

Description

The invention relates to a method and an apparatus for providing an identifying indicium to a surface of a diamond wherein a laser beam is applied to said surface of said diamond and said laser beam is moved intermittently to successive positions along a path corresponding to said indicium in said diamond surface.

In the handling of diamonds, it is common practice to categorize the diamonds in terms of various characteristics, for example, in terms of color, weight, degree of perfection and vendor. Since these categories control the value of a diamond, it is essential that they follow the diamond through its travel from the original vendor to the eventual purchaser.

A method and an apparatus are known in accordance with the prior art portions of claims 1 and 24 (publication "Guide for Material Processing by Lasers" by the Laser Institute of America, 2nd edition, 1978) by which gold and silver jewelry and precious stones including diamonds are engraved by a laser beam, for example a pulsed-ruby laser. Details of the method and apparatus are not set forth. The application of the known method and the known apparatus to diamonds would create difficulties because very high energy densities are necessary for engraving clear diamonds and there is the danger that the value of a diamond is affected by such high laser energy densities.

It is known from US-A-3,527,198, which relates to drilling holes into diamonds, that at the initial stage of drilling the diamonds by a laser beam, it is necessary to use an extremely high energy density but once the point to be drilled begins to burn, the surface of the diamonds will be covered by a film of graphite produced by the incomplete combustion during said initial drilling. Since the graphite film serves to absorb energy, the energy density required for subsequent drilling may be reduced to a fraction of the initial energy density. This document teaches the avoidance of formation of a graphite film so that the energy density can be maintained constant throughout the drilling.

The invention as claimed in claims 1 and 24 in solving the problem of how to provide an identifying indicium to a diamond surface by means of a laser beam without affecting the diamond characteristics which determine its value, utilizes the formation of a graphite film. Initially, the energy level of the laser beam is adjusted to a sufficiently high level to graphitize and inscribe a first diamond surface area. The graphite film produced by the inscription of the first diamond surface area makes it possible to reduce the energy level of said laser beam when inscribing the next surface area overlapping the first diamond surface area. A graphite film is again produced by the inscription of the second diamond surface area, thus permitting inscription of a third diamond surface area at said reduced energy level and so on.

The advantages offered by the invention are mainly that the identifying indicium can be inscribed while substantially preserving the value of the diamond, and the identifying indicium cannot be removed without substantially reducing the value of the diamond. The invention permits inscription of a diamond without damaging the diamond and an extremely small beam width can be used so that the identifying indicium is imperceptible to the human eye. Loss of value of the diamond is thus substantially avoided, while an indelible and integrated identification is created in the sense that removal of the indicium could not readily be carried out by most people handling the diamond and would necessitate recutting of the diamond to an extent which would result in a loss in value. Several ways of carrying out the invention are described in detail below with reference to drawings, in which:

Fig. 1 illustrates in block diagram form a system for providing indicia to a diamond;

Fig. 2 illustrates the matrix of positions to which the laser beam of the system of Fig. 1 can be directed;

Fig. 3 shows the laser beam locations defining a typical indicium which can be inscribed utilizing the system of Fig. 1.

In Fig. 1, a laser beam generation system 2 applies a pulsed laser beam 3 to a diamond 5 for the purpose of inscribing an indicium or a plurality of indicia in the diamond surface 4. The indicia can be of any type such as, for example, numbers, letters, words, decorative patterns, trademark symbols, portraits, images, signets, coats of arms, names, family crests, etc. Furthermore, the indicia can be indicative of the above-mentioned categories of information (color, weight, degree of perfection, vendor) related to the diamond value.

As shown, the surface 4 is what is commonly referred to as the "girdle" of the diamond. However, it should be pointed out that the principles of the invention are applicable to inscription of indicia in any surface of the diamond 5.

Application of the laser beam 3 to the surface 4 is controlled by an optical system 6 which is situated between the beam generation system 2 and the diamond 5. The optical system 6 positions and controls the beam 3 such that the beam is able to inscribe or engrave the surface 4 and produce an indelible indicium which substantially preserves the value of the diamond and which, if removed, would appreciably reduce such value.

