. Stiles' precision, attention to detail, careful formulations, and his approach to research were exemplary, and in the classic style. The results were elegant. So saying, Brindley's definition of a Class A scientist did not necessarily imply best, or that this form or research was the preferred format; rather, Brindley argued that there was more than one approach to answering scientific questions. In this same context, Hans Goldmann's paper proving the SCE-1 was largely retinal in origin[14] is an excellent example of Brindley's type B category of research.[13] *For the graduate student, it is indeed worth seeking an understanding of these differences in experimental design, methodology, and procedure in scientific studies.*[13,14] Working in Stiles' office for that year, JME came to appreciate how very thorough Stiles was in his approach to questions asked. The care taken in analyses, his clear search for the right and definitive path in his experiments and quantitative solutions, were just exemplary.

Brian Hewson Crawford, March 26, 1909 - May 5, 1991: Brian Crawford was an only child whose father died early in his life. Brian was educated at John Lyons Lower School at Harrow, and University College, London. He became a physicist and spent much of his professional life at NPL. He worked there from 1927 (apparently starting at age 18!) until September 30, 1966. After retirement from NPL, he was associated for a number of years with the Conservation Department of the National Gallery of Art; he taught color science and conducted research at the U. of Edinburgh; he was affiliated with the Paint Research Association; with Imperial College, London, and with the Institute of Ophthalmology, London. Brian was unquestionably a first-rate scientist, and a hard and diligent worker! He was awarded the Newton Medal of the Colour Group. Figure 4 is a good portrait of B.H. Crawford.

After joining NPL, Crawford's career was linked for many years to that of Stanley Stiles (who was about 8 years older than him). Together they worked on a variety of research associated with lighting, glare, etc., before their landmark research on SCE-1, and SCE-2.[1] Separately, in 1947, Crawford published in Proc. Roy. Soc. Lond., an important paper on the visual "onset" of a luminous stimulus which is known variously as either "The Crawford effect", or "Crawford masking". JME first encountered this phenomenon in 1953 when he was conducting research with Robert Boynton which examined glare and the effects of a displaced glare source upon increment thresholds measured at a distance (a few degrees) from that source. Both onset and offset of the glare stimulus were considered.[15,16] When making such determinations, initially, it appears as if the sensitivity of the visual system is affected *before the onset of a light source!* This is not some intuitive appreciation of an impending stimulus, or a change in stimulus; rather, this is due to the relatively rapid transmission of onset-of-stimulus-data to the central nervous system where it is detected in advance of more steady state response(s). A rather similar phenomenon is also detected prior to the offset of a luminous stimulus.[15,16] Crawford also provided valuable research on the definition of V'_{λ}, the CIE scotopic spectral response function. When JME was at NPL, Brian was performing very interesting studies on color rendering, which was a major interest of his. Dr. David Palmer of NPL prepared a fine obituary of Brian Crawford.[17]

Figure 4. Brian Hewson Crawford, Ph.D. March 26, 1909 - 1991. (This photograph of Crawford was kindly provided by Dr. Pieter Walraven, the Netherlands. Dr. Crawford served at NPL from 1927 to September 30, 1966.)

In the first section of this paper (above), the speaker sought to give a sense of the atmosphere and culture at NPL where Stiles and Crawford made their landmark discoveries.[1,4,5,18-20] Obviously, JME was not at N.P.L. in 1933; i.e., rather, as noted, he arrived in 1959. In 1933, Stiles and Crawford were then involved in conducting research and setting standards associated with requirements of illuminating engineering.[1]

As part of their research program, Stiles and Crawford designed a rather simple and straight-forward pupillometer to determine the area of an observer's entrance pupil.[1] The observer viewed a bipartite field (the outer boundary of which was limited by aperture "D" in Fig. 5a Top). One beam (forming the upper portion of the bipartite field) passed through the center of the observer's entrance pupil (a Maxwellian view system design was used for this beam; it subtended 1.5 cm. diameter in the entrance pupil of the observer's eye), and the second beam of uniform irradiance in the plane of the entrance pupil of the eye was self-limited by the observer's eye pupil (this is the beam having origin in Fig. 5a at the opalescent diffusing glass "O" surmounted by the right-angle prism (Top Drawing of Fig. 5, or 5a). [Note 1.: The dividing line between the two hemi-fields fields was formed by the upper edge of the right angle prism ("Prism", located near the center of the instrument in the top of Fig. 5a. Note 2.: In Figure 5b (Middle of Fig. 5), the diffusing opalescent glass is designated as D.] One assumes the experimenter viewed the subject's eye ("E" in Fig. 5a, top) through the 40 cm. open-top-area of the device.

This device just didn't work as predicted! *Stiles and Crawford had expected/predicted that all parts of the eye pupil contributed equally to the perceived brightness of the lower hemi-field.* "It appeared that even when the pupil was fully extended and had a diameter of about 8 mm, the value derived by the above method never exceeded 5.5 mm."[1] And, "After all conceivable instrumental errors had been investigated, *it was concluded that the discrepancy was due to the fact that the apparent brightness of an object is not proportional to the pupil area because the rays entering the pupil at points distant from the axis are not so effective visually as rays entering along or near to the axis*."[1] A quantitative study of the effect was then undertaken, and for this purpose, at some point in time, the pupillometer shown in Fig. 5 was superceded by a second device, with Maxwellian fields being used for both beams." See Fig. 6.

The second instrument used by Stiles and Crawford employed a classical two-path or "two-armed" Maxwellian-beam-system to define and to maintain control over each of the two required test fields. A single light source was employed. They used a chopper to alternate between these two fields in order to allow the observer to make a suitable flicker match between the two stimuli. They point out that this device can be employed either for making flicker matches of the two fields (as shown in the Fig. 6), or for use as a bipartite field matching device ("equality of brightness method") as shown at the bottom of Fig. 5, with a modest alteration(s) in the design. Note, in Fig. 6, apertures A_1 and A_2 are focused in the entrance pupil of the eye. For example, the location of aperture A_2 can be translated away from the center of the observer's entrance pupil. The field stops are apertures D_1 and D_2, are designed to be conjugate with the retina. The paired double diffusers (O_1 and O_3), and (O_2 and O_4) provide near uniform luminous fields for each of the two light paths. The surfaces of O_3 and O_4 represent the locations of the effective light source for each of these two light paths. The image of small aperture A_1 is centered in the entrance pupil of the eye at all times during the experiment. Aperture A_2 can be translated in the entrance pupil plane of the eye to test what has been termed "the directional sensitivity of the retina," or the Stiles-Crawford effect of the first kind (SCE-1).[1] Both horizontal and vertical translations were possible/made. In order to obtain a match by either method, the luminance of this field can be assessed by adjusting the density of the neutral density wedge (W). Note, one assumes these capable scientists used a balanced neutral density wedge. That is, balanced neutral density glass wedges were employed for each individual-beam-path in the NPL Trichromator (Figs. 1,2.).

between two fields; the light reaching the retina from one of these depended upon the area of the pupil (A), whereas the light reaching the retina from the other was independent of A. Figure 1 at the top illustrates the final version of this instrument developed and used by Stiles & Crawford (22). Light from the source diffused by the opal glass O was reflected by the prism to fill the hole E in the centre of which the subject's pupil was centred. From this same source, light illuminated a ground glass, a variable attenuator neutral wedge W and the small circular aperture stop P. The lens formed an image of P 1.5 mm in diameter in the plane of the subject's entrance pupil (so that the lens is seen filled with light in Maxwellian view). If the diameter of the subject's pupil is at least 1.5 mm, all the light in this second path is collected by the eye. The two homogeneous fields (below on the left) are divided by the edge of the prism: the brightness of the upper field is independent of, and that of the lower field is dependent upon, the area of the subject's pupil (A). The subject adjusts the transmissivity setting τ of the variable wedge W for a

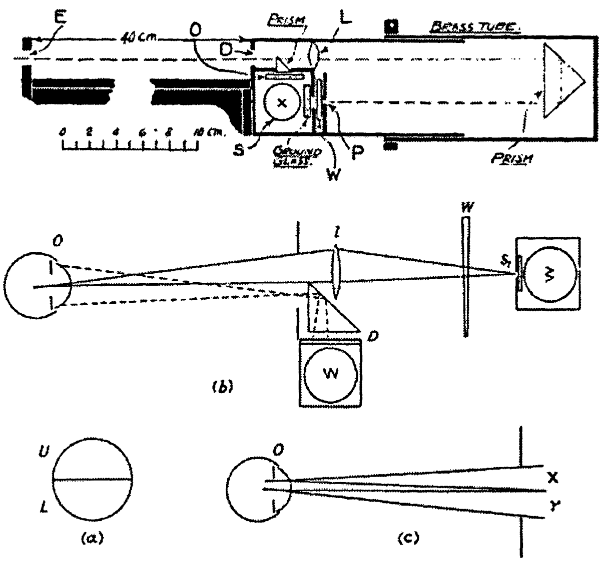

FIGURE 1. Photometric pupillometer. Top: actual section; (*a*) field subdivision; (*b*) ray diagram; (*c*) ray diagram for traverses. (Reproduced, with permission, from *Sci. Prog., Oxf.* 33, 676–689 (1939) and *Ann. R. Coll. Surg.* 30, 73–101 (1962).) (20, 40, 89).

