

EARLY ADVENTURES IN COLOR MATCHING IN DENTISTRY

(The Dark Ages)

by Robert C. Sproull, DDS

It is a distinct honor to be with you today. The familiar faces in the audience bring back happy memories of times gone by. The opportunity to learn where you are today in the search for answers is an exciting one.

When Rade asked me to write a Forward for his book, *Esthetic Color Training* several years ago, I explained that, being retired, the only thing I could offer was how things were for me in the Dark Ages of Color Matching in Dentistry. He wasn't deterred.....and the Dark Ages Scenario was written. The same excuse was offered when he asked me if I would come to speak with you at this meeting. Again he wasn't deterred and so now I am standing before you, knowing that you are far more advanced than what was possible in my time and that there is nothing I could tell you that you don't already know about color technology. However, the problems encountered back in the 60's and 70's and 80's and how some solutions were found and how some failures occurred may be relevant today.



Dr. Robert C. Sproull's keynote address at the 1st meeting of the Society for Color and Appearance in Dentistry, Houston, TX, July 17, 2009

It was one thing to agree to give the talk. Then came the reality of trying to piece together what had happened and when. It's been a pleasant journey! The boxes of files and numerous notebooks brought back many happy memories! You'll notice that Steve Bergen and Jack Preston keep popping up throughout the

memories of those early days. In truth, either one has an equal right to be here giving you this history. They were there on the front line of the quest. Lloyd Miller was another one of those early pioneers.

In the mid 60's the dark ages of color matching in dentistry were indeed dark! Imagine a color matching program where the spectrophotometric curves of natural enamel were unknown, and the word was that a tooth was too small an area to be measured... if, by chance, you were aware of such curves and asked! There were no dental textbooks on color that I am aware of, and they probably didn't exist. The textbooks we did have really gave no meaningful way to navigate the perils of obtaining a correct color match. ADA Guidelines for dental education did not mention color science. The Munsell Color Order System and the three dimensional nature of color had been ably espoused by E. Bruce Clark in the 30's, but when I attended the University of Pittsburgh School of Dentistry in the late 40's, we never heard a hint of Clark or the three dimensional nature of color. Yet Clark had graduated from Pitt in 1918 and had taught there for several years after graduating! We never realized that he existed, even though some of the instructors who taught him were still faculty members and were teaching us!

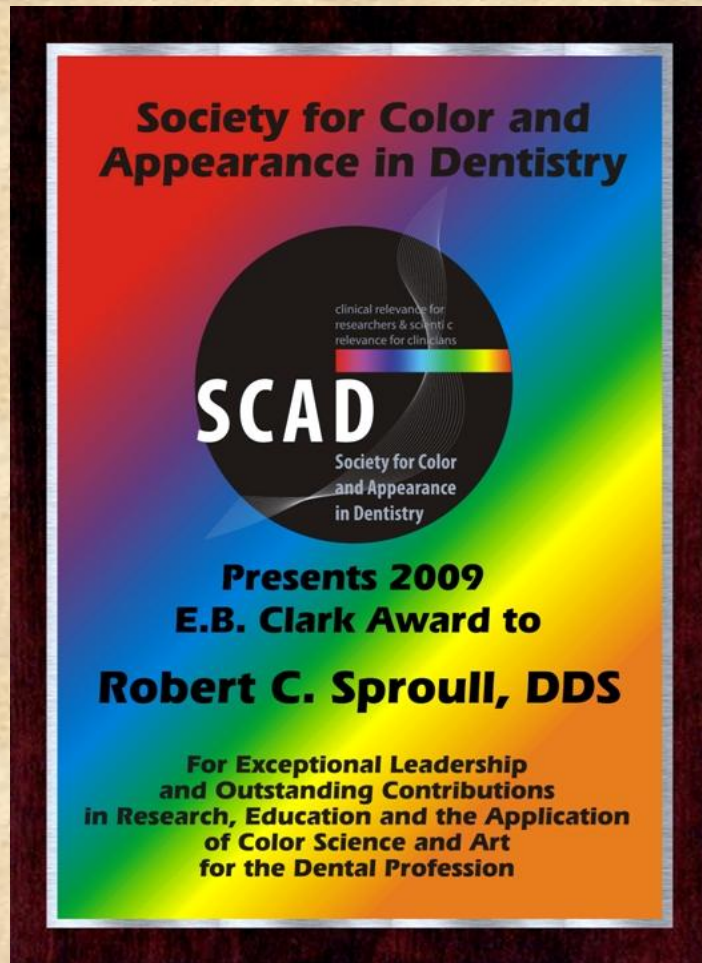


Dr. Robert C. Sproull, the first recipient of the E. Bruce Clark Award, the highest recognition of the Society for Color and Appearance in Dentistry, with **Dr. Stephen F. Bergen**, President of the E. Bruce Clark Award Committee of the SCAD