The expanse of the beam 3 at the surface 4 having sufficient intensity to inscribe the diamond 5 (referred to hereinafter as the "beam scribing width") is maintained at approximately 100 microns or less so as to produce an indicium of similar width and, therefore, one imperceptible to the human eye. While all beam widths within the aforesaid range are useable with the invention, it is preferable to select the beam scribing width such that the resultant indicium can be readily observed with magnification equipment presently used by jewelers in the industry. Thus, a beam

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scribing width resulting in an indicium capable of being read by a conventional ten (10x) power magnifying loupe would be beneficial, as this loupe is one that is commonly used in the trade. The optical system 6 provides beam scribing widths of the desired expanse by focusing the beam 3 and by ensuring that the beam is positioned during inscription such that the surface area being inscribed is within the depth of field of the focused beam.

A table system 7 supports the diamond 5 and is adjusted to maintain the surface 4 of the diamond at the beam 3 focus position during the inscription process. The latter table system, as well as the optical system 6 and the laser generator 2 are sequentially controlled by a computer control system 8.

The table system 7 includes four tables 71, 72, 73 and 74 which are stacked one on the other and which together are mounted on a stationary support or frame 75. Each of the tables 71-74 enables a particular mode of movement of the diamond 5. Translational movement along the x and y directions of a mutually orthogonal coordinate system x, y, z is effected by tables 71 and 72, respectively, the x and y directions being horizontal directions into and in the plane of the drawing respectively. The diamond 5 is rotated about the z direction (a vertical direction in the plane of the drawing) by operation of the table 73. The final movable table 74 provides further translation of the diamond in the y direction.

Stepping motors 76, 77, 78 and 79 drive the tables 71-74, respectively, and, in turn, receive analog activation signals from drive elements 81-84 of computer control system 8. These drive elements are addressed automatically by signals from a control micro-processor 85 or manually by a joy stick control system 86. Positional feedback signals also are fed to the drivers from their respective tables.

Useable components for the tables 71 and 72 might be tables manufactured under model number DC-33 by Design Components Incorporated. Tables manufactured by the latter manufacturer under model numbers RT-601 and LP-35 might be used for the tables 73 and 74, respectively. The motors 76-79 might, in turn, be model number 49FG motors manufactured by PMI Motors.

A memory 87 of the computer control system 8 stores instructions and data (e.g., special and standard indicia instructions and data) for carrying out the inscription process. This information is processed by the micro-processor 85 to develop the necessary signals for sequentially controlling operation of the laser generation system 2, optical control system 6 and table system 7. A keyboard unit 88 permits entry of operator control instructions, including instructions defining the particular indicia to be inscribed. A system display 89 enables keyboard data to be displayed to ensure correct entry and allows prompting of the operator during system operation.

A Rockwell 6502 microprocessor might serve as

the micro-processor system 85, while the memory 87 might comprise a PROM section (for special indicia information) in the form of two 2708 ultraviolet programmable-read-only memories and a ROM section (for standard indicia information). The display 89 might include a 6543 Rockwell controller providing instructions to a CIOTO monitor. Each of the drivers 81-84 might include 74193 bi-directional counters and digital-to-analog converters (DAC-80) having 12 bits of resolution.

Turning to the laser generator 2, a continuous laser source 21 applies the laser beam 3 to a Q-switch 22 which is varied in state to allow high peak power pulses of the beam to pass to the optical system 6. Q-switch RF pulse generator 23 establishes the state of Q-switch 22 as a function of signals from the micro-processor 85.

