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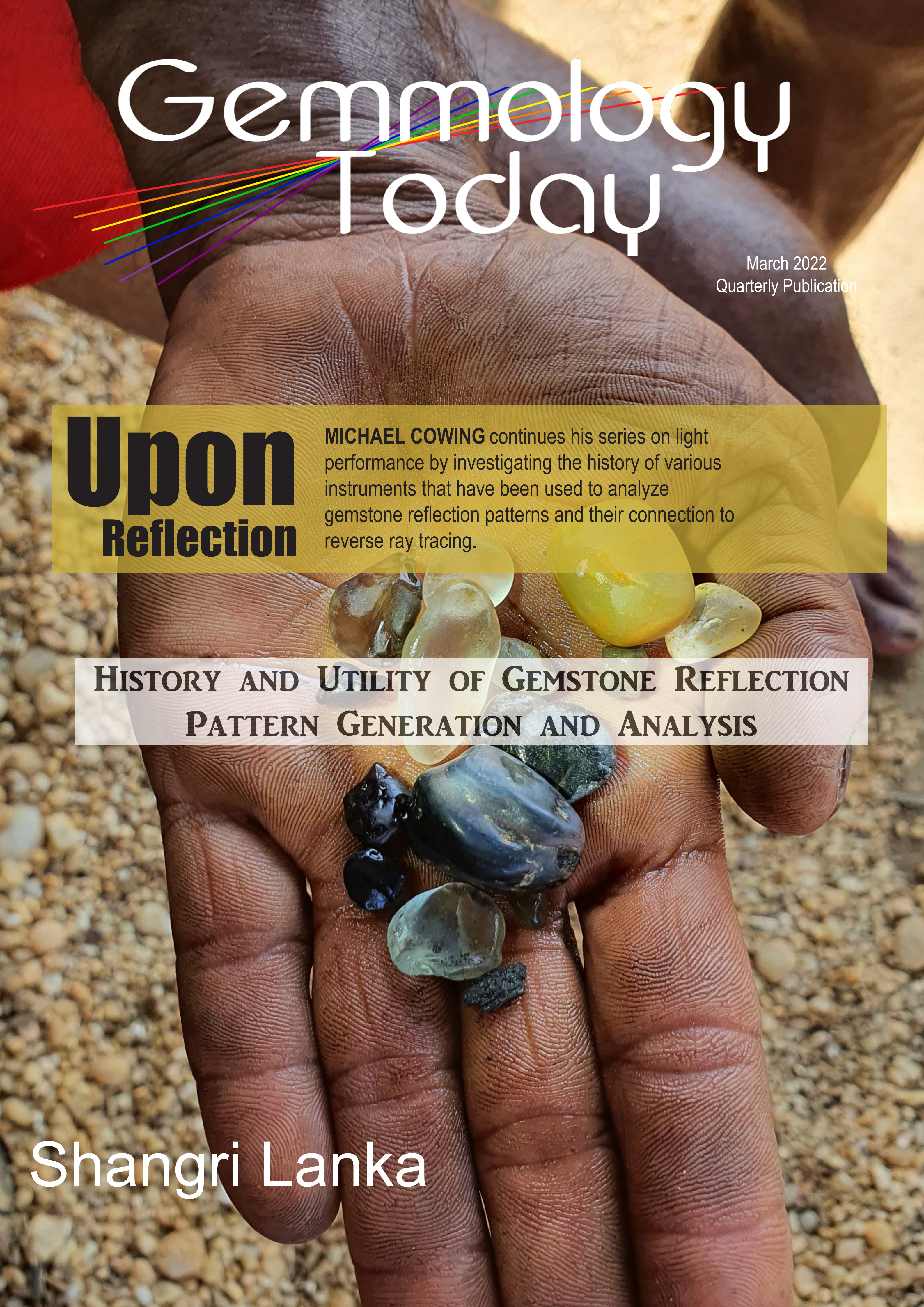

Upon Reflection

MICHAEL COWING continues his series on light performance by investigating the history of various instruments that have been used to analyze gemstone reflection patterns and their connection to reverse ray tracing.

