ARRANGEMENT FOR OBJECTIVELY EVALUATING CHARACTERISTICS OF GEMS, PARTICULARLY DIAMONDS

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The arrangement includes an ellipsoidal mirror having a first focal point and a second focal point. Light is emitted from the first focal point. A gem is supported at the second focal point with such an orientation that the light emitted from the first focal point and reaching and entering the gem will be reflected by the gem towards a plane containing the first focal point and oriented normal to a line joining the focal points. The gem is surrounded and engaged by a light blocking arrangement to prevent the passage of light past such gem around the outermost portions of the gem. The light emitted from the first focal point and reflected by the gem towards such plane is measured.

20 Claims, 14 Drawing Figures
ARRANGEMENT FOR OBJECTIVELY EVALUATING CHARACTERISTICS OF GEMS, PARTICULARLY DIAMONDS

BACKGROUND OF THE INVENTION

The invention relates to an arrangement for the evaluation of gems, such as colored and uncolored precious and semi-precious stones, and particularly diamonds. Although the invention will be described with respect to the evaluation of characteristics of diamonds, it can also be used for the evaluation of other gems.

Several different criteria are of importance in the evaluation of cut diamonds, namely, weight, cut, purity, and color. Of these characteristics, only weight, as expressed in carats, can be readily ascertained in an objective manner using measuring instruments, i.e., a scale. The other characteristics are so-called "subjective" characteristics; that is, they are subjectively assessed by eye, by an expert, usually employing a jeweler's eyepiece. Even when every attempt is made to very strictly observe the established rules for evaluating the quality of diamonds, such as they are, the resulting evaluations of different experts may differ markedly, and not only in borderline cases. This is because of the close interrelationship of all the criteria in the final determination of the quality of the cut stone. For example, in the case of the brilliance of "fire" of a diamond, most determinative is the quality of the cut, after which come the purity of the stone and its color.

An arrangement for the evaluation of the color of cut diamonds is already known. In this known arrangement, the diamond is held by a holding arrangement at a level underneath the Rondist of the diamond, with the entire upper portion of the diamond exposed. Provided over the holding arrangement is a source of monochromatic light, and arranged over the diamond is a photometric detector. With this arrangement the color of the cut diamond is "measured" in a certain sense, but repeatably obtainable recurring measurement, i.e., absolutely measurable, cannot be obtained with this arrangement. This is because all the light from the light source does not actually reach and enter the diamond, and because all of the light reflected by the diamond does not actually reach the photometric detector unit.

Furthermore, the known arrangement cannot be used to ascertain other quality data concerning the diamond.

SUMMARY OF THE INVENTION

It is a general object of the invention to provide an arrangement for evaluating cut gems, especially diamonds, in an entirely objective manner, using measuring instruments, and without the need for expert subjective judgement, so that the quality data or ratings ascertained for a particular stone will be the same no matter how often the ratings for the stone are determined. In other words, it is a general object to provide a rating or evaluating arrangement which enables the generation of objective quality data, and not merely the weight of the diamond as was already possible, but also concerning the other characteristics of the stone hitherto considered subjective.

These objects, and others which will become more understandable from the following description of specific embodiments, can be met, according to one advantageous concept of the invention, by providing an arrangement for evaluating the optical characteristics of gems, especially diamonds, comprised of an ellipsoidal mirror having a first focal point and a second focal point, and light-emitting means operative for emitting light from the first focal point. Gem support means holds a gem at the second focal point with such an orientation that light emitted from the first focal point and reaching and entering the gem will be reflected by the gem towards a plane which contains the first focal point and which is oriented normal to a line joining the two focal points of the mirror. The gem support means includes means surrounding and engaging the gem and blocking off the passage of light past the gem around the outermost portions of the gem. Light measuring means is provided for measuring the light emitted from the first focal point and reflected by the gem towards said plane.

