CORNERSTONE
Journal of the Accredited Gemologists Association

A HISTORY OF ELECTRONIC COLOR ANALYSIS IN THE GEMOLOGICAL TRADE

by John Allaman

Introduction

Science and industry have developed many effective methods of color analysis from the Munsell® color chips to the International Commission on Illumination (CIE) color triangle known as the "1931 2º Standard Observer". In the following history, we will venture along technological byways from the 1940's to the latest releases at this year's gem shows and investigate the operation, technology, benefits, drawbacks and costs of the various methods.

Color space

The Munsell® system (Fig 1a) keeps coming back to the gem trade in various forms because it provides a low cost, physical standard. It is a three dimensional space that when viewed from above appears with red at twelve o'clock, yellow at three o'clock, green at five o'clock, and blue at eight o'clock, with blends of those colors in between. Viewed from the side, white (colorless) is at the top and the deep saturation colors are at the bottom. Unfortunately, not all colors can be seen at one time with this system.

In the Winter 1994 issue of Gems and Gemology, the GIA's Gem Trade Laboratory documented their use of the Munsell® system for grading fancy color diamonds[1]. GTL's new system, the Munsell® "Book of Color" is made up of 1,500 color chips and is available in both glossy ($525) and matte ($590) versions. (The article does not specify which is used but it appears to be the glossy version.) The GTL recommended using the Judge II Illuminator ($1,200) along with the "Book of Color".

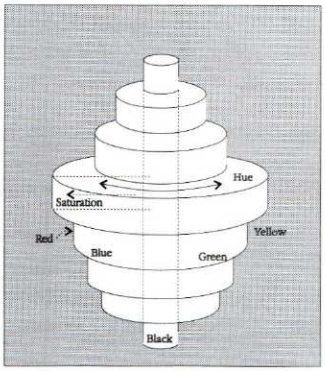

FIGURE 1a. *Munsell Color System goes from colorless at the top to black on the bottom with color hues surrounding. Deeper saturations are toward the outside, less saturated in the center.*

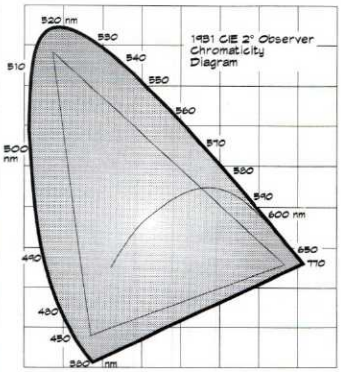

FIGURE 1b. *The CIE 1931 Chromaticity Diagram: Color hues (as denoted by wavelength) surround the diagram. The straight edged triangle denotes the tristimulus sensing area.*

Another widely adopted method for describing color is the CIE color diagram (1931 2º Standard Observer). While it is a simple way to describe color on a chart, the CIE 1931 triangle itself is not intended for color matching. The central area of the CIE 1931 triangle, the near colorless area, is important to diamond grading while the whole triangle can be used by the colored stone trade. Using this diagram (Fig 1b) we will highlight the areas of sensitivity of the reviewed electronic color measurement systems.

Instead of simulated color references, most "real world" color stone merchants use actual stones that are set to their own needs and standards. If a simulated reference is used, it is probably one of the following: GIA's Color Master®, Cap Beasley's Color Scan®, Howard Rubin's Gem Dialogue®, GIA's Gem Set®, and most recently Tom Tashey's Munsell® based system. These systems have become the color space reference for the gem trade but none has proved an end-all solution.

The science of today
is the technology of tomorrow.
— Edward Teller

AGA is a nonprofit research, education and ethics organization, benefiting professional and avocational gemologists as well as the consumer interest. Membership programs include advanced gemological education seminars, professional computer software reviews and workshops, and the AGA-Certified Gemological Laboratory Program.