Figure 5. This illustration was taken from the 1933 published paper by W.S. Stiles and B.H. Crawford.[1] The pupillometer designed by these two scientists is shown. Measurements of entrance pupil area provided by this device were incorrect. W.S. Stiles' and B.H. Crawford's proper interpretation of these data led to the formulation of the "directional sensitivity of the retina", later known as the Stiles- Crawford effect of the first kind (SCE-1).[21] (Permission to reproduce this figure has been received from the Royal Society of London.)

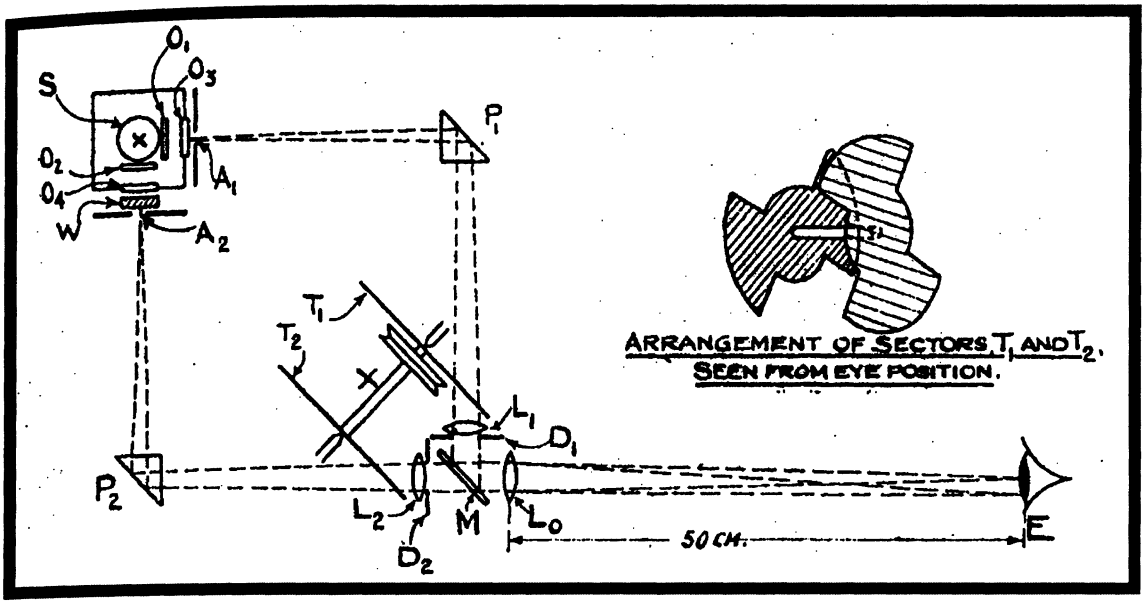

Figure 6. This figure shows the design of the first instrument used to make determinations of SCE-1. It was also taken from the 1933 paper.[1] This was a dual-path Maxwellian view device. As configured, it provides alternate exposure for each of the two light paths; this makes possible a flicker photometric method of matching the perceived brightnesses of the two channels. (Permission to reproduce this figure has been received from the Royal Society of London.)

Dr. W.S. Duke-Elder of the Institute of Ophthalmology, London, recommended that Stiles and Crawford employ the mydriatic, *euthalmine hydrochloride* (this mydriatic only very weakly affects accommodation of the observer).[1] JME notes Stiles used this same mydriatic when he was in residence at N.P.L. in 1959-1960.[5] JME, in turn, used it for many years in his laboratory. It is not clear whether this pharmaceutical agent is still available? That is, some years later, it became very hard to obtain this agent (in the 1980s, it was only possible to obtain this formulation at a single pharmacy in San Jose in the San Francisco Bay Area). Other pharmaceutical mydriatic agents were satisfactorily substituted.

The first SCE-1 data sets presented in their manuscript were obtained from the eyes of Brian Crawford (these comprise Fig. 4, Stiles &Crawford, 1933),[1] [please see Fig. 7, this paper]. The results in the horizontal meridian in each of Brian Crawford's two eyes presented in Fig. 7 were remarkably similar, but data obtained in B.H.C.'s vertical meridians did differ somewhat. Knowing these two investigators well, more than one data set was included here, or at least they satisfied themselves as to the near identity of these data with other data obtained previously. These were extremely careful investigators, and they no doubt reflected the existing culture at NPL. We will not repeat the contents of the remainder of the 1933 paper here. Rather, we urge the reader to peruse the whole as it is a landmark contribution to vision science.