An ellipsoidal mirror is characterized by the fact that all light rays emitted from one of the two focal points thereof will be reflected by the surface of the mirror and pass through the other of the two focal points. With the apparatus of the invention, this has the consequence that, firstly, all of the light emitted from the first focal point will be reflected by the mirror towards the second focal point and will accordingly enter the gem located at such second focal point and, secondly, the portion of such entering light which is thereupon reflected out of the gem will practically in its entirety, reach the light-measuring means. The light-measuring arrangement can for example comprise a plurality of photocells arranged in that plane which includes the first focal point and which is normal to a line joining the focal points. Also, on the support structure beneath the gem there can be provided photocells and possibly also a condensing lens and an aperture, such photocells receiving the light which is "lost," i.e., the light which is not reflected out of the gem in direction towards the aforementioned plane and which instead leaves the gem travelling in the opposite direction, thereby not contributing to the "brilliance" and accordingly the quality of the gem. Light reflected from imperfect cut, from the presence of inclusions or flaws, and may also result from absorption of light by the gem. With the arrangement according to the invention, it is possible to determine the difference between the total light entering the gem and the total light reflected by the gem in the desired direction, in order to determine how much or how little light is "lost" as a result of leaving the gem at the underside thereof and as a result of absorption.

Advantageously according to the invention, the gem support arrangement is rotatable about an axis which passes through the second focal point, and is furthermore pivotable about such focal point. This permits deliberate tilting of the gem to an extent sufficient to compensate for the small amount of measurement error which may be attributed to the incompleteness of the ellipsoidal mirror resulting from the presence of photocells in the aforementioned plane, for example, and to the presence of the light source.

If a plurality of photocells are arranged in the abovedefined plane, then the measurement of the light reflected by the stone is a measurement of the intensity of the light. To determine the color characteristics of the gem, the light employed can be of successive different colors of the spectrum, with the intensity of the reflected light being measured separately for each color. Many cut stones have to a certain extent a fluorescent character; short-wavelength light entering the stone
may produce an emission of long-wavelength light, i.e., there may occur a frequency shift in direction towards the infrared end of the spectrum. In other words, the incident short-wavelength light results in a detection by the photocells of a low efficiency situation (namely, a decrease corresponding to the fluorescence component), whereas upon a subsequent measurement using longer-wavelength light the photocells will detect a greater apparent efficiency with respect to the amount of light reflected, as a result of the fluorescence. For the total measurement of the brilliance of the gem, i.e., for the measurement of the gem’s brilliance over the entire spectrum, this fluorescence is without meaning, because all that is actually determined is the amount of light energy reflected by the stone, irrespective of whether the reflection of energy is direct or the result of a fluorescent effect. However, when the color of the stone is determined, this fluorescent effect results in certain deviations of inaccuracies, explained in greater detail with respect to specific embodiments of the invention.

This will also be the case with other embodiments of the invention, for example, according to which use is made of light-conducting bodies or light-conducting elements or bundles of such elements, operative for conducting the reflected light from the above-defined plane to a light measuring apparatus capable of differentiating between the individual spectral components of the light.

With the first approach mentioned above, polychromatic light is resolved into its spectral components by means of a spectral apparatus, e.g., a monochromator, and the individual spectral components are separately and successively conducted to the first focal point of the ellipsoidal mirror in order to measure the intensity of the reflected light by means of photocells. According to the second approach mentioned, polychromatic light is emitted from the first focal point of the mirror, and the light reflected by the stone is conducted to a spectral apparatus and thereupon resolved into its spectral components, the intensity of such spectral components being measured by means of photocells. This results in a marked simplification and shortening of the measurement operation, and approximates to the natural relationships, since in ordinary use the stone will be illuminated by polychromatic light and the resulting reflected light is what is perceived when subjectively determining the brilliance and color of the stone. The abovedescribed spectral shift resulting from the abovedescribed fluorescent effect will be measured in a manner corresponding to natural conditions.

To determine the presence of flaws or incisions, and to quantify the character of such flaws, use can be made of a laser beam, the laser beam being parallel to the line joining the focal points of the mirror and preferably being shiftable by means of an adjustable mirror. With such arrangement, the gem can be turned, by turning the gem support, and simultaneously the laser beam can be slowly shifted in radial direction, so that a plot of the output signals of the photocells will constitute a sort of spiral “development” of the volume of the stone, and such signals when plotted in graph form constitute objective information concerning the size, position and character of the flaws.

