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(54) METHOD FOR GRADING CUT OF DIAMOND

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Specification

1. Title of Invention

Method for grading cut of diamond

2. Claims

A method for grading a cut of a diamond wherein a simulation is performed, said simulation consisting of making simulated light beams incident on an upper portion from a girdle of a cross-sectional shape of a diamond, and after the simulated light beams are refracted by an inner portion of the diamond, simulating from which portion of the diamond the simulated light beams exit, and the cut of the diamond is graded from the results thereof.

3. Detailed Description of the Invention

The value of a diamond as a gemstone is determined by the so-called “four Cs” of carat (unit of weight), color, clarity (grade that expresses the presence of inclusions), and cut (dimension ratio of each portion).

Among these, carat, color, and clarity are definite grading criteria, but cut is not determined in such a rational manner.

At present, the most common diamond shape is a brilliant cut, and the present invention relates to a method for grading it.

The characteristic of an ideal brilliant cut diamond is that light pouring down from above is reflected by the interior of the diamond and returned upward, which the dimension ratio of each portion is not ideal, as illustrated in FIGS. 2 and 3, light passes through the bottom, and the brilliance of the diamond as a gemstone is diminished. In other words, the objective of the brilliant cut is that all light pouring down from above is returned upward to maximize brilliance as a gemstone.

At present, the method generally used to grade a cut is as follows.

Using precision measurement devices such as a gemstone microscope and gemstone scale, each portion (girdle diameter, table dimensions, total height, crown height, girdle thickness, pavilion depth, angle between girdle plane and upper main facet, angle between girdle plane and lower main facet, and size regularity of facets, girdle, and culet) of the diamond is measured, and the cut is judged and graded based on the magnitude of the differences between those dimension ratios and the ideal dimension ratios. Finally, if the weight of the diamond subject to grading is taken as *a* carats and the weight of the largest ideally cut diamond (4) that could be created by recutting it is taken as *b* carats, the portion of *a* minus *b* carats indicated by hash marks in FIG. 4 is the excess portion, and therefore a deduction is made for this portion and the grade of the cut is *b* carats. The cut is graded by conversion to a weight grade.

This weight deduction method does not associate the degree of brilliance and the quality of the cut of a diamond as a gemstone, and does not result in a grade that is based on the original objective of the brilliant cut.

In consideration of the objective of the brilliant cut, the present invention is a method for grading the quality of a cut based on the degree of brilliance of a diamond. The following two methods are considered as such a method.

Method 1: Light beams are made to enter the diamond, and the degree of brilliance is measured by actually measuring the paths of those light beams.

Method 2: The cross-sectional shape of the diamond is measured, and using the law of refraction when light beams are incident on the diamond and the law of reflection inside the diamond, how the incident light beams advance is theoretically simulated.

Method 1 is difficult to implement in the following respects.

FIG. 5 illustrates the case where a diamond subject to grading (3) is set on a pedestal (5), and light beams from above ((6)-e, (6)-f, (6)-g, (6)-h, (6)-i) are made to enter it, and after refraction and reflection on the interior, whether or not the light beams return upward from the girdle (7) is measured by means of a hemisphere (8) in which photoelectric elements are placed on the entire inner surface.

(a) Because diamonds are generally small, they are difficult to set precisely on a pedestal.

(b) Contamination on the surface of the diamond affects measurement.

(c) Inclusions characteristic of the diamond may block light beams.

(d) Precision equipment is required to accurately measure light beams exiting the diamond.

Therefore, the present invention achieves its objective via method 2.

One method for measuring the cross-sectional shape of a diamond is to overlay an X-Y coordinate scale on the screen of a proportion scope (equipment that magnifies and projects a diamond on a screen), and determine the coordinates of five points 1, m, n, o, and p. As illustrated in FIG. 6, by adjusting the zoom lens of the proportion scope, m is measured at the origin (0, 0) of the X-Y coordinate system, and o is measured so as to lay over the point (N+1, 0) on the X axis. The X axis lays over the girdle of the diamond. Furthermore, l, n, and p are taken as points (X1, Y1), (Xn, Yn), and

conditions described above for ease of explanation, but in actual measurement, simulation can be performed by measuring in any quadrant.