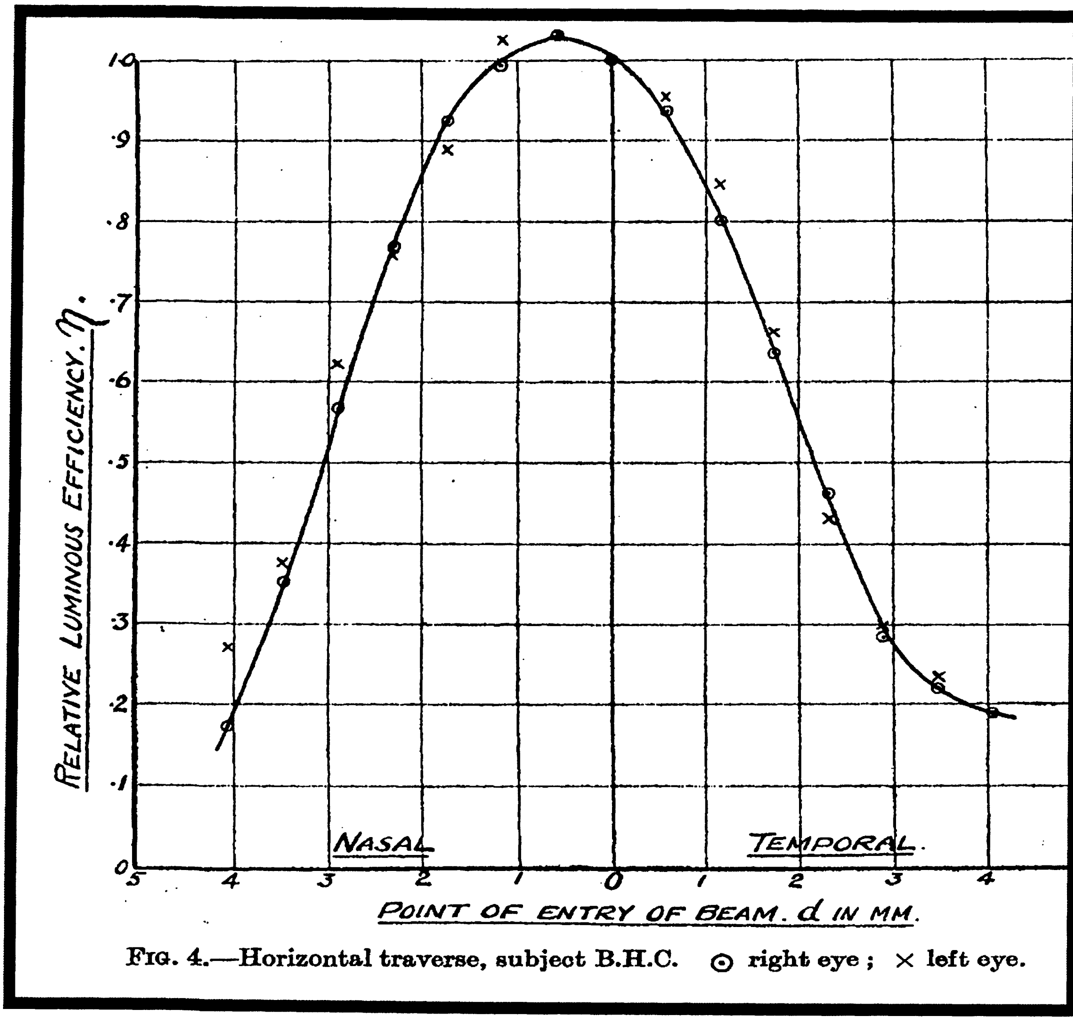

Figure 7. These are the first set of SCE-1 data included in the 1933 paper.[1] Data were obtained from the right and left eyes of subject B.H. Crawford. Note, the abscissa here defines the locations of the moveable test beam in the entrance pupil of B.H.C.'s eyes for nasal and temporal settings of that imaged aperture-stop relative to the center of the entrance pupils of each of his two eyes. Thus, one set of these data were reversed (left-right) relative to the other one. Crawford's data in the vertical direction were not quite the same in the two eyes. (Permission to reproduce this figure has been received from the Royal Society of London.)

Before proceeding, it is important to make a point about reading the classic papers of these two fine gentlemen, particularly papers by Stiles. In one sense, one can think of them as "multi-layered". Each individual, by taking some time, can come to appreciate their content. Yet, if one puts these papers aside for a bit of time, then re-reads them, one finds there is far more content than was appreciated during the first reading. If one re-reads these manuscripts again a year or so later, one appreciates added points, etc. That is, these papers seem to grow with time, and with one's own maturity in dealing with the subject at hand.

In general, seminal papers defining the Stiles-Crawford effect of the first kind (SCE-I) and the Stiles-Crawford effect of the second kind (SCE-2) were the following:

> Walter Stanley Stiles, Brian Hewson Crawford. The luminous efficiency of rays entering the eye pupil at different points. Proc Roy Soc Lond B 1933;112: 428-450. (SCE-1)[1]
>
> Walter Stanley Stiles. Luminous efficiency of monochromatic rays entering the eye pupil at different points and a new color effect. Proc Roy Soc Lond B 1937;123: 90-118. (SCE-1)[18]
>
> Brian Hewson Crawford. The luminous efficiency of light entering the eye pupil at different points and its relationship to brightness threshold measurements. Roy Soc Lond B 1937;124: 81-96. (SCE-1)[19]
>
> Walter Stanley Stiles. The directional sensitivity of the retina and the spectral sensitivities of the rods and cones. Proc Roy Soc Lond B 1939;127: 64 -105. (SCE-1, SCE-2)[20]
>
> G. Hanson. Zur Kenntnis des physiolischen apertur Farbeffekts (Stiles-Crawford Effect II Art). Die Naturwiss. 1943;35/36: 416. (Among other matters, in this brief paper, Hanson differentiated between the SCE-1 and SCE-2 effects.)[21]
>
> Walter Stanley Stiles. The basic data of colour-matching: 18th Thomas Young Oration. Year Book, Phys. Soc. 1955:44-65. (In this Oration, the "Trichromator" was described in some detail.) (SCE-1, SCE-2) Note, this instrument was not employed in the original studies of SCE-1.[4]
>
> Jay M. Enoch, Walter Stanley Stiles, The colour change of monochromatic light with retinal angle of incidence. Optica Acta1961; 8: 329-358. (SCE-1, SCE-2)[5]

Others of Stiles' and Crawford's fine papers might be listed here, i.e., quite a number of these were of considerable importance(!), but the few manuscripts listed above speak to the origins, and early development of our understanding of the Stiles-Crawford effects, *per se*.

Since those early studies, we have come to appreciate the waveguide nature of photoreceptor optics;[e.g., 6-12] the remarkable stability of SCE-1 functions over many years;[22-23] factors inducing changes in SCE-1 such as tractional strains (marked accommodation);[24-27] G-forces; physical changes following traumatic "insults" (and recovery from same),[28] recoveries from retinal detachments,[e.g.,29] the presence of weakened scleral walls and extended ocular growth, often associated with the high myopias (e.g., overlap of *functional* retina and choroid onto the nasal side of optic nerve heads, and induction of transient orientation alterations),[30] the presence of a very different "second" orientation scheme discovered in a rare few eyes/individuals (a tendency for center-of-the-eye-pointing as opposed to the more normal center-of-the-exit-pupil-of the eye pointing);,[31] induction of altered alignments induced by use of a displaced eye-pupil using a painted-iris-contact-lens, and recovery of orientation from both transient and induced changes,[32-33] etc. Much of this material, including work from a number of other laboratories, has been brought together in two books.[34,35]

Additional aspects of this set of discoveries have been studied/described, but it would take a separate major manuscript to consider these many efforts. Included in such a document would also be the relatively recently defined "optical SCE effect."[e.g.,36-38] The latter examines the reflection of energy back through the retina and retinal receptor waveguides. That back-reflected energy is sampled and assessed in the entrance pupil of the observer's eye (which images the exit pupil of the eye).

We include the paper by Enoch and Stiles in the list of citations above, because it provides necessary data needed to advance our understanding of SCE-2. Stiles and JME had a delayed start upon their studies on SCE-1 and SCE-2, due largely to the fact that the NPL Trichromator (as noted above) had been substantially disassembled in order to make necessary modifications which would allow them to ensure proper experimental controls, and to make possible necessary measurements for their SCE-2 studies conducted on the Trichromator.

As a result, JME's post-doctoral period at NPL was divided into three segments. (1) While the Trichromator was disassembled and two tiers were being restructured, he spent this time period at NPL both studying the applicable literature, and investigating E. Snitzer's and H. Osterberg's glass fiber optics elements which had a number of properties similar to those of photoreceptors. The speaker might point out that Stiles was also quite fascinated with the properties of the Snitzer and Osterberg fibers which JME was analyzing and studying. Stiles often spent time examining them as well. Having had opportunity to perform this very meaningful introductory activity, JME was then ready to apply similar techniques to direct study of the optics of photoreceptors shortly after his return to St. Louis in 1960.[6-12,34] Both Drs. Katherine Tansley at the Institute of Ophthalmology and Brian Crawford advised JME on appropriate design of wet cells for studying retinal receptors when performing these studies. (2) Re-assembling, aligning, and calibrating the NPL Trichromator (mentioned above). (3) Conducting research on SCE-1, and SCE-2 using the NPL Trichromator. The latter role included his serving extensively separately as experimenter and subject. Both James M. Burch (at NPL) and W.S. Stiles also served periodically as subjects in this endeavor.

In his role as subject, J.M.E. first had to learn how to make the colorimetric determinations employed in the program of data collection. He then had to provide often repeated baseline data for SCE-1 and color matches at 17 selected loci about the spectrum locus (and for white light, and at a modest number of other sites sampled in each of his eyes. Interestingly, Stiles noted that JME's colorimetric data (at that time) most closely matched the C.I.E. Standard observer of any subject tested to that date.[5] Only after all of this, did JME enter into data collection of colorimetric matches for entrance pupil points located away from the pupil center. *Day after long-day*, during this time period, he worked extensively with Misses Pamela Fowler and Jeanne Vigil, Stiles' very able laboratory assistants.

Because of the late completion of the active data collection phase, the analyses of these extensive data were deferred until after JME departed. Thus, most all subsequent advanced data analyses resulting from this research program were conducted by Stiles after JME's departure from Teddington. JME commented on the manuscript prepared by Stiles, and added material on assessments of the fiber optics elements kindly given to him by the gentlemen at the American Optical Corp. Stiles generously made JME first author! In subsequent years, JME has sought to follow this same generous tradition in his own laboratory.

Some Comments on Color Matching in Studies of SCE II

Because relatively small effects were being measured in the Enoch and Stiles research program,[5] when making these color matches, one had to use special care, particularly when adding R,G, and/or B *desaturating stimuli* to the obliquely incident (at the retina) test field. Note, here, Stiles used R,G,and B rather than L,M, and S.[5] The investigators wanted to be sure that responses recorded were in response to the obliquely incident test beam and were not biased by the sum of added desaturating stimuli. Moves made in color matching were executed carefully and repeated often!