History and Utility of Gemstone Reflection Pattern Generation and Analysis

Shangri Lanka

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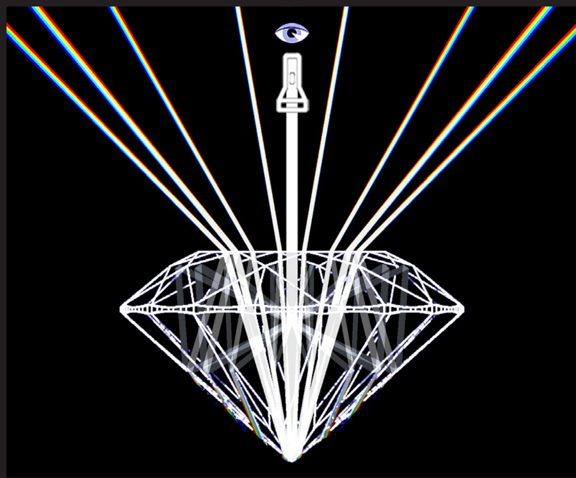
ABSTRACT

The greater utility of a gemstone's spectral reflection pattern and its significance is realized with the observation that its generation is the same process as reverse ray tracing from the eye of an observer viewing the gem face-up. In the process of reverse ray tracing, the same ray/beam light source is sent into the gem from the observer's eye, along the gem's axis and perpendicular to its table resulting in the same spectral pattern radiating from the gem onto a flat screen or hemisphere.



A gemstone's reflection pattern is produced by illuminating it with a narrow beam of light entering through a hole in a white card (or other flat screen). The beam enters parallel to the gem's axis, and perpendicular to its table. After two or more internal reflections the beam emerges as a pattern of many tiny spectrums reflected and refracted back onto the white card.

In the third part of the round brilliant light performance trilogy, titled 'Diamond's Spectral Constellation', the diamond's spectral reflection pattern was utilized to complete the analysis of features of brilliant cut diamond light performance.

The features of best/ideal diamond cutting were studied and analyzed in 'Round Brilliant Cut Beauty and Light Performance Parts 1 and 2'. That study and analysis employed 'reverse ray/beam tracing' through the many 'virtual facets' making up the diamond's crown. Virtual facets are the tiny windows, much more numerous than actual facets, from which radiate the diamond's brilliance, fire and sparkle. The brilliance, fire and sparkle are reflected to the observer from points in the gemstone's surrounding illumination. This article reveals those points to be the the gemstone's reflection pattern.

The spectral reflection pattern of Figure 2 was generated by the setup of Figure 1, which utilized the narrow beam of light from the sun projected through a hole in a white board. The many emerging spectra, one from each virtual facet in the crown, are projected back on the white board, producing the diamond's spectral reflection pattern.

Study and analysis of gem beauty/optical performance, employing various versions of instruments that generate a gem's reflection pattern in all faceted gemstones, not only in diamond, is to be found in faceting and gem cutting literature going back at least to 1916.

This article investigates the history of methods of gemstone reflection pattern generation. It examines their usefulness in judging and analyzing gem cut design and cut quality. A central question addressed is: 'Using a gemstones reflection pattern, what conclusions and determinations have been made or can be made about gem cut design and cut quality?' This question is answered in new and greater depth made possible by recognition that the spectral reflection pattern is the same pattern produced by a ray/beam sent in

Figure 1. Setup to generate and photograph a diamond's Spectral Reflection Pattern utilizing a beam of light from the sun