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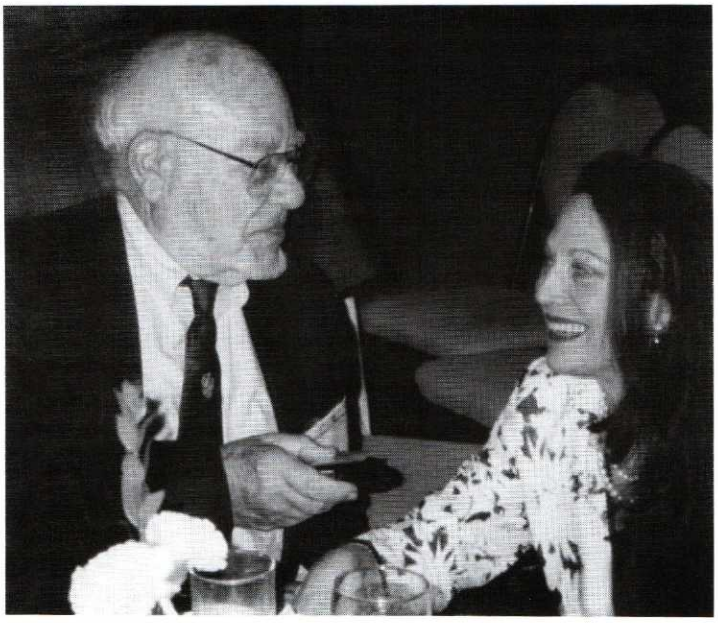
41 East Mill Road, Suite 2,
Long Valley, NJ 07853

With this issue Daloma Armentrout has resigned as editor of the Cornerstone and has been replaced by Lorraine Lopezzo. We are grateful to Daloma for her extensive contribution of time and professionalism.

Tucson 1995 Conference, AGA Board Members
Seated: Leo Schmied, President
2nd Row, Left to Right: Larry Phillips, Governor; Melinda Adducci, Secretary; Stanley Cohen, Governor
Upper Row: Thom Underwood, First VP; David Harris, Treasurer; Joe DuMouchelle, Second VP



AGA Social with GAGTL
Fred Pough tells Antoinette Matlins the answer to a tough gemological question.

Our grand business is not to see what lies dimly at a distance, but to do what lies clearly at hand.
—Thomas Carlyle

Drs. Ditchburn and Huddlestone

In the 1940's, 50's, and 60's, Dr. Ditchburn of DeBeers struggled to develop an automated color sorter that could keep up with the demand for diamonds in the post war era. His enduring contributions to diamond color and spectrophotometry testing are the use of the integration sphere for even illumination through gems as well as a detailed study of the cape lines for color grading[2].

Dr. Ron Huddleston, founder of the Diamond Grading Laboratory in London, built on some of Ditchburn's contributions. Huddleston color graded diamonds by comparing the 415 Cape line to surrounding areas and measuring the absorption from these lines. While he is said to have had success with about 70% of the stones tested,[3] his system was not sold commercially.

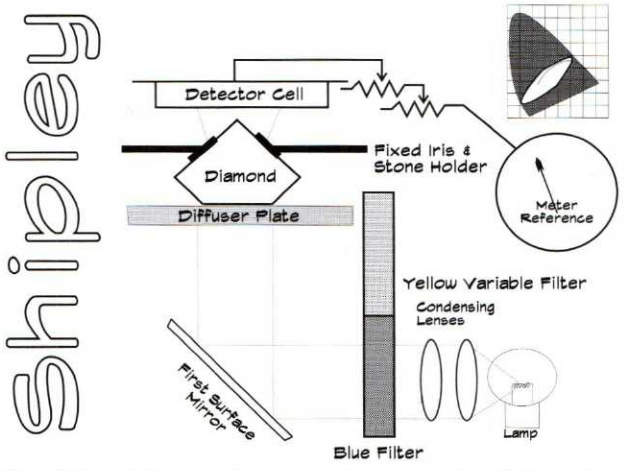


Fig.2 Shipley's Diamond color grader used yellow light to determine the path length or size.

Shipley's Wonderful Vision Of A Filter Based Color Grading Instrument

Robert Shipley, founder of the Gemological Institute of America, had the foresight to develop a near colorless grading system for diamonds that could be easily understood by the buying public. In the mid 1950's he conceived, designed, and manufactured the colorimeter, a two filter color diamond grader that in some cases has lasted almost forty years (Fig 2).

Shipley's idea for the colorimeter was both elegant and straightforward. He realized that the absorption of blue light from the cape lines gives diamonds a yellow tone and that, by measuring the diamond's absorption of blue light, one could accurately measure its color. The gauging of one color's transmittance value against another was his premise.[4]

The Shipley system worked like this: the system's light was first normalized and the blue absorption measured; this value was taken to a circular slide rule on the instrument's panel; next the relative size (path length) of the stone was measured with yellow light; and finally, this value was divided on the slide rule to give an American Gem Society numerical color grade.