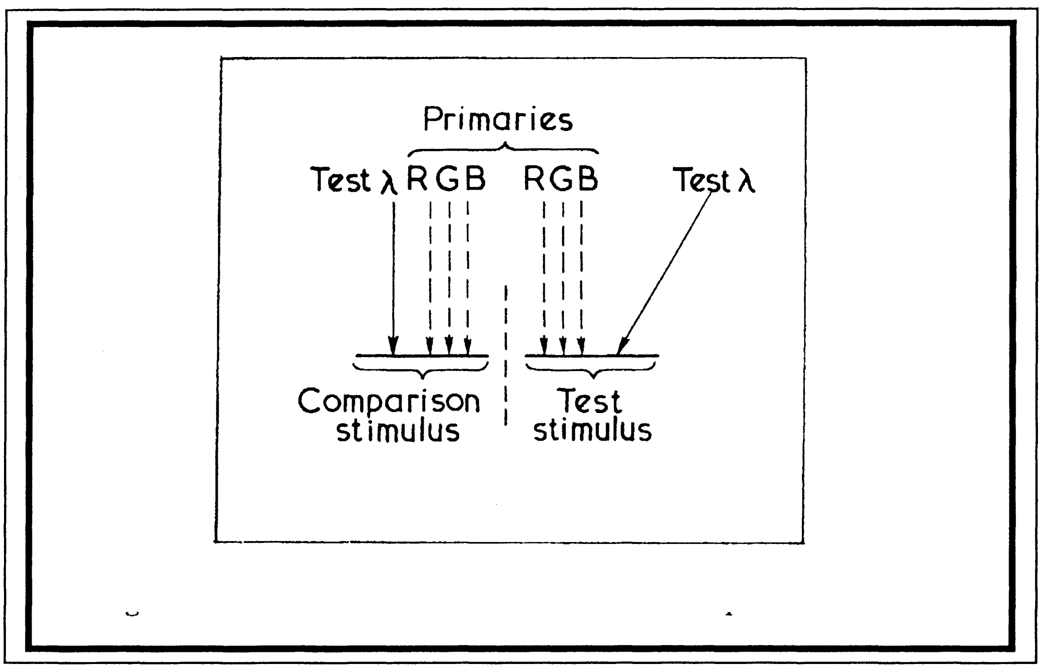

Figure 8. This figure details the experimental arrangement employed when using the bipartite-field test arrangement on the Trichromator in 1959-1960 in order to test for SCE-2 at NPL.[5] Note the oblique incidence of the test beam at the retina of the observer, while all other adjustable beams were incident normally in the at the retina (at fixation). See Fig. 2. (This figure is reproduced with the permisson of the surviving author, and the publishers of Optica Acta.[5])

In the Enoch and Stiles paper (see Fig. 8, right side)[5], control and desaturating stimuli were introduced through the entrance pupil of the eye at its center, and this locus was different from the ray path of the test stimulus (the latter was introduced at a location 3.5 mm from the center of the entrance pupil of the eye in the horizontal meridian). Thus, test and desaturating stimuli were incident at the retina at different angles of incidence. Simply stated, *the effect on color matching of the obliquely incident (at the retina) test stimulus was sought,* and hence the experimenters chose not to confound unnecessarily the result.

In these experiments, rather small apertures were imaged in the entrance pupil of the eye. A central two degree, carefully aligned, and centrally fixated test visual field(s) was(were) employed. Within the two degree fields sampled, on a number of occasions, the observer encountered one or more *small sub-areas* within the test field with hues and saturations which were quite different from the larger 2° field. These *small* sub-areas varied in saturation, and had demarcated boundaries. When making matches it was necessary to ignore effectively these small sub-areas and to attend the colorimetric properties of the larger and dominant field area considered. Even small head/eye movements would alter the sub-patterns.

Prof. Robert Boynton (with Prof. Mitsuo Ikeda) followed Enoch as a guest(s) in Stiles' laboratory. Enoch earlier had worked with Boynton for some period of time in 1953 at the U. of Rochester.[15,16] When questioned by JME, Boynton reported to Enoch that he had encountered these same sub-field area effects (re-affirmed by Boynton shortly before his recent death). Both Enoch and Boynton assumed these were due to sub-areas of receptors with a particular receptor bias or sub-groups of receptors with different alignments within the larger two degree test field area.

A File Not Found?

A true delight experienced by Enoch during his days at Teddington was having been given opportunity by Stanley Stiles to read carefully his *voluminous* correspondence file (JME guesses this was 5-6 inches thick!) with William Rushton assembled over many years. These two scientists clearly were very close friends! Each taught the other, and the reader very much appreciated the results of this in their individual research publications.

As but one of many examples, Stiles provided Rushton with a replica tier from the Trichromator for his studies on color vision.[2,4,5] The tutorials provided by Stiles to Rushton, and which discussed fine points regarding alignment and calibration, and utilization of this fine device were, to say the least, elegant. Over the years, these two scientists criticized each other constructively, each one brought their unique backgrounds to the table on different problems considered, and they mutually sought to expand the conceptual framework of arguments provided. There was much give and take in this correspondence.

It is unfortunate that this fascinating (and important) correspondence seems to have been lost. Enoch called this material to the special attention of Prof. Mathew Alpern at the time Mat wrote the memorial/obituary of Stiles for the Royal Society of London.[2,3] This file was apparently nowhere to be found! So said, Alpern did locate some bits of their correspondence, and these samples were discussed briefly in his obituary.

In Closing

JME and VL are most proud to have had a role in this worthy scientific endeavor, now 75 years old. We very much respect the work of both Stanley Stiles and Brian Crawford. JME personally appreciated their help, their many kindnesses, their advice, and their guidance. These were indeed fine/exceptional men and worthy mentors; their research has stood the test of time! JME and VL have been proud to pursue this subject matter throughout their careers, and they have sought to incorporate much learned from these gentlemen into their research.

There remain problems to be solved, and opportunities for further pursuit both in terms of theory and application. As examples, it would be most useful to understand better the operant feedback system for receptor alignments, the anomalies encountered (and possible means of correcting these anomalies, and/or mitigating them), as well as the evolution of these rather remarkable properties. We have been surprised that the elegant biological-feedback-system evolved has not been more widely considered in modern applications of fiber optics. There is a need to develop more effective interactive models of this system, and so forth. Finally, we express frank amazement at the finely honed visual system with which we have all been endowed. Thank you.

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Johannes Amos Comenius (1592-1670) and his Depiction of Lenses and Spectacles in the First Children's Picture Book

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Abstract
Johannes Amos Comenius (1592-1670) was a Moravian clergyman, teacher, and author. He is recognized as introducing several concepts of modern education. He advanced the views that education should be appropriate to age and development levels and that teaching should make use of everyday sensory experience. One of his many books, Orbis Pictus, followed those concepts. Orbis Pictus, first published in 1657, is hailed as the first children's picture book. Among the many commonplace objects he included in the book were a mirror, spectacles, a telescope, a magnifying lens, and a burning glass.

Key words: *children's books, lenses, history of spectacles.*

Johannes Amos Comenius (or Jan Amos Komensky) was born on March 28, 1592, in Moravia. Comenius was a clergyman in the Unity of Brethren church, a teacher, and an author. Some have called him "the Father of Modern Education".[1] Comenius's parents died when he was a child, and he was raised in the care of relatives.[2] After university studies in Herborn and Heidelberg, in Germany, Comenius became a clergyman and teacher in Moravia.

Comenius's first wife and their two children died of the plague in 1622. The following year, in the turmoil during the Thirty Years' War in Europe (1618-1648), Comenius's home and books were burned. Comenius escaped, eventually settling in 1628 in Poland, where remained until 1641. While in Poland, Comenius became a bishop in the Unity of Brethren church and he became noted for his many writings. After a year in England, Comenius was invited to Sweden, where he worked on the reformation of their school system.[3] Leaving Sweden at the end of the Thirty Years' War in 1648, Comenius lived in Poland and Hungary until 1656, when war broke out again in Poland. Comenius lived his last years in Amsterdam until his death on November 15, 1670. Throughout his many moves, Comenius continued to write textbooks and books on educational theory.