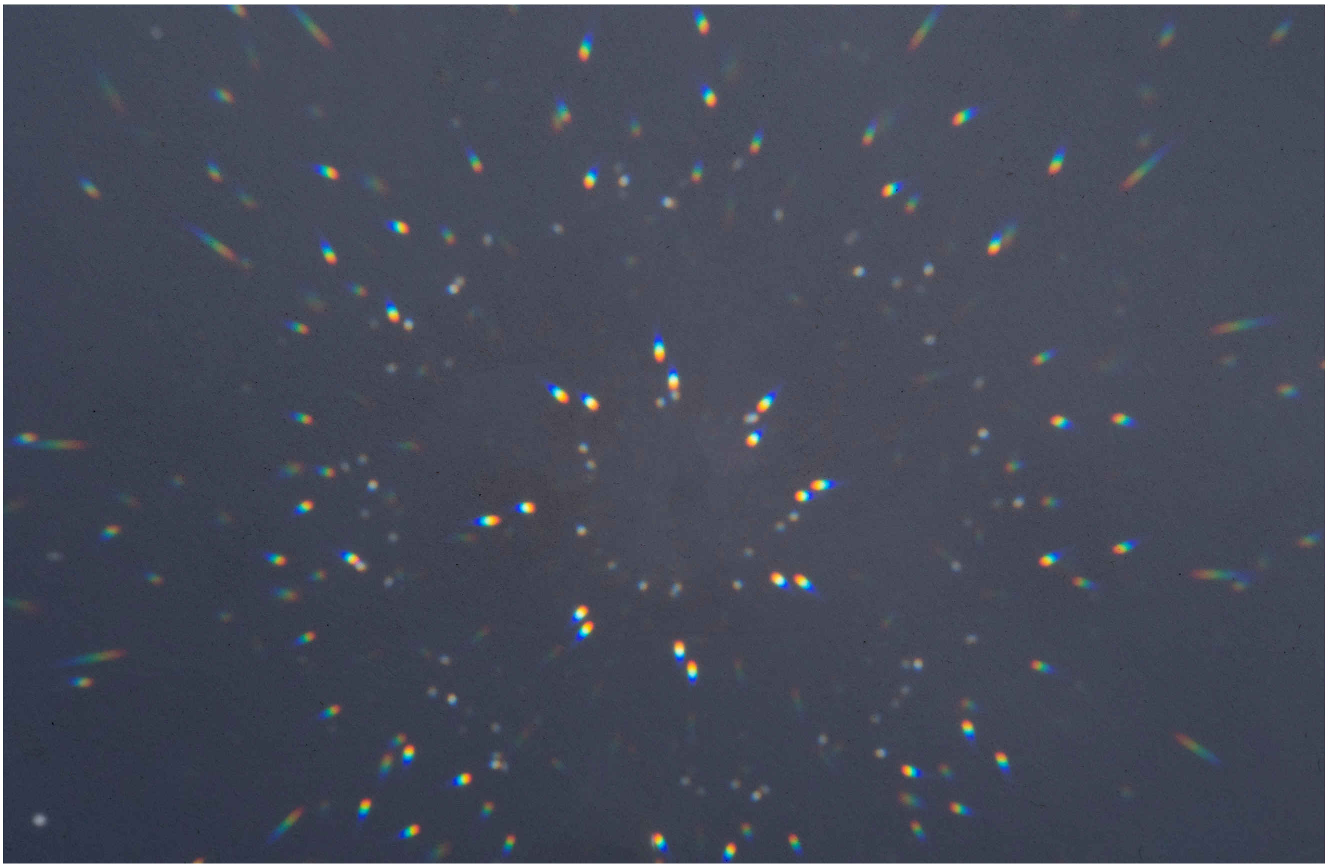


Figure 2. Spectral reflection pattern of a GIA Excellent and AGS Ideal Brilliant Cut Diamond.

reverse of normal light travel, from an overhead observer's eye, along the gem's axis, and entering perpendicular to its table. This results in the same spectral reflection pattern radiating from the gem onto a flat or hemispherical white surface. Thus, the spectral reflection pattern, and the reverse ray trace reflection pattern from an overhead viewer's eye are seen to be one and the same.

In his 1916 book, 'Diamonds: A Study of the Factors that Govern their Value', we find Frank Wade discussing comparing the 'fineness' of diamonds through their constellation of prismatic (spectral) colors. He recommended holding two diamonds in direct sunlight and throwing 'the prismatic colours from each onto the same opaque white card held in the direction of the sun' in order to ascertain the diamond with 'the most attractive group of coloured images'.