Shipley's instrument was not a simple system to use but for its time it was very effective.[5] In the 1960's the American Gem Society leased the instruments to its members. Had it been sold, the cost of the system would have been approximately $4,000.

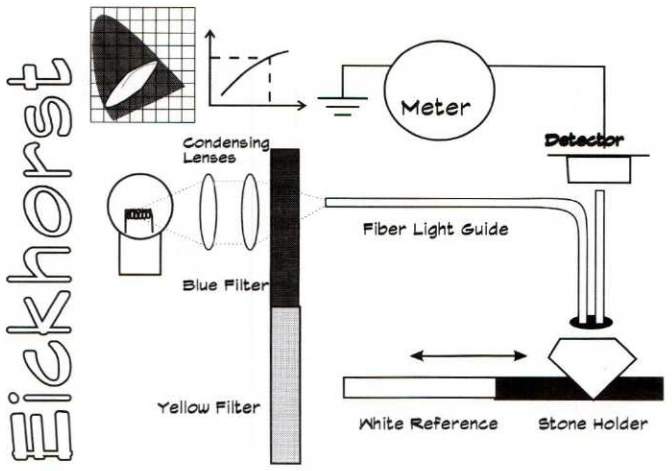


Fig.3 System Eickhorst

Eickhorst and Okuda's Semi-automated Two Filter Systems

During the gold and diamond craze of the 1970's, a number of new instruments were developed which in most cases were refinements of Shipley's method.

Eickhorst (Fig 3) developed a system that used fiber optics to first illuminate the gem and then channel the light back to a detector cell. In the detector cell the transmission of blue light was compared to that of yellowish-green light in a reflecting mode. The user then had to manually compare these with a graph on the instrument to determine a color measurement.[6] This system was marketed in the mid 1970's for approximately $3,000.

Okuda's instrument (Fig 4), also marketed under the name "Presidium", simultaneously measured blue against red, without the exchange of filters. This bi-stimulus system was both simple to operate and unique in that it did not require conversion. Instead, it read directly out in a color grade. Okuda's method had its shortcom-

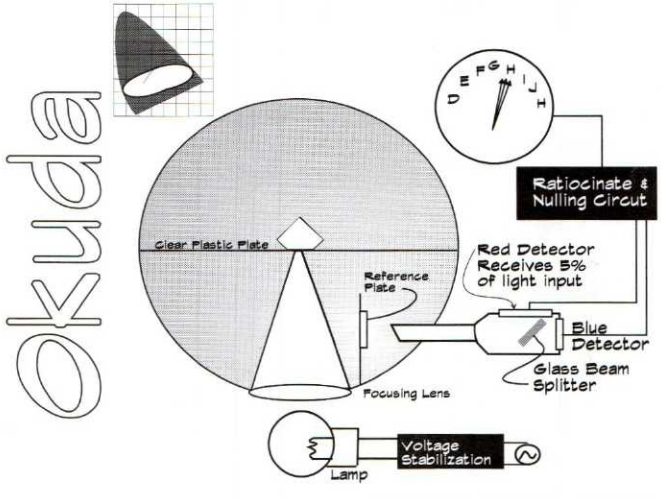


Fig.4 Okuda's Color Checker

ings. Almost an hour was necessary to ready the system for use and any rotation of the sphere resulted in a change of readings. Its major drawback, along with so many systems, was variation in the light source due to voltage fluctuations. During the 1970s, the average cost of these systems in the United States was $3,500.

Yehuda Diamond Grader

Yehuda developed its system in the 1980's and it continues to be marketed mainly to the buyers of rough diamonds When used properly it offers a very high level of certainty[7] and is currently marketed for approximately $14,000.

Tristimulus Color Grading Systems

Tristimulus Color Grading Systems (Fig 5) are the simplest methods used to efficiently measure color in the industrial world. Using three filters, these systems measure the colors between filters and typically read out in CIE color space. Note (Fig 1b) the deep colors outside the straight lines between filters cannot be measured with this type of system.