Comenius's Works and Educational Philosophy

Among his books are *Janua Linguarum*, a Latin textbook; *Didactica Magna (The Great Didactic)*, a famous book on educational theory; *Via Lucis*, on the reform of society through education; *Orbis Pictus*, the first children's picture book; and *Universal Consultation on the Reform of Human Affairs*, a comprehensive treatment of his philosophy for the betterment of human conditions through educational, religious, and social reform.[2,3] Comenius believed that educational reform was essential to the improvement of human society, and he thought that education should be available to all, regardless of social status or gender.[3,4] Comenius suggested that education be tailored to age levels, with learning beginning in early childhood, and with the timing of teaching based on readiness to understand the various concepts.

Striving to make education less oppressive and abstract, Comenius stressed learning through sensory experience.[1,4] So, for example, in *Orbis Pictus*, Comenius used pictures of many familiar everyday objects to try to stimulate children's desire to learn and to improve their cognitive and language skills.[3] *Orbis Pictus* was originally intended for children up to six years of age before attending school, but it became very popular for all ages.

Orbis Pictus

The full title of the book that is generally known as *Orbis Pictus* is *Orbis Sensualium Pictus: Hoc est Omnium principalium in Mundo Rerum, & in Vita Actionum, Pictura & Nomenclatura.* One English translation of the short title is *World Illustrated*, and an English translation of the full title is *Visible World: or, a Nomenclature and Pictures of all the Chief Things that are in the World, and of Men's Employment therein.*

Orbis Pictus was first published in Latin in 1657, and was subsequently translated into many languages. An English translation by Charles Hoole was published in 1658. The copy I examined was a 1968 reissue of an 1887 publication of the 1727 English edition, which was based on Hoole's translation. In the 1727 edition, English words were in the left hand column opposite the corresponding original Latin in the right hand column. The book contains 151 figures and accompanying text.

The book starts with the exhortation "Come, Boy, learn to be wise." (page 1) After an exchange between the teacher and the boy, and an introduction to the alphabet, various ideas and commonplace objects are pictured and discussed. Various elements within the drawings are numbered and the numbers are referred to in the corresponding discussion. Among the first items to be featured are air, water, clouds, metals, stones, trees, and flowers. Animals are discussed, and then the human body. In the latter series, the eye is mentioned as one of the "five outward senses." On pages 52-53, one finds drawings of the sense organs (Figure 1) and the following text:

"There are five outward *Senses*; The *Eye*, 1. seeth Colours, what is white or black, green or blew, red or yellow. The *Ear*, 2. heareth *Sounds,* both natural, Voices and Words; and artificial, Musical Tunes. The *Nose*, 3. scenteth smells and stinks. The *Tongue*, 4. with the roof of the Mouth tastes *Savours*, what is sweet or bitter, keen or biting, sower or harsh. The *Hand*, 5. by touching discerneth the quantity and quality of things; the hot and cold, the moist and dry, the hard and soft, the smooth and rough, the heavy and light.

"The inward *Senses* are three. The *Common Sense*, 7. under the *forepart of the head*, apprehendeth things taken from the outward Senses. The *Phantasie*, 6. under the *crown of the head* judgeth of those things, thinketh and dreameth, The *Memory*, 8. under the *hinder part of the head*, layeth up every thing and fetcheth them out: it loseth some, and this is *forgetfulness*. *Sleep*, is the rest of the Senses."

XLII.
The Outward and Inward Senses.

Sensus externi & interni.

Figure 1. Drawing of the senses from *Orbis Pictus*, page 52.

On pages 56 to 194 (there is a six page index after page 194), there are drawings and descriptions of various occupations, manmade objects, concepts, and activities. Some examples are bread-baking, weaving, the shoemaker, the mason, a house, the blacksmith, wells, the cooper, paper, printing, musical instruments, philosophy, geometry, eclipses, justice, a city, measures and weights, physick (physicianry), tennis-play, the soldier, religion, Judaism, Christianity, etc. A drawing headed "Looking-glasses" can be found on page 97 of the book (Figure 2). The text, continuing onto page 98, describing that drawing is as follows:

"*Looking-glasses*, 1. are provided that Men may see themselves. *Spectacles*, 2. that he may see better, who hath a weak sight. Things afar off are seen in a *Perspective Glass*, 3. as things near at hand. A *Flea* appeareth in a *multiplying-glass*, 4. like a little hog. The Rays of the Sun, burn wood through a *Burning-glass*, 5."

Comenius included commonplace items in his mid seventeenth century book. This makes it particularly interesting that he would include a mirror, spectacles, a telescope, a magnifying lens, and a burning lens in the book.

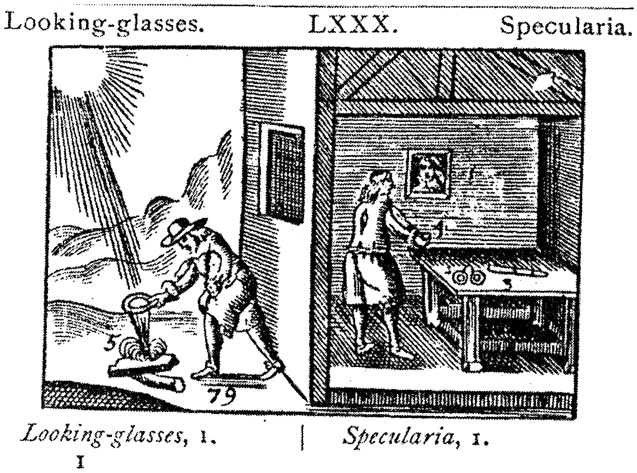

Figure 2. The drawing including spectacles and lenses from page 97 of *Orbis Pictus.*

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Origin of Optometry at Cardiff University

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Editor's Note: *Michel Millodot was asked by the archivist of Cardiff University to write this article about the history of the optometry program at Cardiff. Dr. Millodot has graciously granted permission to have the article published in Hindsight.*

"at every crossing in the road that leads to the future, each progressive spirit is opposed by a thousand men appointed to guard the past"
Unknown source

Introduction

The change of the name of the 'Department of Ophthalmic Optics' to 'Department of Optometry' in 1975 at the University of Wales Institute of Science and Technology, represents the first official use of the term optometry in the United Kingdom. Until then Universities only used the name ophthalmic optics and trained ophthalmic opticians who were usually referred to as opticians. The main professional bodies were the British Optical Association (founded 1895), the Worshipful Company of Spectacle Makers (founded 1629), the Association of Optical Practitioners and the Scottish Association of Opticians.

The adoption of the word optometry by the University of Wales constituted a revolution in the British terminology of the profession as the old terminology was deeply entrenched in the psyche of the practitioners and the public, and remained so for many more years. The happening at Cardiff became a milestone, which had an extraordinary impact on the discipline and the profession.

Brief history

Since the 17th century individuals involved in optical instruments, spectacles, lenses, optical science have been known as opticians. In the early part of the 20th century opticians in the UK who performed sight-testing and dispensing to correct errors of refraction became known as ophthalmic opticians. Courses of training for ophthalmic opticians were devised firstly by the associations and soon afterwards by training institutions. The first such course appears to be at Northampton Institute (now City University) in 1908. It was followed by Manchester College of Technology (now Manchester University) in 1920, then Bradford (1920), Herriot-Watt College, Edinburgh (1924), Birmingham Technical School (now Aston University) in (1926) and at Cardiff Technical College (now Cardiff University) in 1935. In all instances the course was provided within the Department of Physics as was suggested by the word optics in its title, except at Northampton where it was taught in a separate Department of Applied Optics.

UWIST 1974

The ophthalmic optics course at Cardiff Technical College and later UWIST was taught as an ancillary subject within the Department of Applied Physics. In the 1970-71 academic year it became a separate Department of Ophthalmic Optics with a senior Lecturer Mr T.S.P. Tuck in charge. In 1974 a Professor and Head of Department was appointed. The first incumbent of the Chair was Professor Michel Millodot who had been a Senior Lecturer in Optometry at the French-speaking University of Montreal. He began his function in September 1974. The Department had five full-time academic staff and 85 full-time students, all undergraduates.