A frequency multiplier 25 is interposed between laser 21 and Q-switch 22 in order to increase the frequency of the laser radiation and, therefore, obtain radiation of reduced wavelength. This permits obtaining smaller beam scribing widths at the surface 4. Typically, if a Nd-YAG laser at 1.06 microns were used as the laser 21, the multiplier 25 might be a frequency doubler, if beam scribing widths in the range of 1 to 100 microns were desired. To complete the laser generation system, a normally opened safety shutter 26 is provided in the path of the beam 3 forward of the Q-switch 22, the shutter 26 being closed upon micro-processor 85 generating a signal indicating an unsafe condition in the system.

Passage of the beams 3 through the safety shutter 26 brings the beam to the optical system 6. A first scanner or deflector 61 is adapted to deflect the beam in intermittent or digital fashion in the x-direction. Following the deflector 61, is a beam expander 62 which expands the beam 3 prior to entry into a second scanner or deflector 63 which is adapted to deflect in intermittent or digital fashion the beam in the z-direction. A second beam expander 64 follows the deflector 63 and conveys the beam to a variable attenuator 65 which sets the relative intensity or power of the beam before the beam impinges upon a focusing means in the form of an objective lens 66. The latter lens focuses the beam 3 at a point adjacent the surface 4 of the diamond 5.

Control of the x and z scanners 61 and 63 is through x and z RF scan generators 69 and 70 which, in turn, are addressed by signals from the micro-processor 85. The x scan generator 69 also provides on-off control of modulator 61' likewise based on signal control from the micro-processor.

Typical components for the scanners 61 and 63 might be acousto-optic deflectors of the type manufactured by Intra-Action Corporation under model number ADM-70. The scan generators 69 and 70, might be components designated DE-70M and manufactured by the same company.

Prior to inscription of indicia on the diamond 5, an initial procedure must be carried out to provide the computer system 8 with information as to the

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indicia length and the geometry of the surface 4. The latter surface can take on various forms and might comprise plane surfaces (facets) connected by edges or it might be a continuous surface with or without curvature. The indicia and surface geometry information enables the computer system to develop, via calculation subprograms stored in memory 87, the necessary signals for controlling the table system 7 to properly index the diamond 5 and to bring successive regions of surface 4 into confronting relationship with the beam 3 at the point of focus thereof. Viewing microscopes 101 and 68 mounted above and in front of the diamond 5 are provided as an aid to obtaining this information. As shown, microscope 101 permits direct viewing of the diamond from the above, while microscope 68 permits viewing the diamond frontally via beam splitter 67.

Discussion of this initial procedure will be in the context of the surface 4 being at the girdle of the diamond 5, but the procedure can be readily adapted to other surface areas. The operator begins the procedure by introducing into the memory 87, via the keyboard 88, a code indicative of the indicia to be inscribed. The micro-processor 85 is thereupon initiated again by keyboard operation to calculate and store in the memory 87, the total length encompassed by the entered indicia. The diamond is then viewed with the microscope 68 and the diamond fixture (not shown) is moved along the z direction by a micrometer (not shown) to first align the upper and then the lower girdle edges with the microscope horizontal cross-hair. The difference in the micrometer readings at these alignment positions is then taken by the operator who enters same via keyboard 88 into the memory 87.

The operator then views the diamond from above with the microscope 101 and operates the joy stick control 86 to move the tables 71 and 72 to displace the diamond in the x and y directions such that a point in the profile of the girdle is brought to the intersection of the cross-hairs of the microscope. When performing this operation, if the operator views one or more facet edges, the operator enters via the keyboard 88 a code indicating to the micro-processor that the information being introduced is to be analysed with a sub-program adapted to faceted surfaces and stored in the memory 87. If the operator views no facet edges, indicating a continuous surface, then no entry is made and the micro-processor will then automatically analyze the introduced information with a sub-program adapted to curved surfaces. Having conditioned the micro-processor regarding the type of sub-program to be used based on the surface, a keyboard store key is depressed and the locations of tables 71 and 72 are conveyed from the respective driver elements, via micro-processor 85, to the memory 87.