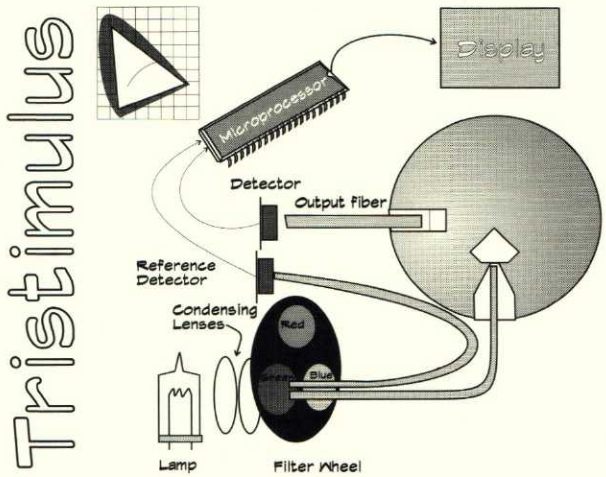


Fig.5 With three filters these systems can better interpolate color than two filter systems.

While a filter based system does not allow for the deep saturation of colored stones to be measured or described, by properly using red, green, and blue filters together, the instrument can deduce white (colorless). Assuming the diamond is not brown or green and that it does not fluoresce, with proper calibration the absorption of blue in a diamond can be measured and a diamond color grade can be derived. Systems like this included the Minolta by Gemological Research Corporation and currently the Gran Computer available from GIA Gem Instruments and Kassoy for under $7,000.[8]

Spectrophotometers

In general, spectrophotometers differ from filter based systems in that they measure a narrow specific band of light and look for peaks that are characteristic of particular substances. These can vary from the Cape nitrogen lines (at 415.5, 423, 435, 452 and 465nm) to the absorption peaks of 595 and 741nm which are extremely rare in natural diamonds[9] but very common in irradiated. Spectrophotometers can also separate natural from synthetic; e.g., Alexandrite, the latter which owes its color to vanadium verses chromic oxide in the natural material.

Monochromatic Spectrophotometers (Fig 6)

Large gem laboratories and research institutes have all utilized spectrophotometry in their gemological analysis with systems that are basically chemical analyzing instruments, such as Pye, Hatachi, Perkin Elmer, et. al. These systems require modification of the sample chamber and most have accomplished this with an integrating sphere. The sphere allows light to be transmitted through and reflected from the stone and then be picked up by a photomultiplier tube. The geometry of the sphere is intended to offset the effect of the cut by diffusing the light over a surface that integrates the "hot spots" and gives a more constant, reliable measurement, regardless of where the stone is placed.

Monochromatic spectrophotometers illuminate the gemstone one wavelength at a time. They take white (colorless) light and refine it through a monochromatic tuner that allows light to project onto the gemstone one single wavelength at a time. The gemstone either transmits or absorbs the light at that particular wavelength and the photomultiplier tube detects the intensity. A basic danger of this technology is that the instrument does not see what the human eye sees, e.g., a diamond can fluoresce at 440nm but if the monochromatic beam of light is set at 370nm the user reads the intensity as 370nm. Therefore, color grading of fluorescent diamonds can't be accurate using a monochromatic spectrophotometer.

The use of monochromatic spectrophotometers is both time consuming and expensive. To run a sample from 300nm to 750nm typically takes over 2 minutes. And, while a great research tool, at about $50,000 plus the cost of a trained and dedicated gemologist to run it, these are not systems for general use.

Imaging Spectrophotometers

While the basic idea was developed in the 1930's for spectral analysis of the sun,

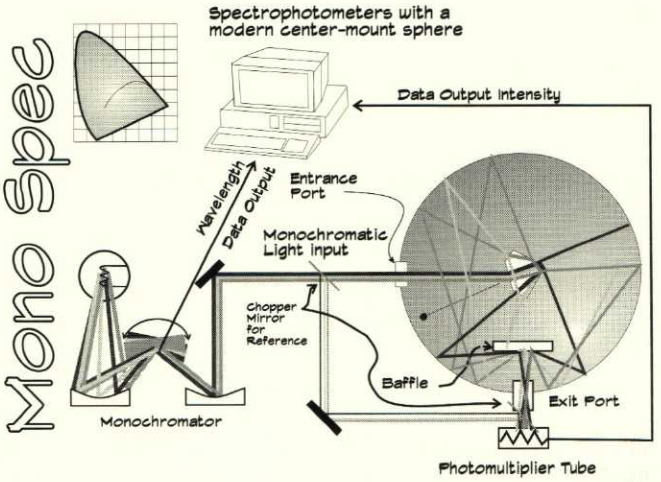


Fig.6 By illuminating one wavelength at a time, the true color of a diamond can not be measured.