UWIST 1975

Professor Millodot soon realized that although the profession used the term ophthalmic optics and ophthalmic opticians, very few people understood what it meant. There was confusion among the public as well as university colleagues in other disciplines. They did not know whether it was a branch of physics or medicine. They confused ophthalmic opticians with dispensing opticians, manufacturing opticians, technical opticians, or even oculist and ophthalmologists.

Before Professor Millodot decided to change the name of the Department he sought the advice of the professional bodies and colleagues. The response was almost entirely negative. Nevertheless he persisted in the genuine belief that a single term like optometry described the discipline more concisely and more clearly than a compound term and that some international standardization of terminology for the same profession would be beneficial. Thus on Wednesday 19th February 1975 Professor Millodot presented a request to the Senate of UWIST. The motion was passed without any difficulty whatsoever (the professor of physics remarked that the new term was much easier to spell!) and the minutes read:

"Resolved that it be recommended to the Academic Board that the title of the Department of Ophthalmic Optics be changed to the Department of Optometry that, if this change was approved, the new name come into use from 01/08/75 with any anticipatory action being taken when appropriate".

Subsequently the Academic Board met on the 6th of March 1975 and the minutes note: "The recommendation that the title of the Department of Ophthalmic Optics at UWIST be changed to Department of Optometry was approved".

Reactions

The change of the name ophthalmic optics for optometry at Cardiff had an extraordinary impact on the profession throughout the UK. Soon after this momentous decision I informed various people and journal editors and I received two congratulatory notes, one from Professor R.J. Fletcher of the City University and the other from the Editor of *The Optician*. Interestingly the latter journal then dedicated an editorial to the subject in the issue of April 18, 1975 (Vol. 169; 4378) and pointed out that, coincidentally, they had adopted the word by renaming the journal, beginning with this issue, *The Optician, the weekly journal for optometrists and dispensers.* The editor Philip Mullins, a New-Zealander, just could not have expected the explosive reaction to the "offending" word. It is unlikely that it was the letters to editors which had the most impact but I understood that it was most likely the pressure from the professional associations and most importantly that of the optical companies that advertise in the journal, which compelled it to remove the word in the title and to resume using its name *The Optician* within just over one year!

Indeed the term optometry was strongly opposed by most members of the profession and by professional associations and Letters to the Editor of the journals, *The Optician* and the *Ophthalmic Optician* echoed the arguments for and against, which appeared in most issues from 1975 to about 1978 when the City University renamed its Department of Ophthalmic Optics to Department of Optometry.

The main reasons for objecting to the word optometry included the fact that the term 'ophthalmic opticians' is the term used in the Opticians Act 1958, the belief that ophthalmic opticians in this country can do more than optometrists in other countries, and possibly the fact that it was an imported word (viewed as Americanism) and not British. Some arguments for its adoption included the fact that a single term is more comprehensible than a compound term, that its ending in 'ist' conformed better with physiologist, physicist, psychologist, ophthalmologist, etc., and that international understanding would be facilitated by the standardization of terms.

Repercussions

Following the decision of the City University in London, the matter was taken more seriously in the rest of the country. The antagonistic dust settled to some extent, it was replaced by some years of acquiescence and was eventually followed by full acceptance of the word optometry. All Departments of Ophthalmic Optics in the country eventually changed their name in the next 15 years and/or taught optometry. In 1980, the British Optical Association, the Worshipful Company of Spectacle Makers and the Scottish Association of Opticians amalgamated to form the 'College of Ophthalmic Opticians (Optometrists)'. It was renamed in 1996 to 'College of Optometrists' and it is now the sole professional, scientific and examining body for optometry in the UK working for the public benefit. The Association of Optical Practitioners changed its name to 'Association of Optometrists' in 1987, it is concerned with the welfare of the practitioners.

Conclusion

It is actually ironic that the word optometry aroused so much opposition in the UK since the word first appeared in 1759 in a book entitled 'Treatise on the eye" by W. Porterfield, a Scottish physician who devised the first optometer to examine accommodation. In the first decades of the 20th century the professional associations of Australia and the USA became known as optometric associations and learned journals of optometry were begun (e.g., *American Journal of Optometry* in 1923, now known as

Optometry and Vision Science; Australian Journal of Optometry in 1918, now known as *Clinical and Experimental Optometry*). In the UK, the *Ophthalmic Optician* ceased to exist in 1984 and was replaced by *Optometry Today* in 1985, and nowadays the term ophthalmic optician has been almost completely buried. Thus it fair to say that this change of name represented a revolution in terminology in the UK, which was triggered by the momentous decision taken in Cardiff in 1975 and which reverberated throughout the profession for a period of about 15 years, until 1990 when all the university department and professional bodies, if not the public and some practitioners, adopted the word optometry.

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Optometry Field Magazine, An Early Twentieth Century Periodical

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Through an inquiry from OHS member Irving Bennett, I recently learned of the existence of a periodical titled *Optometry Field Magazine*. Through some online searching and the examination of one volume of this publication, I have been able to find out a little about it.

The online catalog, WorldCat, indicated that three libraries have holdings of *Optometry Field Magazine*: University of California Berkeley (UCB), Indiana University (IU), and Southern California College of Optometry (SCCO). The online catalog for the UCB libraries said that their holdings began with volume 1 and continued to volume 2, number 2. It further noted that the publication began in June, 1915, and that volume 2, number 2 was published in 1917. The periodical was published monthly in the United States and was 18 cm high.

The SCCO online library catalog listed their holdings as volumes 3, 4, and 5. The catalog stated that those volumes were published in 1924, 1925, and 1926, and that the name of the publisher was not given. Linda Draper of the International Library, Archives, and Museum of Optometry (ILAMO), in an email to Irving Bennett noted that ILAMO held volumes 1, 3, 4, and 5. She stated that volume 1 was thought to be published in 1916, but the dates were uncertain. Volume 1 was bound with the cover referring to it as a yearbook. She said that volumes 3, 4, and 5 were bound with the covers of the individual issues removed and the dates were unknown.

Indiana University holds volume 2, and I checked it out to examine it. There are 12 issues in volume 2, and they are bound in a hard cover which carries the title *Optometry Field Magazine Year Book 1917.* The publication is 18 cm high by 13 cm, and each issue in volume 2 contains 16 pages. The individual issues do not have dates on them, only the numerical designations for volume and issue number. Neither are editor, authors, publisher, or place of publication identified anywhere in the publication. On the back cover of volume 2, issue 8, the following is printed: W.H. Replogle, Optometrist and Optician, 619 Sheridan Ave., Shenandoah, Iowa. Perhaps Replogle was the editor and/or publisher of Optometry Field Magazine. There is no listing of a Replogle in any of the Hindsight indexes. Nor does the name Replogle appear in the name indexes of James Gregg's histories of the American Optometric Association and the American Academy of Optometry.

Issue numbers 1 through 5 have the title *Optometry* on the cover followed by "Published in the Interests of Optometry and its Legitimate Adjuncts – A Monthly Epitome of Optometric Science, Art, Literature and News." Issue numbers 6 through 12 have *Optometry Field Magazine* on the cover. It appears that it was published to promote optometry and vision care, based on the preponderance of articles explaining what optometry is, the importance of vision care and of eyeglasses, etc. Some excerpts will illustrate this point.

In the first issue of volume 2, in the midst of a long essay on various aspects of the eye and vision, the importance of vision, and visual efficiency, there are bolded definitions of optometry, optometrist, optics, optician, ophthalmology, ophthalmologist, and oculist. The definition given for optometrist is "one who practices the profession of optometry. One familiar with the science and art of adjusting lenses to the human eye for the relief of eyestrain and the betterment of vision. An optometrist is not an ophthalmologist either by education or legal requirements." An ophthalmologist was defined as "A medical practitioner who confines his practice to diseases and surgical operations on eyes. An ophthalmologist is not an optometrist either by education or legal requirements." And the definition of oculist is "A medical practitioner who treats diseases of the eye with drugs, and practices surgery. Most so-called oculists, outside the larger cities, also treat the ear, nose and throat. An oculist is not an optometrist either by education or legal requirements."

The cover of the second issue of volume 2 proclaims that it is a "Child's Welfare Issue." The cover contains photographs of five children with esotropia and the statement "Look on the back cover and see what optometry did for these five little cross-eyed kiddies." The back cover shows the five children in spectacles with straight eyes and the notation that "The eyes of these children were straightened, as shown, by properly adjusted lenses and exercises."