The operator then again operates the joy stick control to move tables 71 and 72 and bring a further point on the girdle to the intersection of the cross-hairs. The type of the control exercised in this operation depends upon which sub-pro-

gram is in effect. If the sub-program adapted to curved surfaces is in use, the table 71 is first moved to provide a fixed x displacement to the diamond. This is followed by operation of table 72 to provide a y displacement sufficient to being the further point into coincidence with the cross-hairs. If the sub-program adapted for faceted surfaces is in use, movement of the tables provides x and y displacement sufficient to bring the edge of the next facet to the intersection of the cross-hairs. Once the further surface point is brought to the cross-hair intersection, the table displacements are again entered into the memory 87.

The aforesaid procedure of moving the tables to place additional points of the girdle profile at the intersection of the microscope cross-hairs and the storing the table displacements is confined until the sum of the facet lengths exceeds the previously stored indicia total length. This is automatically calculated by the micro-processor and displayed on the display 89.

At this point, the micro-processor has all the necessary data needed regarding the indicia and diamond surface geometry to properly orient the diamond. In the case of curved surfaces, the entered data is utilized by the sub-program to derive the radius of curvature and center of rotation of the surface. The tables 71, 72 and 74 are thereupon moved to place the center of rotation at the centre of rotation of the table 73 and to place a starting point on the girdle at the focus point of the beam 3. In the case of a faceted surface, the entered data is utilized to determine the intersection angle of the facets. The tables are thereupon moved to place a faceted surface orthogonal to the axis of the beam 3 and to place a point on such surface adjacent the facet edge at the beam 3 focus.

Having positioned the diamond as above-described, based on the geometry of the surface 4 and the indicia length, subsequent indexing of the diamond for indicia inscription can now be readily carried out by the micro-processor controlling the table system 7. In the case of curved surfaces, this indexing amounts merely to rotation of the table 73 to bring a non-inscribed area to the beam 3 focus. For faceted surfaces, translational movement of table 71 brings such area to the beam focus. In this case, however, if the inscription length exceeds the length of the facet, or if a character falls on a facet intersection, the micro-processor 85, having stored the intersection locations, will signal the table system 7 to bring the next facet into position in a similar fashion as the previous facet.

Once the above initial procedure is completed, the system is ready to inscribe the surface 4 of diamond 5 with the entered indicia. Inscription is initiated by the operator again activating the keyboard 88.

The operator also turns on the power supply and cooling system 24 to bring the laser 21 into operation. Signals are then provided by the micro-processor to the generators 69 and 70 to

condition the digital scanners 61 and 63 to provide given amounts of x and z deflection to the beam 3. In the case of acousto-optic deflectors, this would amount to establishing in each deflector an acoustic disturbance at a radio frequency associated with the desired amount of beam deflection.

As can be appreciated, the generators 69 and 70 and deflectors 61 and 63 define an array of positions, shown in Fig. 2, to which the beam 3 can be deflected. The present excitation signals delivered by the micro-processor 85 to the generators, in effect, select one of these positions, which is the beginning position for the present inscription.

The generator 69 also delivers a signal to key the modulator 61' on/off. In the present illustrative case, this signal places the modulator in the full on condition; thereby allowing the beam 3 to pass at full intensity. Such intensity is sufficient to result in the focused beam 3 inscribing the surface 4 in the area covered by the inscribing beam width. Typically, for most applications, the power in beam 3 as it exits variable attenuator 65 might be in the range of 0.5 to 5 kW, the particular value used, amongst other things, being dependent upon the scan rate and pulse rate of the beam 3. A typical scan rate might be 1 millimeter per second and a typical pulse rate 1 kHz.

Having established the initial deflection conditions and the appropriate modulator condition, the micro-processor 85 now signals the generator 23 to operate Q-switch 22 and thereby allow passage of the beam 3 through the optical system 6 to the surface 4 of the diamond 5. During such passage, the beam 3 is deflected by respective scanners 61 and 63, allowed to pass at full intensity by the variable attenuator 65, and brought to focus on the surface 4, whereby, as shown in Fig. 3, a first elemental area A_1 of the surface is inscribed.