A similar version of spectral reflection pattern generation, also using the sun's rays, is discussed by Marcel Tolkowsky in his famous treatise from 1919, 'Diamond Design'. There he says: 'that the diamond owes its extraordinary 'fire' to its very high dispersion (the greatest of all colourless gem-stones). The effect of refraction in a diamond can be shown very interestingly as follows :-- A piece of white cardboard or fairly stiff paper with a hole about half an inch in diameter in its centre is placed in the direct rays of the sun or another source of light. The stone is held behind the paper and facing it in the ray of light which passes through the hole. A great number of spots of the most diverse colours appear then upon the paper, and with the slightest motion of the stone some vanish, others appear, and all change their position and their colour. '

Discussion of later versions of gem reflection pattern analysis that were used to examine light performance, not only in diamond, but in all faceted gemstones, appears fourteen years later in the German gem literature in the book published in Leipzig, Germany in 1933 by Dr. W. Fr. Eppler titled 'The Diamond and its Processing'. There in the section titled 'The theory of the diamond cut', Eppler describes a gem reflection analysis instrument by Siegfried Rosch constructed to test gem brilliance. According to Eppler, the apparatus, called the 'reflectograph' (Figure 3) 'is based on the principle of reflectography.'

The spectral reflection pattern is recorded with the reflectograph by one of two methods shown in the schematic diagrams Figures 4 and 5. Figure 4 illustrates use of the reflectograph to record the spectral constellation pattern on photographic paper in the flat plate cassette labeled P. Eppler says 'the light from the lighting tube L passes through the plate P from behind through a hole and hits the stone in the direction of axis A to reflect the reflection pattern back on the plate.' Figure 5 illustrates use of the reflectograph to record the reflection pattern on photographic paper in the removable cylinder Z, in which photographic paper is lying. 'The choice between both methods is optional, and the change can be done easily.'

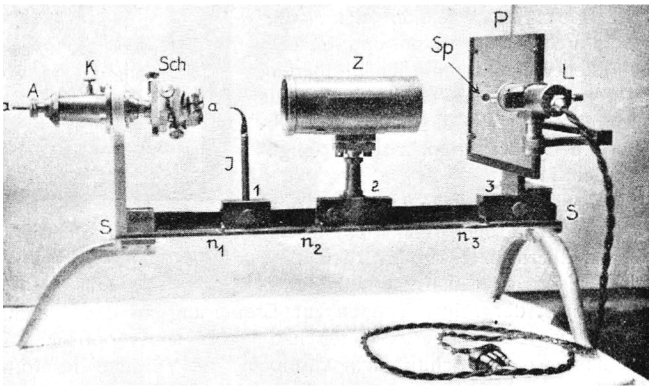


Figure 3. Van S. Rosch reflectograph for measuring brilliance.

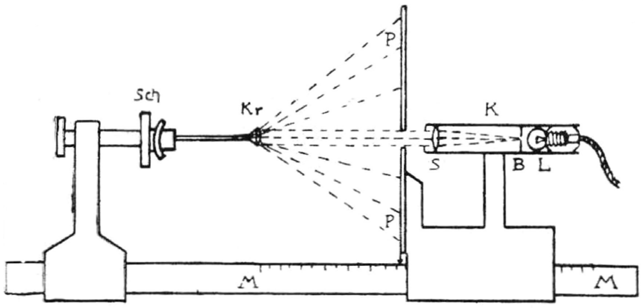


Figure 4. Schematic of the reflectograph. In this arrangement a beam of light illuminates the stone through an aperture in the photographic plate P, which records the spectral constellation reflection pattern.

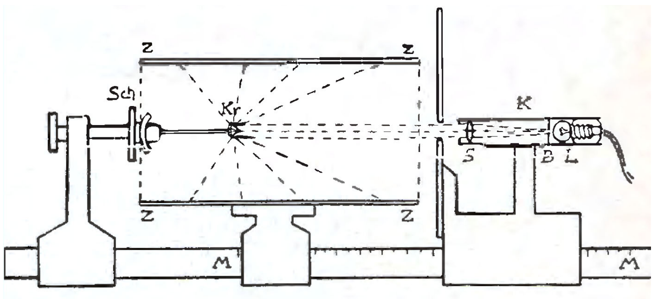


Figure 5. Schematic of the reflectograph arranged to record the spectral constellation pattern on photographic paper in the cylinder Z.