When considering confusion concerning color, there is certainly historical precedence! Aristotle began a huge error concerning color concepts that took 2100 years to correct. He did not differentiate between pigment colors and the colors of light, and if Aristotle said something, it had to be true! To this day the relationship of additive and subtractive mixtures is confused by many, so maybe the confusion will last another millennium.

Color back in my time was something that sissy artists played with----but those sissies knew one hell of a lot more about color than we as dentists! The dentist had to match the natural teeth and was not taught the basics of color. The artist could depict an object in any color he chose, but he was trained in the basics of color.

In 1966 a commercial Color Manual was published based on the color language of Hue, Value and Chroma. The booklet was published to educate technicians and dentists on color modification for dental restorations. It was enthusiastically endorsed and copied by rival companies and began to be used as a text in some dental schools. The problem was that the book was plagued with basic errors----like the definitions of Value and Chroma! We were told that the laws of subtractive color mixing controlled the results. They didn't; that would require transparent modifiers. Theirs were opaque.



2009 E. Bruce Clark Award

When I was transferred to William Beaumont Hospital in 1965, I thought I'd gone to heaven! For the first time in my army service there was a master ceramist assigned to the lab. Tom Maccarrone opened my eyes to what was possible. I got so carried away I decided I would put together a table clinic where we would exactly duplicate six maxillary anteriors. Six months later and innumerable re-bakes, modifications and king sized frustrations, it became apparent that I really knew nothing about color! So we made our own shade guide, thinking that would help. We took all the porcelain shades we had and modified each one with all the color modifiers on hand. We ended up with 97 color tabs of porcelain. You know color, so you know what a hopeless mess that was! If you found a tab almost right, where was the next closest color tab? Impossible to guess!

So it was back to the dental school textbooks to try and find where I had gone wrong. I found nothing of practical value. Information on how to evaluate a color or how to modify it just wasn't there. But in the references at the end of Tylman's chapter on color there was a long list of articles. These were obtained from the ADA and fortunately E. Bruce Clark's articles were among them. The three dimensional nature of color was an eye opener! Errors could be diagnosed and color matching started to make sense. It was at this time that the color booklet came out, based on Hue, Value and Chroma, to instruct dentists and technicians on

how to approach color matching problems. I rejoiced and enthusiastically explained to those who had questions that this had to be the key! Then would come confusion and the realization that something wasn't adding up. Finally the light bulb came on. Their definitions of Chroma and Value were saying the same thing in different words! They were describing a three dimensional entity with only two of the dimensions available!

It was also in 1966 that I became aware of an organization named The Inter-Society Color Council. The Aims and Purposes of the ISCC seemed like a life jacket thrown to someone being swept out to sea! Those aims and purposes were to (1) stimulate and coordinate the work being done by members leading to the standardization, description and specification of color; (2) to promote practical application of this work to color problems in science, art and industry; (3) to promote communication to facilitate more effective use of color; (4) to promote educational activities and the interchange of ideas; (5) and to coordinate with other organizations.

By 1967 the missionary's zeal had struck! Color matching, which had been the bane of my existence, had become a pleasure. I volunteered to present a paper at the October, 1967 Annual Session of the ADA in Washington, DC. The title would be *COLOR: FRUSTRATION OR PLEASURE?* Then came the mad scramble to make sure the "facts" to be presented were indeed facts!

To verify that the teaching of color concepts was inadequate, a survey of the Dental Schools was conducted. To verify that there were no guidelines from the Council on Dental Education on teaching the basics of color, a letter was sent to the ADA Council on Dental Education. To verify the scope of the ISCC, Dr. Fred Billmeyer was contacted. A letter was sent to the U. S. Bureau of Standards asking if they had any active research on color matching of dental materials.

By the time the paper was delivered (23 October, 1967) it seemed that the facts were indeed facts! Answers to the questions and the initial results of the Survey of Color Education in the Dental Schools had been received. On an average only 2.3 hours were devoted to information on color; 79 of the 119 schools who answered were unaware of a recognized color system; only 3 schools had completed research on color. Nothing indicated that the students were given a meaningful introduction to color and color matching.