Thereafter, the deflection amounts are indexed based upon the micro-processor 85 indexing the signals to the generators 69 and 70 pursuant to the program in the memory 87 and the Q-switch is operated, resulting in subsequent elemental areas $A_2, \dots, A_N$ being inscribed in the surface 4 until the desired indicium, shown as an A in Fig. 3, is completed. The micro-processor 85 then signals the pulse generator 23 to again close the Q-switch 22, thereby inhibiting further impingement of the beam 3 on the diamond surface.

If the original operator instructions required further indicia to be inscribed, the micro-processor 85 addresses the appropriate driver element (81 for faceted surfaces and 83 for curved surfaces) causing same to actuate its respective motor and its corresponding table. The diamond 5 is thus indexed to bring a non-inscribed area of the surface 4 to the focus point of the beam 3. After such indexing, the micro-processor again signals the generators 69 and 70 to establish deflection amounts in the scanners 61 and 63 for situating the beam 3 at a first position defining the start of the second indicium. The pulse generator

23 is then addressed by the micro-processor 85 operating Q-switch 22 which allows passage of the beam 3. Inscription of a first elemental area of the second indicium results. Subsequent indexing of the generators 69 and 70 as above-described, results in the production of the desired second indicium on the surface 4. Further indicia are then inscribed in the same manner.

As can be appreciated from the above description, the Q-switch 22 remains operational after each elemental area ($A_1, A_2, \dots, A_N$) is inscribed and remains operational when the system is conditioned to inscribe the next elemental area. As can be further appreciated, when the next elemental area is at the beginning of the next indicium, the Q-switch remains closed for a longer time than if the next area were on the same indicium. As a result, the pulse of beam 3 delivered to each first inscription elemental area (for example A_1) is of greater energy than the later pulses delivered to subsequent areas of the same indicium. This higher energy pulse at the beginning of each inscription provides a needed initial graphitization of the diamond surface. This graphitization, in turn, conditions the adjacent surface area so that it is now able to better absorb laser energy. The lesser energy pulse which follows the initial pulse and confronts this adjacent area is thus able to graphitize and inscribe such area. In doing so it overlaps and conditions its subsequent surface area which, upon receipt of the next pulse, is also now able to be graphitized and inscribed. This process of conditioning a surface area followed by graphitization and inscription of same by the lesser energy pulses continues until the indicium inscription is completed.

In order for graphitization to occur on the first pulse after operating the Q-switch 22, as above-described, the energy of this pulse has to be at an appropriate level. Consequently, micro-processor 85 should maintain the Q-switch closed between inscriptions for a length of time sufficient to result in an initial pulse of such energy or greater. In the case of a Nd-YAG laser, this would mean maintaining the Q-switched closed for approximately 1 or more milliseconds.

Furthermore, when inscribing an indicium requiring movement of the beam 3 to an elemental area removed from a previously inscribed elemental area (i.e., to a non-adjacent elemental area), an initial graphitization similar to that at the start of the inscription is again needed. As a result, a similar high energy pulse is required. The micro-processor 85 at these transitions thus also ensures that Q-switch 22 is closed for a long enough time that the next laser pulse has sufficient energy to provide graphitization.

As above-described, the stepping of the beam 3 to inscribe areas of the surface 4 defining a given indicium is such that successively inscribed elemental areas (A_1, A_2 , for example) overlap. This overlap further ensures that the beam 3 will graphitize and inscribe the successive areas. It also results in an inscription which is substantially

uniform and, therefore, easily readable with the appropriate magnification. A useable overlap for which such uniform condition pertains is about 85 per cent.

It should be pointed out that, in the case of some ultra-clear or highly polished diamonds, an initial Q-switched pulse of the above-described magnitude might still not result in graphitization of the diamond surface. As a result, when inscribing diamonds of this character, it is desirable to apply an energy absorbing material such as, for example, a liquid suspension of carbon black, to the surface 4 prior to inscription. Once this material dries, subsequently applied laser energy will be absorbed and inscription can then be more successively carried out.