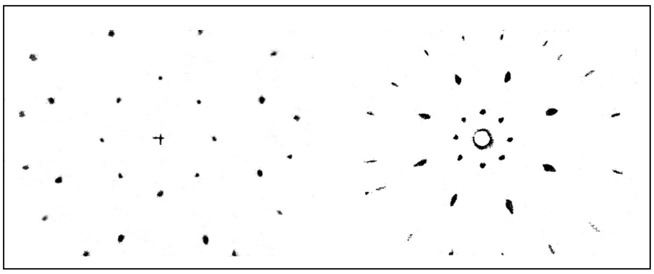


Figure 6 (L). Reflection pattern from the crown of a red garnet recorded on photographic paper in the plate P by the reflectograph in the Figure 4 configuration. Figure 7 (R). Reflection pattern of a deep blue sapphire, brilliantly ground (very regular) recorded on photographic paper in the plate P by the reflectograph also in the Figure 4 configuration.

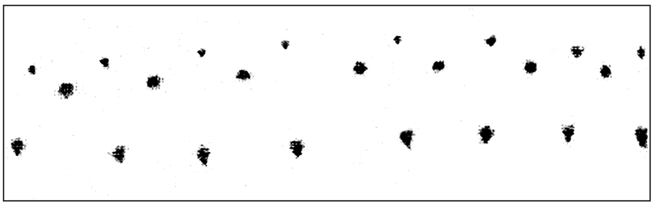


Figure 8. Reflection image from the sapphire of Figure 7. This is a cylinder projection in the reflectograph arranged in the Figure 5 configuration recording the spectral reflection pattern on photographic paper in the cylinder Z.

Figures 6 and 7 are the reflection patterns from the crowns of a red garnet and a deep blue sapphire recorded on photographic paper in the plate P by the reflectograph using the configuration diagrammed in Figure 4. Figure 8 is a cylinder projection from the reflectograph of the sapphire of Figure 7 using the Figure 5 configuration, and recording the spectral reflection pattern on photographic paper in the cylinder Z.

Eppler further says: ‘There is still a second apparatus for the examination of brilliance in the trade, which ... can be used to do a simple comparison of two gemstones. This is the ‘Brillantoscope’ by A. Johnsen (Figure 9). The apparatus is based on the same principle as the Reflectograph from S. Rosch.’ However, the ‘Brillantoscope’ is equipped with two hemispheres for a better side-by-side comparison of the reflection patterns of the two stones.

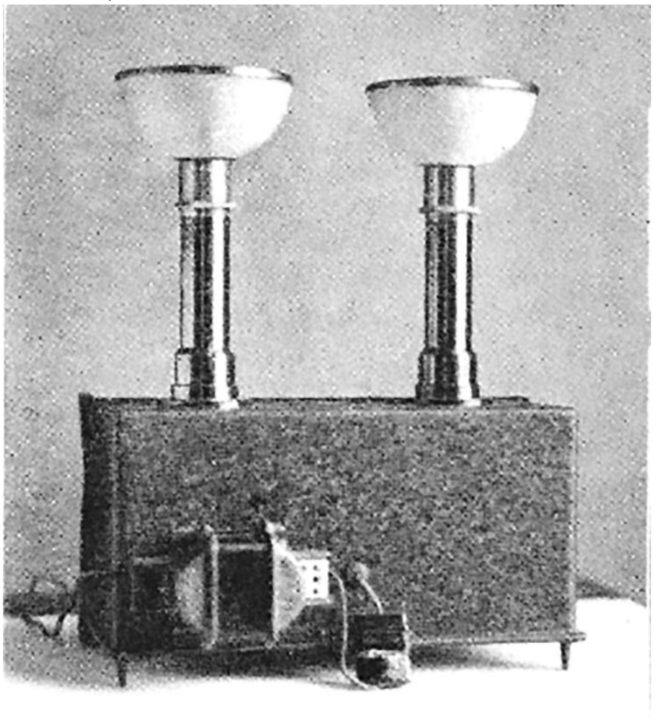


Figure 9. Brillantoscope by A. Johnsen for the examination of cut quality.