(The Notebook containing all the returns relating to the Survey of Color Education in the Dental Schools of the World has been given to Rade.)

The Council on Dental Education had responded and said that they had no guidelines for education on color for the dental students. (Dr. Lester W. Burkett. Aug. 1967.)

Dr. Fred Billmeyer stated that the ISCC was open to individual members and to organizations.

The National Bureau of Standards responded that they had no active research related to color matching in dentistry. (They had done some research published in 1959 using a Colorimeter to obtain the tristimulus values of large specimens of silicate cement.)

At the beginning of the paper, *Color: Frustration or Pleasure*, E. Bruce Clark's opening statement at the 1932 Annual Session of the ADA was quoted.

"Color, like form, has three dimensions; but they are not in general use. Many of us have not even been taught their names, nor the scales of their measurement. In other words we as dentists are not educationally equipped to approach a color problem."

In making that statement I admitted that it came from Clark's opening remark in 1932, thirty five years before, and that unfortunately things hadn't changed; that the profession as a whole was still as unaware of the

dimensions of color as they were in 1932. Now it is 77 years later. It would be interesting to know how we stack up now!

Another of Bruce Clark's statements I've come to regard as equally important:

“In the study of color not only is an intimate acquaintance with its three dimensions the first requisite that should be acquired, but it is, without a single exception, the most important.”



E. Bruce Clark, 1923

It was an exciting time in the late 60's! There was so much to learn! The question was: Where to find the answers? The correspondence with Dr. Billmeyer was fruitful. In 1967 I became a member of the ISCC and started attending their Annual Meetings. The contacts there were beyond expectations! Fred Billmeyer, Max Saltzman, Dorothy Nickerson, George Gardner, Louis Graham, Phil Hunter, Fred Simon, Midge Wilson, Blanche Bellamy, Angela Little, Rolf Kuehni, Ralph Evans, Walter Granville, Ruth Johnston, Norman Macbeth, Gunter Wyszecki, Richard Hunter, Henry Hemmendinger, Hugh Davidson.... the list is endless! These were the people who were writing the books and articles about color and color matching. And there they were! And they were universally helpful in answering any questions and in pointing the way to understanding!

The problem of matching the color of teeth was brought into focus at the Annual ISCC meeting in 1968. Max Saltzman, noted for color research with Billmeyer (and his bluntness) asked me “What in the hell are you doing here?” when he learned I was a dentist. I told him I wanted to learn about color matching. He then asked me, “What are you trying to match?” My response, “Teeth.” He rolled his eyes and said, “What sort of a spectrophotometric curve?” My response, “I haven't a clue!” He sighed and said, “You really do need help!”

In later conversations, he, Billmeyer and others explained that a tooth was too small a target to run such a curve, but if anyone could do it, Henry Hemmendinger could.

I contacted Henry and in October he asked me to come to his lab in Easton, Pennsylvania. On the 23rd of October, 1968 he ran the demonstration. He took a piece of cardboard, punched a hole in it and affixed the cardboard to the light source of his GE Spectrophotometer, collimating the beam to hit the target tooth. He ran the curve and handed it to me and said with a smile, "That's what you have to match!" Henry subsequently ran hundreds of curves for me of natural teeth and shade guides, and thousands for other researchers and commercial manufacturers. The invisible barrier was broken!



Tooth Color Indicator, a shade guide designed by **E. Bruce Clark** in 1933, on loan to **Dr. Sproull**

As a result of the Survey on Color Education I learned of Toshio Hayashi's work in creating a Tooth Color Guide based on the Munsell Color System. I was a little chagrined as I had been working on that concept with Blanche Bellamy, but congratulated Toshio and later met him in New York. His concept is beautiful, Five Hues, Five Chromas, Five Values for a total of 125 color tabs. Establish the Value and you have 25 Tabs to consider. Establish the Chroma and you then have 5 tabs to consider. The next closest matches in any of the dimensions of color are easily identified. The one overwhelming obstacle was that the Guide was paper and the paper tabs had radically different spectrophotometric curves from that of natural enamel. Converted to appropriate porcelain, it would be the guide I'd want if I were still practicing.

Things did start to accelerate. The American College of Prosthodontists began gestating in 1967 and by 1971 the organization was formed and the first Annual Meeting was held at a small motel in Cherry Hill, New Jersey..When the committee chairs were assigned, I found myself the Chairman of the Education and Advancement Committee. Not having any idea in the world what an Education and Advancement Committee was supposed to do, I divided the work into sub-committees as they did in the ISCC and created a sub-committee for Color and Color Matching in Dentistry and eventually it gained full committee status.