When the volume of the stone is geometrically “developed” in this manner using a laser beam, then it is also advantageous to support the stone upside down, with the pyramidal bottom part of the stone facing the light source and with the table of the stone facing in opposite direction, use still being made of the light-blocking means surrounding and engaging the stone, for example at the edge of the Rondist plane thereof. With this approach, the laser beam enters the stone at the pyramidal lower portion thereof. The laser beam will then emerge from the opposite side of the pyramidal body of the gem; should the beam encounter an inclusion inside the stone, a portion of the beam will be dispersed, and the component of the beam emerging out of the table face of the stone, in direction normal to the table face, can be measured by means of photocells provided in the gem support structure in order to generate data concerning the presence and size of inclusions. This radiation emerging from the table face of the stone, in a direction normal to the table face, can be condensed by means of a convergent lens and passed through an aperture onto the photocell arrangement.

The advantage of this kind of geometric “development” of the volume of the stone, for the purpose of detecting and evaluating flaws, resides in the fact that the “developed” laser beam will not pass through the numerous facet edge portions of the lower or back portion of the stone, with the light beams necessarily impinging upon the photocells and illuminating with stray light, which during the evaluation of the “development” must somehow be excluded from consideration, since they are not produced by flaws.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a vertical section through a first embodiment;
FIG. 2 shows a modification of a portion of the embodiment of FIG. 1;
FIG. 3 shows a modification of a portion of the embodiment of FIG. 1;
FIG. 4 is a diagrammatic depiction of a set-up for determining the color of a stone using the arrangement of FIG. 1;
FIG. 5 is a diagrammatic depiction of a set-up for determining the color of a stone using the arrangements of Figs. 6 and 7;
FIG. 6 is a vertical section through another embodiment;
FIG. 7 is a vertical section through a further embodiment;
FIG. 8 depicts a modification of a portion of the embodiment of FIG. 1;
FIG. 9 depicts a cut diamond as seen from above;
FIG. 10 is a depiction of the path travelled by a laser beam employed to detect flaws in a cut stone;
FIG. 11 is a graph depicting the results of a geometrical “development” of the volume of the stone being evaluated;
FIG. 12 is a graph depicting results of measurements taken to determine the color characteristics of a stone.
using the arrangement of FIG. 8 and the method of FIG. 10; FIG. 13 is a vertical section through a set-up for performing a geometrical "development" of the volume of the stone, to detect flaws; and FIG. 14 depicts a modification of a portion of the structure shown in FIG. 13.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The arrangement shown in FIG. 1 is designated generally with reference numeral 10. It is comprised of an ellipsoidal housing, in turn comprised of a lower part 12, a reflector part 14 and a top or cap part 16, these parts being connected together by means of annular flanges 13, 15 and corresponding annular projections 13a, 15a received in and retained by the flanges 13, 15. The interior surface of the reflector part 14 is formed as an ellipsoidal mirror 20. Light is emitted from the first or upper focal point 18 of the ellipsoid. The emitted light originates from a non-illustrated light source, travels in direction of the arrow 39a and enters an elongated fiber-optic light-conductive element 39, from the end of which the light is emitted into the interior of the arrangement 10. The end portion 40 of the fiber-optic element 39 is positioned at the first focal point 18 and has a radiation characteristic of 180°; for example, it may be of hemispherical configuration. Substantially all of the light emitted from this end portion 40 in the first focal point 18 is reflected by the ellipsoidal mirror 20 towards the second focal point 19; a small error is introduced inasmuch as the ellipsoidal mirror does not include the interior surfaces of the cap portion 16 and of the lower housing portion 12. However, this small error can be compensated for, in a manner described below.

The illustrated diamond, designated with numeral 21, is held in a support 26, so positioned that the second focal point 19 of the ellipsoidal mirror lies in the Rom dist plane 22 of the diamond. The edge 23 of the diamond 21 is surrounded and held by a suitable closure, for example an elastic sealing ring 34, in order to prevent light from passing around the edge 23. In the embodiment of FIG. 1, the support 26 is comprised of a conical or pyramidal chamber into which the lower portion 35 of the diamond 21 projects in which there is provided a plurality of photocells 36 so arranged that they lie adjacent to and facing the surface of the lower portion 35 of the diamond 21. The support 26 is provided at its lower end with a socket 28 into which can be inserted the output shaft 29 of a non-illustrated drive motor, to rotate the support 26 in the direction of the arrow 32. The lower housing portion 12 is provided with a cover plate 24 which merges into a central portion 25 the inner surface of which is a portion of a spherical surface. The diamond support 26 is provided with a complementary portion 27, the outer surface of which is a portion of a spherical surface. The portion 27 fits in the portion 25, so as to form a ball-type joint, permitting movement of the support 26 in the direction of the double-headed arrow 31. Specifically, the diamond support 26 can be pivoted about the center of the spacial surfaces of portions 25, 27, by means of the shaft 29. The shaft 29 passes through an opening 30 in the housing portion 12 large enough to permit a substantial degree of such pivoting movement.