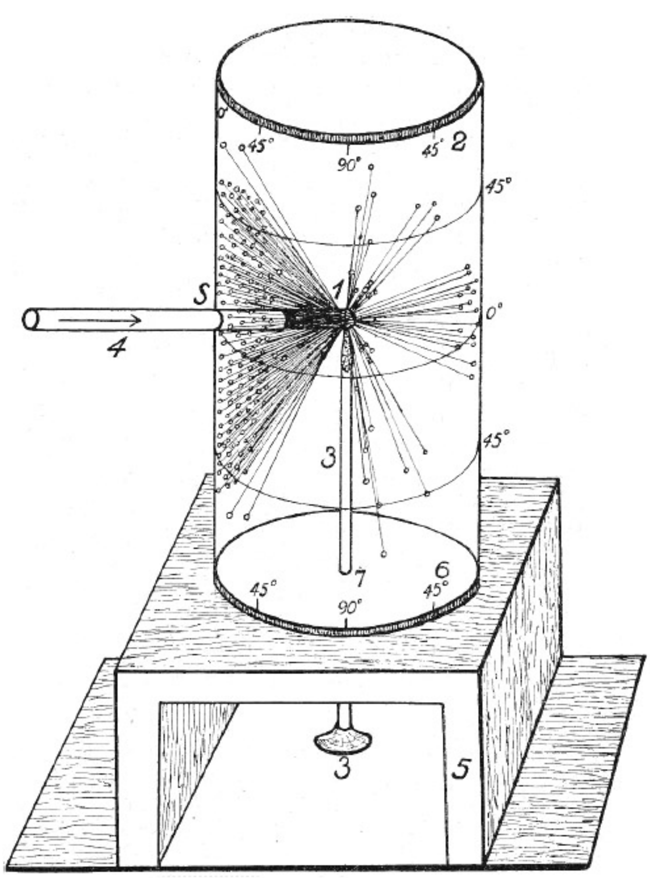


Figure 10. The ‘Brillanzoskop’ (trans: brilliance-scope) 1 diamond; 2 screen; 3 stone carriers; 4 radiant tube.

Sixteen years after Eppler’s book, Dr. Wilhelm Maier published his treatise ‘Diamonds and pearls’ in 1949 in Stuttgart, Germany. In a section of his book titled, ‘The Brillanzoskop’ (trans: brilliance-scope), Maier says this instrument tests the diamond’s brilliance. He says: ‘All the brilliance scopes built up to now are based on the intention of making the external and internal reflections, produced by a bundle of light incident parallel to the axis of the gemstone cut, visible on a screen. Johnson used a frosted glass hemisphere as a screen, while Rosch, in order to be able to carry out measurements, used plates and cylinders, the axis of which is aligned with the incident light. Brilliance scopes or brilliance meters of the type Figure 10, prove to be even more suitable.’

The example reflection diagram in Figure 11 is generated by the Brillanzoskop of Figure 10. It is the reflection pattern from the crown of an imitation of the ‘Star of Este’ diamond.

A couple of decades later, gemstone reflection patterns were demonstrated to the gem faceting community in the United

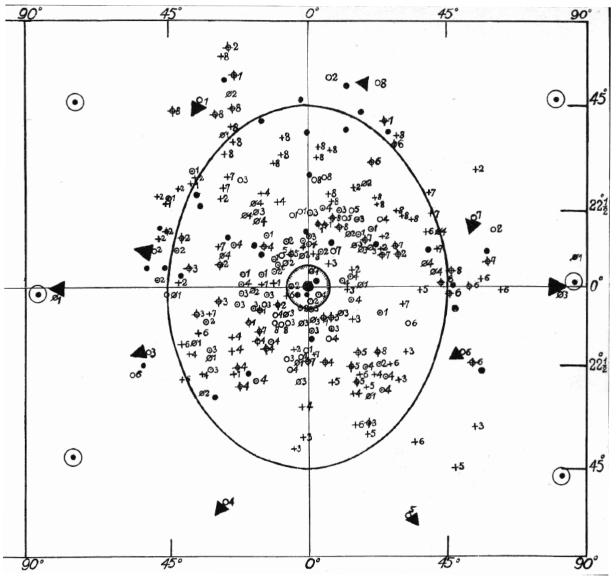


Figure 11. Drawn Brillanzoskop reflection diagram of the crown view of an imitation of the 'Star of Este' diamond.