The request that the College be granted member body status in the ISCC was approved in 1972. For the first time a medically oriented organization became a part of the ISCC.

The request that the ISCC approve a Sub-Committee to deal with color matching problems in Dentistry was approved and Sub-committee #35: Color and Appearance Matching of Living Tissue was recognized. Thus began a lengthy cooperative effort between the ACP Color Committee and the ISCC Sub-committee #35 to coordinate and serve as a communication network for color researchers around the world.

In 1968 I met Jack Preston at a dental meeting in Florida, and that friendship has endured. Those of you who know Jack know that he forgets nothing! His memory of the meeting is that I told him about diopters, so in exchange he told me about the Hogarthian Curve of Beauty. Jack has never forgiven me for urging him to see *Barbarella*, the movie where Jane Fonda floats nude in a bubble. He wouldn't buy the notion that the film was an exercise in Hogarth's Curve of Beauty. Jack has a vineyard now and gives those grapes the same loving passion that he gave to dentistry. Jack and Charlotte's '04 Cabernet Sauvignon recently won "Best of Show" at the Orange County Fair!



Dr. Alma Dozic (right), recipient of Robert C. Sproull award for the best poster, her coauthor **Dr. Ghazal Khashayar** (left), and **Dr. John M. Powers**, President of the Poster Award Committee

In 1969, at the Annual ADA Convention in New York City a young dentist and his wife were giving a table clinic on color matching. The meeting with them was most fortunate! Steve Bergen and Juliet have become treasured friends. When I asked Steve when that Table Clinic was given, he knew the exact date.and he still has that Table Clinic stashed away. So I'm not the only packrat! Steve has probably been president of every group to which he has ever belonged His accomplishments in the field of color-and in other areas of dentistry are phenomenal! It was Steve who succeeded in incorporating the Dvorine Pseudoisochromatic test for anomalous color vision onto slides and having them distributed to the dental schools, free of charge, through the American College of Prosthodontists. In talking recently to Kristine Seagren, a dental student, I learned that the slides are still being used.

One of the staunchest allies in the ISCC proved to be Blanche Bellamy, office manager of the Munsell Color Company located in Baltimore. I first met Blanche at the ISCC Meeting in New York in 1967 where we discussed the Munsell Color Tree, the student kits to teach the Munsell System and other learning aids that they stocked. It became a habit to visit the Baltimore Munsell Store on Calvert Street any time travels took me

to the east coast.....and Blanche always had time to visit and discuss color. She remembered that another dentist used to visit as I did, E. Bruce!! When she learned that I wanted a color tree for a presentation but hadn't the funds, she lent me one. In the articles written about color, she cheerfully proofread them for accuracy and typos. And she would save a place at her table at the ISCC meetings where I had the pleasure of visiting with Dorothy Nickerson and other color pioneers!

Angela Little, another ISCC attendee, wrote a book with Gordon MacKinney , *The Color of Foods* which offered surprisingly good information on color! Her definition of Metamerism was the best I'd heard: "Invisible spectral differences." Metamerism has such an important role in color matching, but at times it is difficult to get the concept across. With her definition and a D & H Color Rule as an aid, it can be demonstrated with startling clarity and ease.



Dr. Frederick Rueggeberg, recipient of Robert C. Sproull award for the best poster, and **Dr. John M. Powers**, President of the Poster Award Committee

Color had come in out of the cold! Dental meetings began featuring speakers with accurate information about the intricacies of color and color matching and hundreds of lectures were presented. The published literature kept pace and books and articles on color began appearing. One sustaining source of encouragement was the support of the Residents in training at WBAMC. Without exception they only asked what they could do to help. Phil Thomas, Ken Turner, Don Smith, Pete Whitbeck, Leon Sheffield, Clark McCoy and John Goodman will always be remembered fondly. (Pete Whitbeck asked me after the SCAD meeting if I had confessed to sending him out to give color discrimination tests to anything that moved!)

All events were not positive! The letter I had written to the Council on Dental Education in 1967 requesting that the Council specify standards for education in color for the dental and pre-dental students was answered in a letter dated May 31, 1968.

After careful consideration, it was the opinion of the Council that dental students receive a sufficient depth of knowledge in the area of color dimensions. The Council also believes that

present faculties currently conduct quality courses in this area and that there is no need at this time to include this subject area in the Council's standards.