Reference numeral 17a designates a plane which is oriented normal to the line 17 which connects together the two focal points 18, 19. Arranged in plane 17a are a plurality of photocells 37.

The arrangement thus far described is employed for the evaluation of the brilliance of a diamond in the following manner:

The diamond 21 is inserted into the support 26. If diamonds of greatly differing sizes are to be evaluated, it may be necessary to provide more than one support 26, so that with any particular diamond the edge 23 thereof will be properly engaged by the sealing ring 34. The reflector part 14 and the cap portion 16 are put into place, and light is emitted from the end portion 40 of the fiber-optic element 39.

This light is practically completely reflected from all sides by the ellipsoidal mirror 20 into the upper portion of the diamond 21. In the case of an ideal diamond, all the light will be reflected back from the diamond and onto the photocells 37; that is, in the case of an ideal diamond none of the light originating from member 39 will pass through the diamond 21 and emerge from the lower portion thereof to impinge upon the photocells 36, and none of the light will be absorbed by the diamond. The greater the output from the photocells 36 (i.e., the greater the amount of light incident thereon), the worse must be considered the "brilliance" of the diamond 21, any such poorness of quality being essentially attributable to imperfect cutting or the presence of inclusions or faults in the body of the diamond. Furthermore, the difference between the light emitted from the member 39 and the total light incident upon the photocells 36 and 37, constitutes an indication of the amount of light absorbed by the diamond.

A small measurement error arises, due to the fact that the inner ellipsoidal surface of the cap portion 16 does not participate in the reflection of light emitted from fiber-optic element 39. However, this measurement error can be eliminated by pivoting and rotating the support 26 holding the diamond 21. However, this error, represented in FIG. 1 by the angle α, is extremely small; this is because in practice use can be made of an ellipsoidal shape whose cross-section is not of the breadth of the ellipse shown in FIG. 1, which was selected quite broad for clarity of illustration.

The output terminals of the photocells 36 located in the movable support 26 can be connected to mercury contacts, to ensure a low-loss transmission of the output signals of the photocells.

Care must be taken to ensure that the photocells 37 are not directly exposed to the light transmitted by the fiber-optic element 39.

It should be noted here that in the present description the expression "photocell" is employed in the broadest possible sense and is to be understood as signifying any light-sensitive or light-responsive element or device capable of generating a signal or indication of the intensity or amount of incident light, in addition to such elements and devices as produce a light-dependent electrical current or voltage or vary the magnitude of such current or voltage (e.g., a photoreistor).

As will be understood by persons skilled in the art, with the arrangement of FIG. 1, a central vertical beam of light incident upon the upper portion of the diamond 21 will pass right through the diamond and emerge from the lower vertex thereof. In order to eliminate the
resulting measurement error, use can be made of the somewhat modified arrangement shown in FIG. 2.

In FIG. 2 components corresponding to those of FIG. 1 are designated by the same reference numeral, but primed. These need not be described again.

In the arrangement of FIG. 2, use is made of a box-shaped support 26'. Provided in the interior of support 26' are photocells 36' corresponding to photocells 36 of FIG. 1. However, there is additionally provided a photocell 36a located to receive the just-mentioned beam of light which passes through the central portion of the diamond. Separate detection of this beam of light makes it possible to add or subtract from the various measured and computed amounts of light an amount corresponding to this through-passing central light beam, thereby eliminating the measurement error referred to.