imaging systems are completely new and employ a multi-filter (approximately 30 step) analysis[10]. Their detectors are typically Close Coupled Devices (CCD's) much like a monochrome video camera. Once integrated into a computer, they merge the data from the filters and display an image in color. Additionally, the intensity of each pixel's filter value gives a wide band spectral data. Imaging spectrophotometers can detect peaks of absorption at wavelengths as narrow as 10nm and can possibly detect such anomalies as chromium in Colombian emeralds.

At Tucson '95, LambdaSpec (Fig 7) of Milwaukee presented its new method (Fig 6)

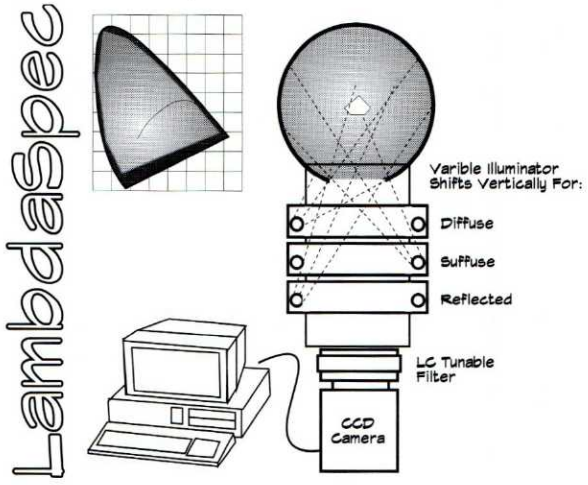


Fig.7 The variable illumination provides for different appearances in gems due to lighting.

that seems to offer a good solution to the illumination problem. By adjusting the distance of the lamp from the stone, they appear to succeed in getting diffuse, suffuse and reflected illumination that can vary the appearance of the gem. With their technology, LambdaSpec can give CIE and Munsell values to overall views or different parts of a stone, e.g., center and ends of marquise cuts. The LambdaSpec system currently sells for about $50,000.[11]

Zeiss / Gubelin's Spectrophotometer

Zeiss Optics along with the Gubelin laboratory in Switzerland released probably the first true polychromatic (white light) spectrophotometer for gemology in 1993. In this system, the gem is placed on the base of a sphere and illuminated with a xenon flash lamp. A fiber optic goes from the stone's table, to a diffraction grating, and on to a linear diode array– a line of photo-sensitive detectors that measure the intensity of light that falls on them. The light is reflected off or through the diffraction grating and a spectrum is projected onto a linear array. Thus, the whole spectrum of visible light can be measured in one brief flash[12]. This includes the visible fluorescent component that is undetectable with a monochromatic spectrophotometer.

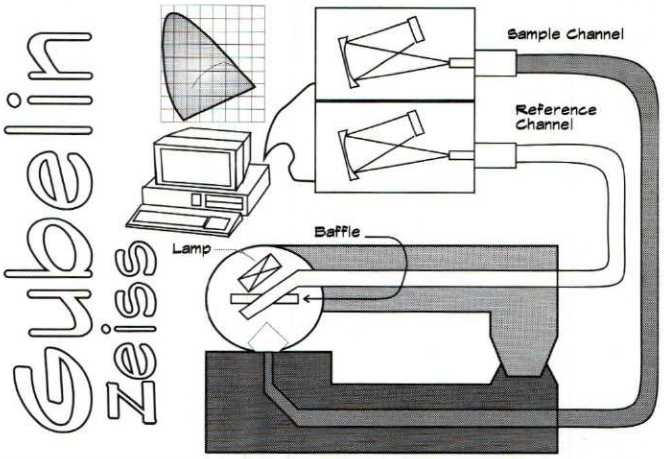


Fig.8 White light illumination provides for color measurement including color caused by fluorescence.