States by Bob Long, co-inventor with Norman Steele, of meet point faceting, and reproducible computer aided gem facet design. Long's reflection patterns were generated in the usual manner similar to that of the Figure 4 reflectograph configuration. Bob demonstrated a version of the technique of gemstone reflection pattern generation at United States Faceters Guild meetings. His setup, which was published in the July, 1986 Seattle Facetor Design publication, is diagrammed in Figure 12.

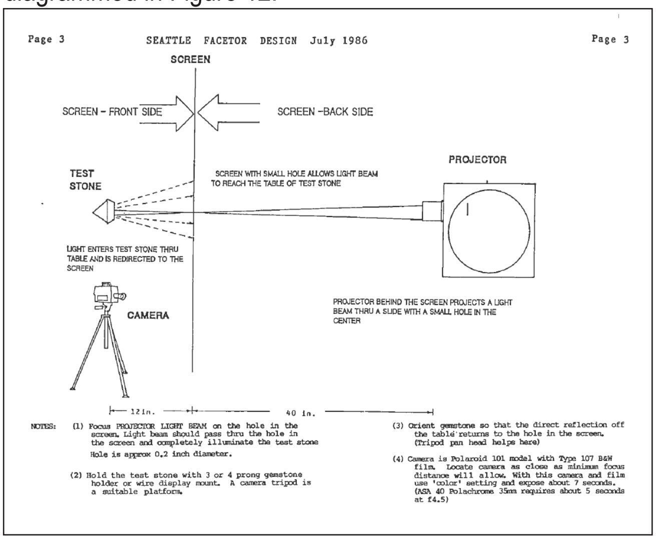
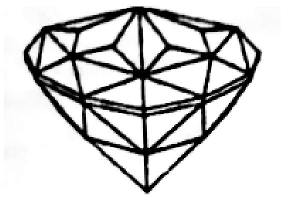


Figure 12. Bob Long's demonstration setup to generate a gemstone's on axis reflection pattern

Figure 14 is Long's computer generated reflection pattern of the shield facet cut design diagrammed in Figure 13.

Bob Long asked: 'Can we relate the Light Reflection Pattern (LRP) to observable features in gemstones?' What conclusions and determinations about gem cut design and cut quality can be or have been made from studies of a gemstone's reflection pattern?



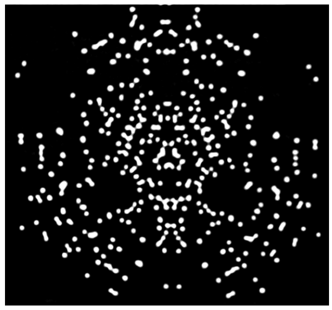


Figure 13. Shield shape, London Shield cut design. Figure 14. Computer generated reflection pattern of Figure 13 shield design.

Al Gilbertson, member of the GIA research team that studied and modeled the 'Appearance of the round brilliant cut diamond,' including 'An Analysis of Fire', responded to Bob Long saying: 'The LRP may be a representation of the fire pattern if the fire generated by a stone is strong enough in the environment to be viewed by an observer.'