When the line segment mo is divided into N equal parts and simulated light beams L_1, L_2, … L_q, …, L_N are set above the diamond perpendicular to line segment mo (parallel to the Y axis) so as to pass through each of the equally-spaced points, the equation of L_q is represented by x = q (the range is up to the point of incidence on the diamond). L_q advances downward and intersects any of line segments lm, op, and pl, where it is refracted and enters the interior of the diamond. The equation of the path after refraction can be determined by (e), (f), and (g) below.

(e) Equation x = q of simulated light beam up to before incidence

(f) Coordinates of l, m, n, o, p

(g) Snell's law, which expresses the relationship between the angle of incidence r and the angle of refraction s

$$\sin r / \sin s = \text{index of refraction} (\approx 2.42)$$

The simulated light beam after incidence intersects with any of line segments lm, mn, no, op, and pl, but if the angle of intersection is greater than a critical angle (≈ 24°26'), it results in total reflection (angle of incidence = angle of reflection). The equation for the path after total reflection can be determined by (h), (i), and (j) below.

(h) Equation of path of simulated light beam immediately before total reflection

(i) Coordinates of l, m, n, o, p

(j) Rule that angle of incidence = angle of reflection

If the totally reflected simulated light beam is also totally reflected inside the diamond, the equation of its light path can be determined by the above (h), (i), and (j).

On the other hand, if the angle of intersection is smaller than the critical angle, the simulated light beam exits to outside the diamond. The equation of the light path after exiting can be determined from (k), (l), and (m) below.

(k) Equation of path of simulated light beam immediately before exiting

(l) Coordinates of l, m, n, o, p

(m) Snell's law (item (g) above)

In the method described above, the simulated light beam x = q is theoretically calculated from when it exits to the outside. If the line segment that it intersects with when it exits to the outside is any of lm, op, or pl, this simulated light beam returns upward and thus results in brilliance. Conversely, if it exits to the outside from mn or no, it passes through downward, and therefore does not result in brilliance.

Simulation is performed for each of the simulated light beams $L_1, \ldots, L_N$, and if N' rays among the N simulated light beams result in brilliance, N'/N is used as the grade of the cut. Considering the case where total reflection is repeated and the simulated light beams never exit to outside the diamond, the limit of the number of times of total reflection is set, and if that limit is exceeded, it is not deemed as brilliance.

Since a diamond has rotational symmetry, a more rational result can be obtained if several cross-sections are measured and simulated and the respective results are judged comprehensively.

Furthermore, to achieve better precision and to know which direction of light will result in the most efficient brilliance when setting a diamond for ornamentation, a method of simulation that adds one or several of the following items according to objective may be used.

I. Regarding cross-sectional shape measurement (FIG. 7)

A. Considering girdle thickness, measure m and o by separating into m-1, m-2, o-1, and o-2.

B. Similarly, measure the culet as n-1 and n-2.

In this case, if a simulated light beam exits to the outside from the girdle portion or the culet portion, it is not deemed as brilliance. Further, since the girdle portion is not normally polished, total reflection does not occur, and therefore, light beams that advance in it do not result in brilliance.

II. Regarding setup of simulated light beams

A. Light beams perpendicular to line segments lm, op, and pl are set up, and simulation is performed. (FIG. 8)

B. Incidence points are set up by dividing the aforementioned three line segments at equal intervals. (FIG. 9)

C. Simulation is performed using parallel light beams from a certain specified direction. (FIG. 10)

D. Simulation is performed using light beams from all directions. (FIG. 11)

E. Light is made incident while restricting the incidence point to the portion of the table of line segment pl. (FIG. 12)

III. Regarding judgment of brilliance

A. Among the light beams that exited from any of the line segments lm, op, or pl, only those light beams having certain directions after exiting are considered brilliance. For example, when a light beam exits to the outside from the line segment op, if the slope of the equation calculated by the aforementioned (k), (l), and (m) is negative, the light beam is directed downward, and therefore is not considered brilliance. (FIG. 13)

B. Only light beams that exited from line segment lm, op, or pl are considered brilliance. (FIG. 14)

Grades such as proportion (normally expressed by the five points l, m, n, o, p while ignoring girdle thickness and the culet portion) and symmetry are gleaned from the above judgments, but for grading of the cut, there are cases where various exterior features such as exterior damage are also included. In such cases, they should be added into the results obtained by the grading method of the present invention.