Once inscription of the diamond 5 has been completed, the operator using microscope 68 and oblique illumination can view the surface 4 to see whether the inscription was correctly carried out. In this way, if an indicium is not inscribed, the operator can communicate this to the computer control system 8 and the system 8 can return to the area of the diamond and inscribe the required indicium.

It should be pointed out that the present inscription practice is believed to be highly advantageous in that it not only does not diminish the value of the diamond 5, but, in fact, adds value to the diamond through the inscribed indicia. Thus, for example, inscription of the origin of the diamond (i.e., the vendor name or trademark), enables the diamond to be easily identified, thereby protecting the diamond against loss or theft. Likewise, indicia indicative of the diamond value, prevent misrepresentation of such value, thereby affording protection against possible fraudulent practices.

If the system requirements dictate that the Q-switch 22 cannot be operated to produce an initial pulse sufficient to cause graphitization, the latter can be effected by allowing not only the high energy initial pulse but also one or more lesser energy pulses to impinge upon the initial surface area to be inscribed. In such case, the microprocessor 85 would control the scanners to hold their deflection states until the desired number of pulses impinge upon the surface area. If desired, subsequent surface areas also may be confronted by more than one pulse by using a similar practice.

Claims

1. A method for providing an identifying indicium to a surface of a diamond (5), comprising applying a laser beam (3) to said surface (4) of that diamond;

moving said laser beam (3) intermittently to successive positions along a path corresponding to said indicium on said diamond surface (4); characterized in that

said beam at each succeeding position covers a diamond surface area ($A_2, \dots$) overlapping a diamond surface area ($A_1, \dots$) covered by the

beam at the immediately preceding position on the path corresponding to said indicium;

the energy level of said laser beam (3) is adjusted to a higher level to graphitize and inscribe a first diamond surface area (A_1) corresponding to a first position on the path; and

the energy level of said laser beam (3) is adjusted to a lower level to graphitize and inscribe each succeeding diamond surface area ($A_2, \dots$) corresponding to each succeeding position on the path.

2. A method in accordance with Claim 1 wherein:

the application of said laser beam to said diamond surface is controlled to inscribe an indelible indicium on said diamond surface.

3. A method in accordance with Claim 1 wherein:

the application of said laser beam to said diamond surface is controlled to inscribe an indicium on said diamond surface while substantially preserving the value of said diamond.

4. A method in accordance with Claim 1 wherein:

the application of said laser beam to said diamond surface is controlled to inscribe an indicium on said diamond surface which cannot be removed without appreciably reducing the value of said diamond.

5. A method in accordance with Claim 1 wherein:

the application of said laser beam to said diamond surface is controlled to inscribe an indicium on said diamond surface which is imperceptible to the human eye.

6. A method in accordance with claim 1 wherein:

the intensity, width and time duration of application of said laser beam are controlled to inscribe said indicium.

7. A method in accordance with claim 1 wherein:

the expanse of said laser beam having sufficient intensity to inscribe said diamond is controlled to be equal to or less than approximately 100 microns at said surface.

8. A method in accordance with claim 7 wherein:

the expanse of said laser beam having sufficient intensity to inscribe said diamond is controlled to be equal to or greater than approximately 1 micron at said surface.

9. A method in accordance with claim 1 wherein:

the power of said laser beam is controlled to be within a range of approximately 0.5 to 5 kW at said surface.

10. A method in accordance with claim 1 wherein:

moving of said beam includes deflecting said beam in a first direction and a second direction transverse to said first direction.

11. A method in accordance with claim 10 wherein:

the degree of deflection of said beam in said

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uniform and, therefore, easily readable with the appropriate magnification. A useable overlap for which such uniform condition pertains is about 85 per cent.