FIG. 3 depicts one light source which can be employed. It includes a laser 45, the laser beam 46 of which is deflected by a mirror 44 into the interior of the arrangement 10. The mirror 44 is advantageously mounted on a small pipe-shaped member 48 secured to a supporting structure 43, there being mounted at the lower end of member 48 a ground glass sphere 47. The sphere 47 emits the laser light over an angle of 180° and will, as was the case with the end portion 40 in FIG. 1, be positioned coincident with the focal point 18 of the ellipsoidal mirror 20.

The manner in which the apparatus of FIG. 1 is used to perform the chromatic evaluation of the diamond will be explained with reference to FIG. 4.

Polychromatic light from a light source 39a is broken up into its constituent color components by passage through a spectral apparatus 380, for example, a monochromator, and the individual color components are individually led into the interior of the apparatus 10 by means of the fiber-optic element 39. Use is made of an ammeter of voltmeter 38 to measure the electrical signal developed across the outputs of the photocells 37 in response to the reflection back upon them of the monochromatic light directed towards the diamond. The photocells 37, which will be arranged so as to form as nearly as possible an unbroken photosensitive surface, may each have a pair of output terminals, with the individual photocells being all connected together in series or in parallel, depending for example upon whether the photocells generate a light-dependent voltage or a light-dependent current. In this way, the measurements explained with reference to FIGS. 1 and 2 can be performed for each of the spectral components separately. This will be explained still further with respect to FIG. 12.

Another embodiment of the invention is depicted in FIGS. 5-7, the operation of this embodiment being explained with reference to FIG. 5. Components corresponding to those shown in FIGS. 1 and 5 are designated with the same reference numerals, but with the addition of a double prime.

Polychromatic light is emitted into the interior of the apparatus 10'' from a light source 39a''. The light reflected back from the diamond impinges upon a light conducting arrangement 371-375, and is conducted to a spectral apparatus 380'' which resolves the light into its constituent color components, which are then individually measured by means of non-illustrated photocells provided in the apparatus 380''. The electrical output of the plurality of photocells is measured by an ammeter or voltmeter 381''.

According to this approach, which will be explained in greater detail with respect to FIGS. 6 and 7, in a single measuring operation, corresponding to the natural relationships, polychromatic light is emitted from the first focal point of the ellipsoidal mirror, and the light impinging upon and reflected back from the precious stone is resolved into its constituent color components and measured. The results of the measurements automatically imitate the natural action of the earlier-described fluorescent effect, although it is of course possible to also separately measure the extent of such fluorescent effect.

In the structure shown in FIG. 6, the photocells 37 of FIG. 1 are replaced by a relatively thick bundle 371 of light-conducting elements, for example glass or fiber-optic elements.

In FIG. 6 a modified gem support 126 in the form of a generally annular body provided with an annular portion 127 whose outer surface is spherical and cooperates with a complementary spherical surface of a central portion 125 of the cover plate 124 of the lower housing part 12'' of the apparatus 10''. The gem support 126 is provided at the lower end of an apron portion 132 with a circle of radially extending gear teeth, cooperating with a worm-gear drive 130 fixedly mounted on the apparatus 10'' and operative for rotating the gem support 126 about its vertical central axis.

The photocells 136 are arranged in the interior of the box-shaped member 128, member 128 being rigidly mounted on a shaft 129. The box-shaped unit 128 is pivotable in the direction of the double-head arrow 131 together with the rest of the gem support 126, by reason of the spherical configuration of the facing surfaces of portions 127 and 125. The outputs of the plurality of photocells 136 can be connected by leads or other suitable means to a suitable measuring device.

The gem support 126 is provided at the upper surface thereof with a recess 138 having two removable thin sheet-metal or plastic disks 139. These are provided with central openings 140 and serve to encircle and engage the gem above and below the Rondist edge thereof, as clearly shown in FIG. 6. Depending upon the size of the stone, use will be made of different ones of a plurality of such disks 139, having central openings of different respective diameters. The facing surfaces bounding the annular gaps 141 can be coated with an antifriction layer, for example, tetrafluoroethylene, to reduce friction. With this embodiment, the diamond 21 together with the rotatable support 126, driven by the worm gear 130, turns, the box-shaped unit 128 turning therewith, and the whole assembly being pivotable. (See FIG. 13 for an illustration of the gem support assembly in pivoted position.)