In 1978 some incorrect information concerning color published in a dental journal led to a renewed request that the ADA Council on Dental Education establish standards for education in color for the pre-dental and dental students. This request went down in flames as had the request in 1967, but at least it was a longer letter! I can see now that my approach was wrong. Instead of a request to establish standards for education in color for the students, a sample standard should have been drafted for their consideration.

But, back to positive events!

The inaugural meeting of the American Academy of Esthetic Dentistry was held in Las Vegas, Nevada in August, 1976. To "Foster greater awareness of esthetic principles" was one of their stated goals. Jack Preston and Steve Bergen were on that program with a presentation titled: *Color – What's Really Important?*

In 1976 Ron Goldstein published his book, *Esthetics in Dentistry*, which covered a wide gamut of esthetic problems for the practicing dentist, including a chapter devoted to color! In 1977, Henry Yamada organized a *Colloquim on Dental Porcelain: The State of the Art* and published the result of the proceedings. The book included eight papers devoted to color vision and the esthetics relating to color. Also in 1977 Henry Frajder published a small book in Paris, *L'Assortment des Couleurs en Odontologie*. It was a translation into French of a series of my color articles which had been earlier published in the *Journal of Prosthetic Dentistry*. *Color Science and Dental Art* was published in 1980 by Jack Preston and Steve Bergen. It was a self paced learning unit designed to guide the reader to understand and use color science as a foundation for better dental art, much of which was based on the conclusions drawn from Steve's 1975 Master's Thesis on the ability to teach and learn about color and how to distinguish between small color differences. Rhoads, Rudd and Morrow's *Dental Laboratory Procedures*, published in 1980, had a chapter devoted to Color in Ceramics.

Dental Journals featured an increased volume of accurate information on color matching. Other books were published expanding the ability to comprehend color matching. Both Preston and Bergen published meaningful articles on light and lighting. Lloyd Miller, working with Henry Hemmendinger, published some beautifully illustrated articles showing the distribution in color space of natural teeth and shade guides.

Today there is available to the profession instrumentation that we only dreamed of back in those early days. But there was a yearning for it, both by the dentist and the dental laboratories. In the *Journal of the NACDL* for October, 1970, Ralph Rothstein, CDT of Washington, DC wrote an article on *Dental Laboratory Evolution* with advice to the heads of dental laboratories on how to upgrade their operation. To quote him: "How about coming up with a shade taking device? I honestly feel if a practical shade taking device were perfected and the price was within reason, the sale of the device would far exceed the formidable impact of high speed handpieces!"

Throughout this time period, the joint ventures of the ACP Color and Color Matching Committee and the ISCC Sub-Committee were successfully pursuing their goal of coordinating color research and serving as a communication network for color researchers around the world. Researchers from across the United States as well as from England, Australia, Japan, Brazil, France, Canada and other countries were in the network. Dentists, lab technicians, representatives from industry as well as the Bureau of Standards, the ADA and other researchers were part of that network.

Hand held colorimeters and spectrophotometers are realities today. You who work with them are aware of their potential. However, I am reminded of the words of Fred Billmeyer in an article he wrote in 1967 titled *The Look and Think Steps in the Analysis of Color*. He summed up his paper with these two points:

1. A machine can extend and supplement a trained color matcher, but never replace him.
2. The reason why a machine alone will never replace the human observer is that the machine can't LOOK with the discrimination of the human eye and brain and, above all, the machine can't THINK.

His final comment in the Summary? *"The eye is the final arbiter, the instrument the aid."*

Max Saltzman also had an interesting comment about instrumentation. At an "Instrumental Colorant Formulation" meeting in 1976 Max stated, "With intelligence you can do color matching without an instrument. Now if you can do it without instruments with intelligence, think of what an intelligent, well educated person can do with instruments. There is no limit. However, ignorant or stupid people, using the finest instruments, can botch a job as fast as the computer can print out the wrong answers.... Thus people are the first and most important ingredient for success in computer color matching, and we cannot ignore it... people come first."

The search for answers to color matching problems has been an adventure. We had successes and we had failures. I think the why of those successes and failures would be helpful. Perhaps we'll never know for certain!

E. Bruce Clark has been acknowledged as a true pioneer in the struggle to bring order to our understanding of color. Many have probably wondered why his worldwide acclaim ended in a whimper. Being curious, I asked for aid from a friend who researches genealogies and histories as a hobby. Forty pages later, as I sifted through Bruce's life, a possible answer emerged.