It should be pointed out that, in the case of some ultra-clear or highly polished diamonds, an initial Q-switched pulse of the above-described magnitude might still not result in graphitization of the diamond surface. As a result, when inscribing diamonds of this character, it is desirable to apply an energy absorbing material such as, for example, a liquid suspension of carbon black, to the surface 4 prior to inscription. Once this material dries, subsequently applied laser energy will be absorbed and inscription can then be more successively carried out.

Once inscription of the diamond 5 has been completed, the operator using microscope 68 and oblique illumination can view the surface 4 to see whether the inscription was correctly carried out. In this way, if an indicium is not inscribed, the operator can communicate this to the computer control system 8 and the system 8 can return to the area of the diamond and inscribe the required indicium.

It should be pointed out that the present inscription practice is believed to be highly advantageous in that it not only does not diminish the value of the diamond 5, but, in fact, adds value to the diamond through the inscribed indicia. Thus, for example, inscription of the origin of the diamond (i.e., the vendor name or trademark), enables the diamond to be easily identified, thereby protecting the diamond against loss or theft. Likewise, indicia indicative of the diamond value, prevent misrepresentation of such value, thereby affording protection against possible fraudulent practices.

If the system requirements dictate that the Q-switch 22 cannot be operated to produce an initial pulse sufficient to cause graphitization, the latter can be effected by allowing not only the high energy initial pulse but also one or more lesser energy pulses to impinge upon the initial surface area to be inscribed. In such case, the micro-processor 85 would control the scanners to hold their deflection states until the desired number of pulses impinge upon the surface area. If desired, subsequent surface areas also may be confronted by more than one pulse by using a similar practice.

Claims

1. A method for providing an identifying indicium to a surface of a diamond (5), comprising applying a laser beam (3) to said surface (4) of that diamond;

moving said laser beam (3) intermittently to successive positions along a path corresponding to said indicium on said diamond surface (4); characterized in that

said beam at each succeeding position covers a diamond surface area ($A_2, \dots$) overlapping a diamond surface area ($A_1, \dots$) covered by the

beam at the immediately preceding position on the path corresponding to said indicium;

the energy level of said laser beam (3) is adjusted to a higher level to graphitize and inscribe a first diamond surface area (A_1) corresponding to a first position on the path; and

the energy level of said laser beam (3) is adjusted to a lower level to graphitize and inscribe each succeeding diamond surface area ($A_2, \dots$) corresponding to each succeeding position on the path.

2. A method in accordance with Claim 1 wherein:

the application of said laser beam to said diamond surface is controlled to inscribe an indelible indicium on said diamond surface.

3. A method in accordance with Claim 1 wherein:

the application of said laser beam to said diamond surface is controlled to inscribe an indicium on said diamond surface while substantially preserving the value of said diamond.

4. A method in accordance with Claim 1 wherein:

the application of said laser beam to said diamond surface is controlled to inscribe an indicium on said diamond surface which cannot be removed without appreciably reducing the value of said diamond.

5. A method in accordance with Claim 1 wherein:

the application of said laser beam to said diamond surface is controlled to inscribe an indicium on said diamond surface which is imperceptible to the human eye.

6. A method in accordance with claim 1 wherein:

the intensity, width and time duration of application of said laser beam are controlled to inscribe said indicium.

7. A method in accordance with claim 1 wherein:

the expanse of said laser beam having sufficient intensity to inscribe said diamond is controlled to be equal to or less than approximately 100 microns at said surface.

8. A method in accordance with claim 7 wherein:

the expanse of said laser beam having sufficient intensity to inscribe said diamond is controlled to be equal to or greater than approximately 1 micron at said surface.

9. A method in accordance with claim 1 wherein:

the power of said laser beam is controlled to be within a range of approximately 0.5 to 5 kW at said surface.

10. A method in accordance with claim 1 wherein:

moving of said beam includes deflecting said beam in a first direction and a second direction transverse to said first direction.

11. A method in accordance with claim 10 wherein:

the degree of deflection of said beam in said



first and second directions is changed intermittently.