Zeiss / Gubelin's system also takes into account substitution error. Critical when analyzing all materials, substitution error is a result of placing any substance into an area (in this case a sphere) that was previously empty. Error can occur when light is transmitted through a gem, reflected back onto the sphere wall, reflected back into the gem, and then picked up by the detector. Without correction, a false, more intense color will be detected. This problem is even more pronounced in deeper tones.

The Zeiss system, which costs approximately $40,000, was greeted with much fanfare but limited sales success. The success it does enjoy comes from within the colored diamond market where it has allowed some diamonds previously graded "brownish" to be measured in a better light, thus increasing the stone's price[13].

Spectrophotometry, The Next Generation

Our desire for colorless diamonds as well as deeply saturated emeralds, rubies and other colored gem stones has fueled the search for a color grading system to be used for both colored and colorless stones. Unfortunately, we grade diamonds and colored stones differently and, so far, there isn't one tool that can do both jobs.

Help is on the way. In the very near future you or a neighbor in the gem trade will simply place a diamond on a platform, press a button, and the answer will appear without a sound. You won't give a second thought to how that box "knew" that the gem is a *Fancy Intense Blue* diamond of *Natural Color* from the *Golconda Mine.*

[1]J.M. King et. al., *Gems & Gemology* XXX, Winter 1994, p. 220.
[2]pers conversation with P.G. Read.
[3]pers conv. with Ian Mercer who works at DGL
[4]R.M. Shipley, Jr. US Patent 2,960,909.
[5]M. D. Haske, AGA Cornerstone, Summer 1993 & Winter 1993.
[6]P.G. Read Gemmological Instruments - 2nd Ed, p 75.
[7]pers conv. Julius Meister.
[8]GIA *Gem Instruments* and *I. Kassoy* catalog.
[9]I. Reintz, *Gems & Gemology*, Spring 1994.
[10]pers conv. with Berry Hovey at Cambridge Research and Instrumentation.
[11]Talk by R. Wagner of LambdaSpect Instruments at *A Microscopic View*, Tucson 95.
[12]*Color Measuring System for Diamonds and Transparent Gemstones* - Gem 2000, Carl Zeiss product information.
[13]H. Harris, Europa Star, 148-6 1991.

Research tells us that fourteen out of any ten individuals like chocolate.

Book Review

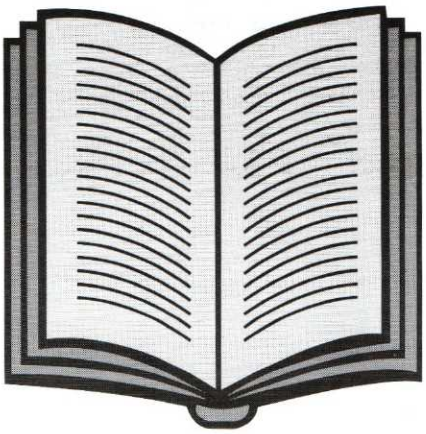


Photo Masters for Diamond Grading
by Gary Roskin, GG, FGA.
1994 Gemworld International,
Northbrook, IL.....$75.00

Reviewer: David S. Atlas

Most of us have the common bond of GIA diamond training and, like it or not, we have to admit our GG does not make us complete diamond graders. Instead, we are qualified only to learn how to grade diamonds properly. In particular, we need to learn how to grade diamonds that are larger than the GIA diamond course practice stones. While the underlying principles are constant, the actual grading determinants enter a less well understood arena as diamonds get larger. One might say there is more subjectivity involved.

Photo Masters for Diamond Grading is a logically organized 94 page reference guide that reduces the subjectivity that occurs when larger diamonds are clarity graded. The book includes background text dealing with the history of GIA clarity grading, split grading, and actual GIA lab practices.

If a picture is worth a thousand words, diamond grading pictures may be may be worth volumes. There are precise photos of different inclusions and the corresponding GIA/GTL clarity grades in sizes from light carats to over 3.00 carats, as well as a section on "Grade Makers", those inclusions that are most influential in determining an overall clarity grade in a specific stone. Reflecting inclusions, while not discussed at length, are nicely covered by photos. Of particular note are the photos of polish, girdle, and culet. The polish photos are the first I have seen where one can see and comprehend the various grading effects. The excellent girdle and culet size photos are probably the most useful reference tools in the book and will add consistency to a reader's grading work. The symmetry photos, while good examples, were limited.