Whereas in the construction of FIG. 6 a relatively thick bundle of light-conductive elements 371 is employed, the construction of FIG. 7 makes do with far fewer. In the FIG. 7 construction, there is provided in the plane 17a', oriented normal to the line 17'' connecting together the two focal points of the ellipsoidal mirror, an annular condensing lens 372 which condenses the light reflected back from the gem and focuses such reflected light onto an associated focal ring 374. Use can accordingly be made of a relatively thin ring of light-conducting elements 375 having ends positioned coincident with such focal ring, these light-
conducting elements conducting the focused light to the spectral apparatus or monochromator. Other lens systems or lenses can be employed, for example, a lens having an eccentric focal point and a bore through which can pass the light-emitting light-conducting element or bundle of elements.

In FIG. 7 there is depicted in dash-dot lines a further possibility, namely the use of an annular parabolic mirror, instead of the annular condensing lens. The annular parabolic mirror would have a focal ring substantially coincident with the ends of the light-conducting elements.

Reference will be made to FIG. 12, to describe the manner in which the output signals of the photocells of the arrangement of FIGS. I–4 are employed to determine the color, color intensity and color absorption of the diamond. Either a spectral apparatus is connected to the output of the light source (see source 39 in apparatus 380 in FIG. 4), or use is made of an adjustable laser 45 (FIG. 3), and the diamond is illuminated by monochromatic light in the color sequence of the spectrum, from ultraviolet, to blue, to green, to yellow, to red, to infrared. The output signals of the photocells are continuously measured during this continuous change of color, and the results are plotted in the form of the curve 73 of FIG. 12. The abscissa 71 represents the wavelengths of the light in nanometers (1 = ultraviolet, 2 = visible, 3 = green, 4 = yellow, 5 = red, and 7 = infrared). The ordinate 70 represents the light transmission. Also depicted in FIG. 12 is the standard color transmission curve 72 for a diamond of the highest quality, and the ordinate 74 relative to the wavelengths of the light and the corresponding colors indicated along the abscissa 71. The diamond can be examined for the color characteristic of the color indicated along the abscissa 71, and the magnitude of the transmission differences corresponding to the standard color transmission curve 72 and the measurement curve 73 constitutes objective data concerning the intensity of color of the diamond. The integral of the difference between the curves 72 and 73, and corresponding to the sum of areas 74 and 74, constitutes a total measure of the color characteristics of the diamond being evaluated in comparison to that of a standard diamond.

To determine the presence of inclusions or flaws in the diamond, and to ascertain their character and size, use can be made of the arrangement shown in FIG. 8, in conjunction with the apparatus of FIGS. 1–3.

The cap portion 16 is provided with a slit-like opening through which passes a small pipe-like element 48' carrying a mirror 44' which deflects the laser beam 46'. The length of the slit-shaped opening is approximately equal to the radius of the largest diamond 21 to be evaluated. Also, in order to provide a corresponding slit-like opening 42' in the arrangement of photocells 37' (FIG. 8), a segment of the photocell arrangement is removable (this segment being designated by numeral 41 in FIG. 1). The pipe-like member 48' in this embodiment (FIG. 8) is not provided at its lower end with a glass sphere, such as sphere 47 of FIG. 3.

In the embodiment of FIG. 8, the pipe-like member 48' with the deflecting mirror 44' thereon, can be shifted in radial direction, as indicated by the double-headed arrow 49, with the laser beam 46' accordingly being likewise shifted in radial direction. If simultaneously therewith the diamond 21 is turned in the direction of the arrow 32 in FIG. 1, then by measuring the output signals of the photocells there is achieved a sort of spiral-shaped geometrical "development" of the volume of the diamond 21, indicated in FIG. 10 by means of a broken spiral line 56. FIG. 11 depicts an example of the results of such a "development." Plotted along the abscissa of the graph in FIG. 11, number 3 of the turn of the spiral, for example, the numbers 1, 2, 3, designating the first, second and third turns of the spiral line 56, intermediate the successive integers along the abscissa are indications of the angle of rotation, relative to a preselected reference orientation. Plotted along the ordinate in FIG. 11 is the magnitude of the output signal of the photocell arrangement 36.