In the fourth issue of volume 2, there is an editorial that mentions that "most advanced optometrists" use dynamic skiametry. It states that, in contrast, oculists rarely use that procedure. The editorial notes that optometrists have qualified themselves in the prescribing and fitting of glasses, but there is "no assurance" that the oculist has. Later in that issue on page 61 below a list of the states that have optometry licensing laws, there is a definition of optometry that states that "Optometry is the scientific and drugless method of examining the powers and visual conditions of the eyes, together with the strength and poise of their related muscles and giving the proper assistance – exercise or lenses – to overcome their defects."

On the cover of the volume 2, number 6, the word OP-<u>TOM</u>-E-TRY appears, presumably to indicate the proper pronunciation, followed by the words "Eye Sight Conservation." An editorial in this issue quotes Thorington, Herman Snellen, Francis Volk, Edward Jackson, and other ophthalmological authorities on the disadvantages of refracting using drops. Elsewhere in the issue the point is made that there is a significant economic cost of eyestrain.

Inside the back cover of the seventh issue of volume 2, one finds the following three paragraphs: "To qualify for the examination in optometry in states having optometry laws, now thirty-eight, the applicant must be at least twenty-one years of age, in addition to having a preliminary training of at least two years in an accredited high school, or must give evidence of having studied optometry, preferably by presenting a certificate of graduation from a registered school of optometry.

"These courses include such subjects as mathematics, physics, theoretical optics, general anatomy and physiology, theoretical optometry, practical optometry, physiological optics and pathological conditions of the eye.

"Standard schools of optometry are located at Boston, New York (Columbia University), Philadelphia, Rochester, Columbus (Ohio State University), Chicago, St. Paul, Minneapolis, Kansas City, Los Angeles, San Francisco, Portland and Spokane. In addition, several state universities are giving lectures – notably the California State University at Berkeley."

The editorial in the eighth issue is headed "Reading Causes Indigestion Through Eyestrain." The issue carries "The Story of Jim and Joe," a story in verse about two boys on pages 131-138. On the top of page 132, we find that:

Now Jim liked the school
    And was willing to go;
But a laggard in study
    And learning was Joe.

The next few pages elaborate on that theme, and a perceptive teacher recognizes that Joe has a vision problem. Then on page 136:

The next day Joe went
    To an optical place,
Where a "Licensed Optometrist"
    Took care of his case.

He went in a dullard,
    A crabbed kill-joy;
He came out with specs
    But a real living boy.

Joe then had as much success in school as Jim. Jim became a lawyer and Joe a "doctor". The last stanza of the story says that Joe appreciated his optometrist:

And among his best friends,
    Whatever their classes,
Is the optical man
    Who supplied his first glasses.

The editorial in volume 2, issue number 10 is titled: "Beauty in and Behind Glasses." It emphasized that properly fitted glasses are comfortable and individualized to the appearance of the patient. The primary topic of the twelfth and last issue in volume 2 was headaches. The editorial claimed that most headaches are eyestrain headaches. That editorial concluded by saying that: "With proper ventilation, meaning by that all the fresh air you can get, sleeping with all the windows open, regularity of the bowels, exercise outdoors and nourishing food and correction of your eye defects, you have the best preventives of headache."

Several questions remain concerning *Optometry Field Magazine*. How well was it accepted by the profession and the public? Was it successful in its promotional message? Was Replogle the editor and/or publisher? Was it discontinued after volume 5? Are 1924 to 1926 the correct dates for volumes 3 to 5? And, if so, why was there a seven year gap between volumes 2 and 3?

Optometry's "Leading Society" Celebrates its 100th Year: Notes on the Western Pennsylvania Optometric Society

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Editor's Note: *Many state and local optometric associations and societies were founded in the early years of the twentieth century in efforts for the passage of licensure laws and/or for the promotion of professional practice. As a result, many are celebrating their 100th anniversaries. The Western Pennsylvania Optometric Society recently observed its centennial anniversary. Here Irving Bennett highlights some of the remarkable individuals populating the society and some of its important contributions to optometry.*

During the decade or two following the end of World War II, the Pittsburgh Optometric Society enjoyed the distinction and reputation as being the most influential local optometric society in the entire American Optometric Association (AOA). And there were very good reasons for this.

But before that, we need to set matters straight. The records are a bit fuzzy. Pittsburgh's organization of optometrists came into being in 1906 and, from 1919 on, it was called the Pittsburgh Association of Optometrists. In 1940 the name was changed to the Pittsburgh Optometric Society. With the area of membership extending far beyond Pittsburgh's city limits, the Society changed its name to the Western Pennsylvania Optometric Society (WPOS) in October 1957.

In the style of David Letterman, here are ten reasons, not in any order of importance or chronology, why ours has been the most outstanding local society for so long:

1) In the mid-1940s, the AOA Public Information Bureau (the public relations arm of national optometry) was headquartered in the Jenkins Arcade in downtown Pittsburgh. First Ward Ewalt and then Elmer Soles were chairs of this important AOA department. (Later, when the Bureau was moved to St. Louis, Bob Phillips became its Director). All were our Society members.

2) Three AOA Presidents came from the Pittsburgh Society – William T. McConnell in 1917, Thomas Martin in 1923, and H. Ward Ewalt, Jr. in 1962. The National Parliamentarian was William J. Van Essen for a decade in the 1940s. One remarkable lady, Mrs. Mary Schempp, the wife of Dr. Ed Schempp, then State Board Secretary, became the President of the Woman's Auxiliary of the American Optometric Association, the national organization, in 1946. That was the only year that the AOA Congress was ever held in Pittsburgh. The national annual meeting was held at the William Penn Hotel and the Pittsburgh Society

was its host. Currently, the president of the (national) American Academy of Optometry is Mark Eger. This is an honor that parallels being AOA president.

3) Three of the nine Editors of the Journal of the American Optometric Association came from the Society (Irving Bennett 1957-1964; Milton Eger 1965-1985; and the current editor Paul Freeman who began his stint in 1990). The Journal is now called "Optometry." Two of the editors, Eger and Bennett, combined their talents in the mid-1960s and started the statewide think-tank conference called Allenberry. It was held at the Allenberry Resort in Boiling Springs, PA in October. Well over 50 ODs from all over the state convened for a shirt-sleeves no-holds-barred meeting on the pressing problems facing optometry in the state and in the nation.

4) The rivalry between the Pittsburgh Society (led by William J. Van Essen) and the Philadelphia Society (led by Albert Fitch) during the middle 1930s is legend. It led to the strengthening of the Optometric Act in many ways and the landmark court case (Neill vs. Gimbel) declaring optometry as a separate independent profession, not subservient to medicine. In 1937, legislation that would have granted optometrists TPA and <u>surgical</u> privileges failed passage by one single vote in the Pennsylvania Assembly!

5) A statewide public relations campaign – that had national overtones – featured Pittsburgh TV artist ("The Musical Sketchpad") Marty Wolfson and his KDKA TV program, comic books ("Dewey C. Well") and others public relations items. The ambitious program began in Pittsburgh in the early 1950s and led to the formation of the Vision Conservation Institute (VCI), which remains today as a public relations arm of the Pennsylvania Optometric Association (POA).

6) At least 16 optometrists who were WPOS or Pittsburgh Society members ended up as President of the Pennsylvania Optometric Association, including the current POA President Bob Bittel, Jr. One member of the Society received AOA recognition by being granted a prestigious Apollo Award (Ewalt) and two members were honored with AOA's highest award – the Distinguished Service Award (Eger and Bennett). Three members of the WPOS (Ewalt, Eger and Bennett) were among the 49 optometrists who have thus far been inducted in the National Optometric Hall of Fame.

7) The Pittsburgh Society was so big in the late 1950s that, under Bob Phillips' direction, it was split into five "Forums" so the members could meet more often as smaller study groups. The only Forum remaining is the one in Beaver Valley.

It still meets infrequently. A standout O.D. who was a female from Pittsburgh was Anna Miller; she was the first chair of the POA's Assistance to Graduates and Undergraduates Committee. And it was Dr. Miller who was the force behind the beginning of a viable para-optometric organization in this state. It became a model for other states to emulate. She was a lady "before her time."