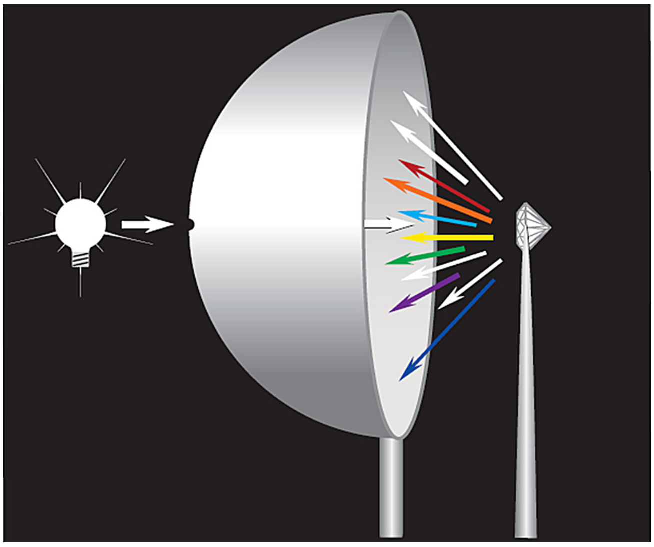


Figure 15. Setup to study fire by generating and projecting a diamond's spectral reflection pattern on a hemisphere, as A. Johnsen did with his Brilliantoscope. Courtesy of GIA

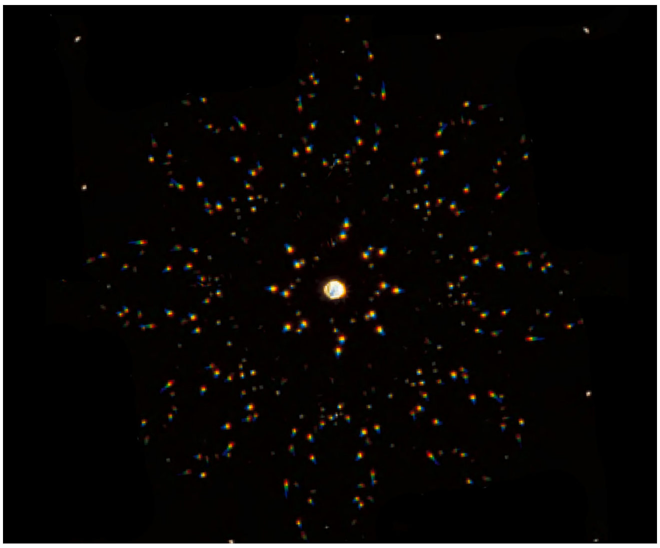


Figure 16. Spectral Reflection Pattern from a GIA Excellent cut diamond, created from a quadrant of the pattern photographed by Al Gilbertson. Courtesy of GIA

He went on to say, 'a German mineralogist, A. Johnsen, developed a Brilliantoscope, (See Figure 9) to back his findings of which angles produced the best stones. He placed a diamond in each of the two globes and their patterns were compared to determine which was better. GIA also used this approach (reflection pattern projection on a hemisphere) to study fire and develop metrics for fire in diamonds.' The experimental design (Figure 15) allowed GIA to observe dispersed light from actual diamonds. Figure 16 is the spectral reflection pattern of an Excellent/Ideal cut diamond photographed by Gilbertson in the hemisphere.

Conclusions of cut quality and beauty/light performance gained from study of spectral reflection patterns

These reflection pattern generation methods and instruments, from Wade and Tolkowsky to the present, all generate a gemstones on-axis reflection pattern.

Historically, the reflection pattern was mainly used to judge or validate the symmetry and cut perfection of a gem's design and faceting. A symmetric reflection pattern was pointed to as evidence of excellent gem symmetry and cut quality. The unique reflection pattern of each gem has also served as a form of identification, as, like a fingerprint, no two patterns are exactly the same.

Because each wavelength (spectral color) of light follows the same path in either direction, it is proven that each tiny spectrum is the location being reflected to the observer's eye from one of the many virtual facets that comprise the diamond's crown.

The optical analysis using reverse ray tracing in the three study articles provided answers to why the round brilliant Ideal cut's small range of angles and proportions are superior in beauty and light performance to diamonds cut with parameters outside these best ranges. This trilogy of articles has shown why the 'Ideal Cut's' three most important parameters; the crown and pavilion main angles and lower half length, in proper combination with the other four defining parameters, result in the best/ideal round brilliant beauty/ light performance.

Because of the equivalence of spectral pattern generation, and reverse ray tracing from the face-up viewer, both of which generate the same spectral reflection pattern, they both can be used together, furthering the analysis and evaluation of gem design and cut quality accomplished in the three previous articles. In a follow-on article, methods will be shown that augment use of the spectral reflection pattern through identification of the particular virtual facet that corresponds to each individual spectrum.

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