The diamond 21 depicted in FIGS. 9 and 10 contains two inclusions 57, 60. The small inclusion 60, on account of the dispersion of the laser beam 46', which the inclusion 60 effects, appears in the graph of FIG. 11 only in between the third and fourth turns of the spiral path, for example, and at angular orientation of about 270°, as a jump in the curve. The large inclusion 57 appears as several jumps 57', 57'', 57''', 57'''' in the curve, in the third through eighth turns of the spiral beam path, at an angular orientation of about 180°, and increasing in magnitude and then decreasing in magnitude. Thus, a single jump 60' in the curve of FIG. 11 indicates the presence of a small inclusion, whereas a plurality of successive jumps 57', 57'', 57''', 57'''' indicates the presence of a large inclusion. The intensity of the light dispersion caused by the inclusion can be deduced from the magnitude of the jump in the curve of FIG. 11, and provides in addition information upon which may be based a determination of the type of inclusion, i.e., whether a gaseous inclusion, or a bodily inclusion (impurity).

Instead of performing this kind of spiral geometric "development" of the volume of the diamond, it is possible to perform other such "developments", for example, a zig-zagging back-and-forth development, by swinging the diamond back and forth in the direction of the double-headed arrow 32 of FIG. 1, but in a plane perpendicular to the picture plane of FIG. 1, while simultaneously effecting radial shifting of the laser beam 46' in the manner described above.

A variation of such "development" of the diamond, for the purpose of determining the presence of inclusions or flaws, will be explained with reference to FIG. 13. Here, use is made of a gem support 126' like the gem support 126 of FIG. 1, with the laser beam arrangement 44'', 45'', 46'' of FIG. 8 being shown here only diagrammatically. The parts of the support 126' in FIG. 13 corresponding to those of FIG. 6 are identified with the same reference numerals, primed. In contrast to the set-up of FIG. 8, in FIG. 13 the diamond is supported by the earlier-described disk arrangement 139 in upside down position. The laser beam 46' emitted by the laser 45' is reflected by the mirror 44' into the diamond 21, and in the case of a perfect or ideal diamond the beam 46'' will in its entirety be reflected out of the diamond and emerge from the upper portion thereof (as viewed in FIG. 13) as a beam 52. However, if the diamond contains inclusions, then the laser beam will to some extent be dispersed within the diamond, resulting in the emission from the face 150 of the diamond 21 of parallel rays 151, the intensity of which is mea-
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3,867,032 sured by means of the photocells 136 in the support 126. These rays emitted from the diamond face 150 provide a further way of measuring or determining the presence of inclusions in the diamond 21, and can be used in conjunction with a geometric "development" of the diamond 21 such as explained with reference to FIGS. 8-11.

In order to achieve the desired total reflection of the incident laser beam from the diamond face 150, the aforedescribed geometric "development" of the volume of the diamond 21 by pivoting and rotation of the diamond support 126 can be preprogrammed, by experimentally determining the optimum angle of incidence of the laser beam 46 near the lower vertex of the diamond 21 and near the Rhonidist plane (22 in FIG. 1); then, the already described geometric "development" of the volume of the diamond can be performed relative to this optimum angle of incidence.

Furthermore, it is possible to increase the range of angles within which the desired total reflection by the gem occurs, by inserting the gem into a fluid of high refractive index during the determination of the presence of flaws or inclusions in the gem. In this way, the angle of refraction is decreased with the entry of the laser beam into the stone.

FIG. 14 depicts a modification according to which there is provided beneath the diamond a convergent lens 152 which condenses the parallel rays 151 emitted from the lower face of the diamond (as viewed in FIG. 14) and guides the light through an aperture member 153 to the photocells 136. The arrangement is otherwise the same as described with respect to other embodiments above, and makes use of a box-shaped compartment 128 mounted for pivoting movement but rotatable with the illustrated drive shaft.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in an arrangement for evaluating the characteristics of a precious stone, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. An arrangement for evaluating the optical characteristics of gems, especially diamonds, comprising, in combination, an ellipsoidal mirror having a first focal point and a second focal point; light-emitting means for emitting light from said first focal point; gem support means for holding a gem at said second focal point with such an orientation that light emitted from said first focal point and reaching and entering the gem will be reflected by the gem towards a plane containing said first focal point and oriented normal to a line joining said focal points, said gem support means including means surrounding and engaging the gem and blocking off the passage of light past such gem around the outermost portions of the gem; and light-measuring means for measuring the light emitted from said first focal point and reflected by such gem towards said plane.