E. Bruce's grandfather, James Armstrong Clark, was born in Scotland in 1832 and migrated to Butler County in western Pennsylvania where they had six children. James A Clark, Bruce's father was born in 1870. (My Scotch Sproull ancestors had followed a similar path, starting in 1800, and ended up in Butler County also. My great, great uncle and the Clarks lived within several miles of each other.)

E. Bruce's father, James, was also a dentist. Bruce was born on the 4th of July, 1896 in New Wilmington, PA where his father had his dental practice. E. Bruce's given first name was Edwin, but he obviously preferred Bruce. He was a graduate of Westminster, Tufts College and then graduated from the University of Pittsburgh School of Dentistry in 1918. (Also in that class were Bert Sproull (my father), Jock Sutherland (a legendary football coach) and Bill McClellan (a legendary Coroner of Pittsburgh and feisty politician). Bruce taught at Pitt for several years and then opened a practice in Uniontown, PA, south of Pittsburgh. He met Elsie Baer in Uniontown and they were married in 1927. She managed his office and laboratory until his retirement. His wife's brother, Donald Baer, was highly decorated submarine commander in WWII and retired as an Admiral.

It is clear from the multitude Newspaper stories that E. Bruce was a master at getting his findings and research in tooth colors published. He generated a lot of excitement in the dental community and the general public. He traveled extensively in the United States and abroad. It was not unusual for these lecture tours to take a month or two. His ceramist would accompany him on these trips. The highest dental honors were awarded him and his name was constantly in the spotlight.

I was fortunate to spend a weekend with Bruce in 1973. He had become very withdrawn and reclusive, but since he had graduated with my Dad, he invited me to his home for the weekend. He was still sharp! And he did understand the intricacies of color. And the role of additive, subtractive and partitive color mixing! In a later letter his disillusionment showed when he told me not to try to "dig up a horse that has been dead for 40 years!" in referring to his writings.

So what were the reasons he slipped into obscurity?.The depression may have been a factor as was WWII. Perhaps the porcelains available played a factor. But in reading the multiple news reports we may find another hint. Perhaps he was offering more than what the state of the art at that time could deliver! He had no spectrophotometric data to check the accuracy of his conclusions on the volume of color space of the human teeth nor the similarities between his porcelain and natural enamel. The news items promised restorations that could “not be detected with the human eye!” His articles, though brilliant, did require concentration and his results depended upon the support of expert ceramists who would be out of reach for most dentists. But I think that the most devastating blow was the lack of education in color technology at our dental schools. They failed to teach their students the bare bones of color and color technology!! There wasn't an audience who could appreciate his research!

Another giant who, it appeared, had slipped off the radar was Henry Hemmendinger. Henry was born on April 1, 1915 and died in 2003 after devoting 50 years to color research. He was regarded as one of the world's preeminent experts in color science. He graduated from Harvard and Princeton with a Ph. D. in Astronomy in 1939. (There was a total eclipse of the sun in Siberia in 1936, and Henry was there as a student). He joined the Navy in WWII and worked in submarine warfare research (He may have aided E. Bruce's brother in law, Donald Baer). He became a friend, and Peg and I spent time with him at his retirement home in New Jersey. I remarked to Steve how the literature I was reviewing failed to mention Henry. Steve pointed me to the obvious answer! Although Henry was a veritable treasure trove of information for many researchers, for some reason Henry never wrote articles for the dental journals that I am aware of. If you don't publish it, it is hard to quote you! I have many personal letters and papers which Henry wrote. To any who would be interested, they are available.

Disappointments??

1. The American College of Prosthodontists is no longer a member of the ISCC.
2. The Color and Color Matching Committee of the ACP no longer exists.
3. The ISCC no longer has a Sub-Committee #35

Reason for cheer?

1. Steve Bergen is still an active member of the ISCC and has obtained “Friend of the ISCC” status for SCAD
2. Wayne Wozniak is with us today from the ADA. Wayne and I worked together on Sub-Com. #35 and I was always impressed with his dedication. He could guide us in our relations with the ADA.
3. The Society for Color and Appearance in Dentistry has been launched!!

As I stated at the beginning, there is no way I can tell you anything about color technology that you don't already know, but there are things I would recommend.

1. Become an individual member of the ISCC.
2. Have SCAD become a Member Body of the ISCC
3. Work with ADA Council on Dental Education to ensure that Guidelines for pre-dental and dental students include education in color science.
4. Enjoy the experience!

But one final thought. In dealing with color matching, expect frustration!! We still don't have all the answers!