The last chapter compares grading from one major lab with another. Gary Roskin has taken a diplomatic approach and has drawn no conclusions for the reader. For most readers, the major labs do similar grading. However, there are not enough photos to make exact determinations.

A few excellent photos of fracture filled diamonds are included, but we are left to arrive at our own conclusions in regard to uniform grading of this problematic material. Another book, another time, no doubt.

While more photos of the clarity grading of very large diamonds would be welcome, the sizes the trade generally encounters were nicely covered. When one gets a taste of something good, there is the desire for more and more. Fancy shapes, fancy colors, and diamonds greater than 10 carats, could have been covered more as these are areas where few of us have adequate training. Of course, these additional photos would have made the book too costly for the majority of readers.

While not a total reference guide, this is material you'll be glad to include in your library. Consider Photo Masters for Diamond Grading as one more part of your educational process if you are building a reference library or if you grade diamonds larger than 0.50 carat.

AGA CERTIFIED GEM LABS

submitted by Sharon Wakefield

INCREASING THE FOLD

I am pleased to report that the Certified Gem Lab Program has three new members: Brenda Reichel, Barbara Leal (nee Shaieb) and Lorraine Lopezzo.

Ms. Reichel owns *Carats and Karats Fine Jewelry* in Honolulu, Hawaii and has been actively engaged in all aspects of gemstone identification and grading as well as appraisal work since 1982. Brenda is also active in many trade organizations with the GIA Alumni Association, Hawaii Jewelers Association, Jewelers of America and Association of Women Gemologists topping her list.

The addition of **Ms. Leal** to our membership roster expands our international influence — this time to Cambridge, England. Barbara, owner of *IRIS International, Inc.* moved to the United Kingdom shortly after completing the requirements for CGL membership. She was previously located in Tucson, Arizona. Barbara has been a member of AGA since 1989 and includes the GIA Alumni Association, America Society of Appraisers and American Gem Society among her list of trade organization memberships.

Ms. Lopezzo's gemological laboratory is located in Long Valley, New Jersey. Lorraine is a *Fellow of the Gemmological Association of Great Britain* as well as a *Graduate Gemologist.* She is also a Senior Member of the American Society of Appraisers, an affiliate member of the American Gem Society and a member of the National Association of Jewelry Appraisers.

Please join me in welcoming these new members to a very important component of the Accredited Gemologists Association: The Certified Gemological Laboratory Program.

For you to be successful, sacrifices must be made.
It's better that they are made by others but failing that, you'll have to make them yourself.
–Rita Mae Brown

EDUCATIONAL COMMITTEE

submitted by Anna Miller

The Education committee held a start-up meeting in Tucson in February, to investigate ways of reviving the Certified Master Gemologist Program. The issue is under study by the committee, but no new program will be instituted until 1997. Careful planning and writing of the program is an agreed upon point by all committee members.

There will be a one day educational day at the AGA Conference next February. Details will be announced later in the year.

The Educational Committee is composed of: Anna M. Miller, Chair, Susan Eisen, Stanley Cohen, Cortney Balzan, Sue Whitaker, Melinda Adduccci, Gary Roskin, Tony F. Laughter, and Dr. Kathleen Bates Mayer.

The wisest mind has something yet to learn.
— George Santayana

Welcome!

With this issue, Lorraine Lopezzo of New Jersey becomes Editor of *Cornerstone.* Ms. Lopezzo holds a Masters of Business Administration, is a Graduate Gemologist (GIA) and a Fellow of the Gemmological Association of Great Britain (FGA). In addition to her ASA credentials, she recently has been recognized as an AGA-Certified Gemological Laboratory.

Articles "in the works" include an examination of emerald filling, and an investigation of the latest synthetic ruby. Lopezzo plans to maintain the current *Cornerstone* format, and wishes to involve more AGA members in publication. Contact Lorraine with your ideas for articles, questions and suggestions (41 East Mill Road, Suite 2, Long Valley, NJ 07853).

ILC: The International Learning Center

Located in San Francisco, California, The International Learning Center (ILC) was founded in 1994 by AGA Past President Cortney Balzan. The ILC concept is simple: establish and furnish a center for gemological learning that is global and unrestricted. What does ILC represent?