2. An arrangement as defined in claim 1, wherein said light-measuring means comprises a plurality of photocells arranged in said plane and oriented to receive light emitted from said first focal point and reflected by such gem towards said plane.

3. An arrangement as defined in claim 1, and further including light-measuring means comprised of light-sensitive means so positioned relative to said gem support means as to be located to that side of the supported gem which is opposite to the side thereof which faces said plane and operative for measuring the amount of light emitted from said first focal point which penetrates the gem and emerges from such opposite side thereof.

4. An arrangement as defined in claim 3, wherein said light-measuring means includes condensing lens means for condensing onto said light-sensitive means light penetrating the gem and emerging from such opposite side.

5. An arrangement as defined in claim 3, wherein said light-measuring means includes a member provided with an aperture so positioned relative to said gem support means that light penetrating a gem supported by said gem support and emerging from such opposite side must pass through said aperture to reach said light-sensitive means.

6. An arrangement as defined in claim 5, wherein said light-measuring means includes condensing lens means for condensing onto said light-sensitive means light penetrating the gem and emerging from such opposite side.

7. An arrangement as defined in claim 1, wherein said gem support means is rotatable about said second focal point and furthermore is pivotable about said second focal point.

8. An arrangement as defined in claim 7, wherein said gem has a Rhonidist plane and wherein said gem support means comprises a chamber in which said light-sensitive means is positioned, said light-sensitive means being rotatable and pivotable with said gem support means, and wherein said gem support means comprises two centrally apertured members oriented and positioned to surround and releasably engage a gem being supported by said support means above and below the edge of the Rhonidist plane of the gem.

9. An arrangement as defined in claim 8, wherein said centrally apertured members are removable, and including a plurality of additional centrally apertured members having central apertures of different sizes to accommodate gems of different sizes.

10. An arrangement as defined in claim 7, wherein said gem support means comprises a gem-engaging first portion having an outer spherical surface and a second portion having a complementary inner spherical surface, said first portion being mounted in said second portion so as to permit both rotational and pivoting movement of said first portion relative to said second portion.

11. An arrangement as defined in claim 1, wherein said light-measuring means comprises a light measuring instrument for separately measuring the spectral com-
ponents of light, and light-conducting means operative for conducting light from said plane to said light measuring instrument.

12. An arrangement as defined in claim 11, wherein said light-conducting means comprises condensing lens means operative for focussing the light reflected into said plane onto a second plane, and means for transmitting the focussed light from such second plane to said light measurement instrument.

13. An arrangement as defined in claim 11, wherein said light-conducting means comprises focussing mirror means operative for focussing the light reflected into said plane onto a second plane, and means for transmitting the focussed light from such second plane to said light measuring instrument.

14. An arrangement as defined in claim 11, wherein said light measuring instrument comprises means for resolving light into its spectral components and for separately measuring the intensity of such components.

15. An arrangement as defined in claim 11, wherein said light measuring instrument comprises photosensitive means operative for converting light incident thereupon into electrical signals, and electrical measuring means operative for indicating the intensity of the light by indicating the strength of such electrical signals.

16. An arrangement as defined in claim 1, wherein said light-emitting means comprises a remotely located source of light and light-conducting means having a first end connected to said source to receive light and having a second end located at said first focal point to emit light and having a radiating character of 180°.

17. An arrangement as defined in claim 1, wherein said light-emitting means comprises a laser arrangement operative for emitting from said first focal point a laser beam.

18. An arrangement as defined in claim 17, wherein said light-emitting means further comprises deflecting mirror means operative for deflecting the laser beam of said laser beam arrangement to cause such beam to travel in direction parallel to the line joining said focal points.

19. An arrangement as defined in claim 17, wherein said light-emitting means comprises a ground glass sphere located at said first focal point, said laser beam being oriented to intersect said first focal point.

20. An arrangement as defined in claim 17, wherein said light-emitting means comprises a ground glass hemisphere located at said first focal point, said laser beam being oriented to intersect said first focal point.