Furthermore, since it takes time to perform the aforementioned calculations in this procedure, it can be implemented easily if a computer is used or a special calculator programmed with the aforementioned logic is used.

Additionally, since a brilliant cut is used for the purpose of ornamentation, it is appropriate to use the index of refraction of visible light beams in air, but brilliance using infrared rays in water, for example, may also be simulated.

4. Brief Description of the Drawings

FIGS. 1, 2, and 3 are plan views illustrating the direction of advancement of light beams on the interior of a diamond.

FIG. 4 is a plan view illustrating the excluded portion of the grading method that is generally performed at present.

FIG. 5 is a plan view of an embodiment of a device for grading a cut using actual light beams.

FIG. 6 is a plan view illustrating a diamond measured on an X-Y coordinate system.

FIG. 7 is a plan view illustrating the cross-sectional shape of a diamond.

FIGS. 8, 9, 10, 11, and 12 are plan views illustrating embodiments of the setup of simulated light beams.

FIG. 13 is a plan view of a diamond on an X-Y coordinate system, illustrating an embodiment of the exit direction of simulated light beams.

FIG. 14 is a plan view of a diamond illustrating an embodiment of the exit range of simulated light beams.

(1): Advancement direction of light inside ideally cut diamond. (2): Advancement direction inside a diamond that is not ideally cut. (3): Diamond subject to grading. (4): Largest ideally cut diamond that could be created by recutting. (5): Pedestal. (6): Light beam. (7): Girdle. (8): Hemisphere with photoelectric elements on entire inner surface. (9) Incident simulated light beams. (10): Simulated light beams exiting from diamond.

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FIG. 1

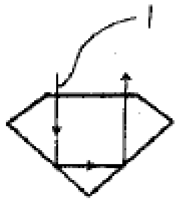


FIG. 2

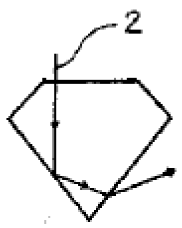


FIG. 3

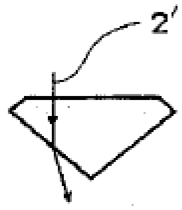


FIG. 4

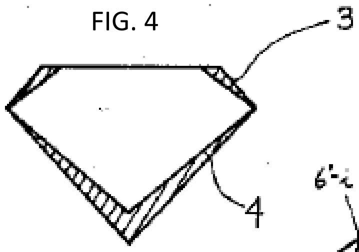
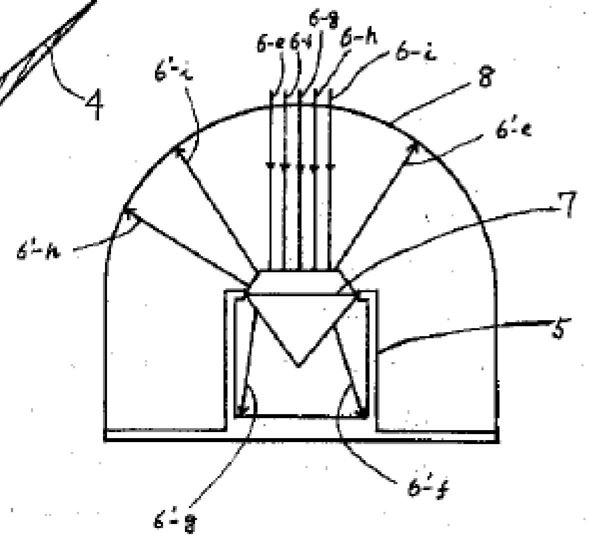


FIG. 5



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