8) Third party vision programming actually started in Pittsburgh when the Teamsters asked AOA for a contract so its members could get eye exams and eyeglasses as a worker benefit. This led to the formation of the national Vision Institute of America (VIA) which changed later into Vision Service Plan (VSP). A member of the WPOS (Bennett) was on the first national VIA Board of Trustees.

9) The society can boast that it had the first "Co-ordinated Classroom" school building as per the direction of the famous architect Darryl Harmon and the OEP. It was located in Beaver Falls, the city that also passed a city ordinance in the 1950s that made it illegal to price advertise eye exams or eye glasses.

10) The Society was not purely all business – it held annual North Park picnics (featuring Dr. Van Essen's famous hot German potato salad) and other social gatherings. Most of the members during the formative years were male and it was common to bring their wives for meetings with their own "Auxiliary."

And so it goes. The Western Pennsylvania Optometric Society – the society that helped make history.

The European Scientific Tradition in Philosophical, Religious and Institutional Context, from Prehistory to A.D. 1450

The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious and Institutional Context, from Prehistory to A.D. 1450, Second Edition. David Lindberg. Chicago: U. of Chicago Press, Chicago, 2007 (the first edition appeared in 1992). xvi + 488 pages, 116 figures, and 6 maps. ISBN-13: 978-0-226-48205-7. ISBN-10: 0-226-48205-7. Paperback, $25.00.

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An updated book by David Lindberg (a second edition) has appeared, in which there is much material on vision science, but, in addition, it covers science as a whole. This volume provides added coverage relative to the first edition. Western traditions are well represented. He also addresses Mediterranean and Near Eastern Arabic contributions to research. Optics, vision, and development of medicine are well treated.

Prof. David Lindberg, the author, is located at the University of Chicago, and quite a number of years ago, he wrote authoritatively on development of visual science from antiquity to Kepler (and a bit beyond), in his Ph.D. dissertation. This book brings together a rather complete treatment of science covering the early developmental years through medieval times. The writer's paperback copy was obtained on sale from the U. of Chicago Press. Lindberg is a fine writer and scholar and he holds the interest of the reader well. This volume largely covers Medieval History of Western Science. It is well illustrated, and he explains contributions made by the Greeks and Romans as well as the Arab scientists who contributed not only to vision and other science, but who perpetuated ancient knowledge, per se, during the European Dark Age. They also contributed to re-introduction of that science to the European continent through the Iberian peninsula. The associated bibliography is well ordered and voluminous. Illustrations and maps are pertinent and ample. The book is recommended to those interested in the early history of optics and vision.

Book Review: Spectrum of Belief: Joseph von Fraunhofer and the Craft of Precision Optics

Spectrum of Belief: Joseph von Fraunhofer and the Craft of Precision Optics. Myles W. Jackson. Cambridge, MA: The MIT Press, 2000. x + 284 pages. ISBN 0-262-10084-3. Hardcover, $40.

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This book uses the working life of Joseph von Fraunhofer and surrounding events to illustrate the economic importance of glassmaking, relationships of science and society, and the relationships of skilled craftsmen and scientists in the early nineteenth century. The author emphasizes that the book is not a biography of Fraunhofer, but he notes that Fraunhofer's life story is an interesting one, "a rags-to-riches story worthy of a Hollywood production." (page 5)

Joseph von Fraunhofer was born in 1787 into a family of generations of German glassmakers. His mother died in 1797 and his father in 1798. Fraunhofer was sent to apprentice and live with mirror maker and glass cutter Philipp Anton Weichselberger in Munich. It was not an entirely happy association as, for example, Weichselberger tried to keep Fraunhofer from using a lamp to read about optical theory at night.

In 1806, King Maximilian's privy councilor Joseph von Utzschneider, who had watched over Fraunhofer since 1801, when Weichselberger's house collapsed, arranged for Fraunhofer to work at his Optical Institute at Benediktbeurn in Bavaria. Fraunhofer went to work making achromatic lenses for refracting telescopes and surveying instruments. The author states that "Within 15 years, the orphaned lad from the most humble of origins produced the finest achromatic lenses and prisms the optical community had ever seen." (page 5)

Fraunhofer's laboratory was housed in an old Benedictine monastery purchased by Utzschneider for the purpose of making lenses. The monks who worked there provided an environment in which manufacturing methods could be kept secret, and the surrounding forest contained plenty of wood to heat the furnaces for making glass. Fraunhofer perfected the glass recipes, the stirring procedures, and the heating methods that made excellent homogeneous achromatic lenses free of bubbles and distortions. The book emphasizes the importance of lenses for economic, military, and scientific purposes and for national pride.

The author discusses attempts by the English to duplicate Fraunhofer's lenses. For example, Michael Faraday analyzed the chemical composition of Fraunhofer's lenses and tried making lenses using the same ingredients. However, perhaps in part because glassmaking was Fraunhofer's life work and it was a minor sideline to Faraday, the lenses made by Faraday were never of the same quality as Fraunhofer's. John Herschel, expecting Fraunhofer to adhere to the philosophy of open communication among scientists, visited Fraunhofer to learn the manufacturing methods. However, Fraunhofer kept the philosophy of artisans that the secrets of manufacturing processes should be carefully guarded. In fact, after Fraunhofer's death, "even the apprentices who had worked most closely with him, in the same glass hut and with the same equipment, achieved only limited success in the manufacture of optical glass." (pages 8-9)

Fraunhofer also undertook various optical investigations. In 1807, he wrote his first scholarly work, which dealt with catoptrics. His most famous work was the discovery of the "Fraunhofer lines." The author notes that this work "was not the culmination of any concern on his part with the nature of light. Nor did he use those lines to analyze substances. Rather, his work was a product of artisanal training with a view to perfect the construction of achromatic lenses for astronomical instruments...and...surveying instruments." (page 45)

In 1817, Fraunhofer became a corresponding member of the Royal Bavarian Academy of Sciences. Because he was an artisan and did no have a university education, he did not achieve acceptance among all members of the scientific community. In 1822, he received an honorary doctorate degree from Erlangen. Fraunhofer died in 1826 of lung disease, presumably due to exposure to lead oxide from glassmaking. He was only 39 years old when he died.

The author observes that after Fraunhofer's death, he "became a powerful historical example of the benefits of merging scientific research and technological innovation with industrial and state support....Hermann von Helmholtz and Ernst Abbe used Fraunhofer to unify the efforts of science, technology, and industry during the 1870s and 1880s." (page 9)

The book includes a number of black and white illustrations, a time line appendix, an extensive bibliography, and an index. It uses an interesting and well-researched historical story to illustrate relationships of science, craft, industry, and the state.

Book Review: Spectacles, Lorgnettes and Monocles

Spectacles, Lorgnettes and Monocles, 2nd ed. D.C. Davidson and R.J.S. MacGregor. Buckinghamshire, UK: Shire Publications, 2002. 40 pages. ISBN 0747805458. Paperback.

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This is an attractive little (21 x 15 cm) forty page booklet describing rivet spectacles, seventeenth century to twentieth century spectacles, lorgnettes, and monocles. The book contains 69 illustrations, most of which are nicely produced color photographs of spectacles, lorgnettes, and monocles at various times in history.

A two page introduction discusses the invention of spectacles and has a photograph of a replica of rivet spectacles and an illustration of the fact that the frames for rivet spectacles could have been cut from the metacarpal bone of a bull. The next six pages discuss and picture spectacles from the seventeenth and eighteenth centuries. A section headed "Vision and fashion" extends over nine pages and deals with scissors spectacles, quizzers, monocles, and magnifying glasses, as well as silver, brass, tortoiseshell, and horn spectacles.

On ages 21 to 32, discussion of "Nineteenth-century developments" includes lorgnettes, gold spectacles, steel-wire spectacles, pince-nez, rimless spectacles, and others. Three pages are devoted to Chinese spectacles and two pages to spectacles in the twentieth century. The booklet concludes with a two page diagram of the terminology of spectacles through history, a list of seven books on the history of spectacles, and a list of museums in England and Scotland that have collections of optical items.

This booklet can be consulted for a brief but interesting introduction to the history of spectacles. Derek C. Davidson was an optician who founded the Ophthalmic Antiques International Collectors Club. Ronald J.S. MacGregor is a retired optometrist who is the editor of *Ophthalmic Antiques*, the newsletter of the Ophthalmic Antiques International Collectors Club.

Instructions to Authors

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