- **I** International scope brings in a mix of worldwide cultures, in both teachers and students.
- **L** Learning involves the concepts of life-long education, intensive instruction and practical knowledge from industry leaders.
- **C** The Center is surrounded by active industry trades. Diamond cutters, lapidaries, jewelry manufacturers, gemstone and diamond dealers will participate in the learning process. The historic Phelan Building of Union Square is home to ILC.

Participants have a range of interests, from simple fascination with gemstones to those professional students preparing for their FGA title. ILC concentrates on quality of instruction, not quantity of students. The Center focus is on reaching the Heart, Soul, Spirit, Compassion and Concerns of each student.

The Revere Academy of Jewelry Arts

Other schools and associations have asked to participate with ILC. In 1995, **The Revere Academy of Jewelry Arts** joined forces with ILC. The well-known Revere Academy offers short, intensive classes in jewelry design, production and gems for beginners as well as seasoned professionals. Academy students, after completing their course of study, can gain experience with additional tutelage from ILC. Instructors guide students individually as they progress through both theoretical materials and hands-on laboratory skills. This approach insures that students receive more than theory, and more than practical knowledge. They gain the confidence to succeed.

Gemmological Association and Gem Testing Laboratory of Great Britain

ILC is now fully designated as a **GAGTL Allied Teaching Centre**, and has been accepted by GAGB to offer coursework leading to the Diploma in Gemmology. The **Gemmological Association of Great Britain**– the oldest gem institute in the world– offers the prestigious FGA designation.

The Fellow of the Gemmological Association designation is earned via a demanding examination, held on but one day each year worldwide. The pass rate for Diploma examinations this year was only 40%. Obtaining this credential requires commitment. ILC is open five days a week from 9am to 6pm, to help students reach this important goal. Those requiring additional coaching can reserve the Center for weekends and evenings.

Challenge Yourself

AGA members are invited to take the challenge. Take the gemmology or diamond course from the Gemmological Association and Gem Testing Laboratory of Great Britain. AGA member scores should be much higher than the norm.

Members that are GIA Graduate Gemologists and wish to continue their training in gemological sciences, and to reach for the highly-respected FGA title or Diamond title may do so at ILC. The costs associated with study and testing are significantly reduced by undertaking the process through the International Learning Center in San Francisco.

For AGA Members, ILC support systems are free of charge. For an enrollment form and course listings offered by GAGTL, contact the International Learning Center at 415/834-9209.

Want to be Boss?

"It's not about personality. It's about behavior." So says Renato Tagiuri, PhD, professor emeritus of social sciences at Harvard Business School. Decades of research have led him to this one conclusion. But there's more.

According to Tagiuri, 10 essential actions make for a good manager, regardless of personality type.

- Clarify objectives of job assignments
- Describe assignments clearly
- Listen to your employees' views
- Provide resources necessary to carry out assignments
- Be explicit about evaluation standards
- Reward effort and offer incentives
- Give prompt feedback on performance
- Avoid personal friendship with employees
- Admit errors, don't tell lies
- Make decisions that are yours to make

Mom knew it all along.

One never notices what has been done;
one can only see what remains to be done.
–Marie Curie

We have too many high sounding words,
and too few actions that correspond with them.
–Abigail Adams, letter to John Adams (1774)

Please send me a membership application for Accredited Gemologists Association

Name _____

Address _____

City _____ State _____ Zip _____

Phone # _____

Application Guidelines

Membership with full voting privileges is available to professionals holding gemological diplomas from accepted institutions.
Associate Membership is available to students of gemology and avocational gemologists.
Supplier Membership is available to providers of goods & services to the gem & jewelry industry.

Membership Dues & Fees

$25 Processing Fee (one-time, non-refundable) will be retained by AGA.
$125 Initial Voting Member Dues.
$75 Initial Associate Member Dues.
$175 Initial Supplier Member Dues.
Make checks payable to Accredited Gemologists Association, in US funds.
Membership is renewable annually (Voting $100, Assoc. $50, Supplier $150).

AGA will not discriminate against any applicant based upon race, creed, color, national origin, age or gender. Applicants are required to meet substantial member qualifications, and to adhere to the AGA Code of Ethics.

Return This Request To:

Stanley Cohen, AGA Membership Chair
4747 South Hulen, Ste 109
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