12. A method in accordance with claim 1 wherein:

controlling of said beam includes focusing said beam onto said surface of said diamond.

13. A method in accordance with claim 1 wherein:

said beam is controlled to inscribe a plurality of further indicia on said surface.

14. A method in accordance with claim 13 further including:

maintaining said diamond stationary during inscription of each said indicium and moving said diamond subsequent to inscription of an indicium and prior to the inscription of the next successive indicium to bring a non-inscribed area of said surface into confronting relationship with said beam.

15. A method in accordance with claim 14 wherein:

said method further includes initially orienting said diamond to situate the center of rotation of said surface at a point which is on the axis of said beam and which is spaced from the point of focus of said beam by a distance equal to the radius of curvature of said surface;

and moving of said diamond includes rotating said diamond about said point to bring each non-inscribed area into confronting relationship with said beam, whereby said beam is maintained in focus on the successive areas of said surface being inscribed.

16. A method in accordance with claim 12 further comprising:

prior to initially orienting said diamond, moving said diamond to at least three positions for which said surface is at the point to which said beam is to be focused and calculating from said positions the center of rotation and radius of curvature of said surface.

17. A method in accordance with claim 14 wherein:

said method further includes initially orienting said diamond to situate said surface orthogonal to the axis of said beam;

and moving of said diamond includes translating said diamond to bring each non-inscribed area into confronting relationship with said beam, whereby said beam is maintained in focus on the successive areas of said surface being inscribed.

18. A method in accordance with claim 17 further comprising:

prior to initially orienting said diamond, moving said diamond to a number of positions for which said surface is at the point to which said beam is to be focused and calculating from said positions the intersection angle of said surfaces.

19. A method in accordance with claim 1 further comprising:

initially applying an energy absorbing material to said surface of said diamond prior to applying said laser beam to said diamond surface.

20. A method in accordance with claim 19 wherein:

said material is carbon black.

21. A method in accordance with claim 1 wherein:

applying said laser beam includes Q-switching the output of a continuous laser source.

22. A method in accordance with claim 7 wherein:

the expanse of said laser beam (3) having sufficient intensity to inscribe said diamond (5) is controlled to be equal to or greater than approximately 10 microns at said surface.

23. Method in accordance with claim 1 wherein the said surface (4) is on the girdle of said diamond (5).

24. Apparatus for carrying out the method of claim 1 for applying a laser beam (3) to a surface (4) of a diamond (5) to provide an identifying indicium to said diamond surface (4) comprising means (6) for moving the laser beam (3) intermittently to successive positions along a path corresponding to said indicium on said diamond surface (4) characterized in that said moving means (6) move said laser beam (3) such that said beam at each succeeding position covers a diamond surface area ($A_2, \dots$) overlapping a diamond surface area ($A_1, \dots$) covered by the beam at the immediately preceding position on the path corresponding to said indicium; and

by means (22, 65) for adjusting the energy level of said laser beam (3) to a higher level to graphitize and inscribe a first diamond surface area (A_1) corresponding to a first position on the path and for adjusting the energy level of said laser beam (3) to a lower level to graphitize and inscribe each succeeding diamond surface area ($A_2, \dots$) corresponding to each succeeding position on the path.

25. Apparatus in accordance with claim 24 wherein said surface (4) is on the girdle of said diamond (5).

26. Apparatus in accordance with claim 24 wherein:

the adjusting means (22, 65) adjusts the energy level of the laser beam (3) to inscribe an indelible indicium on said diamond surface (4).

27. Apparatus in accordance with claim 24 wherein:

the adjusting means (22, 65) adjusts the energy level of the laser beam (3) to inscribe an indicium on said diamond surface (4) while substantially preserving the value of said diamond.

28. Apparatus in accordance with claim 24 wherein:

the adjusting means (22, 65) adjusts the energy level of the laser beam (3) to inscribe an indicium which cannot be removed without appreciably reducing the value of said diamond.

29. Apparatus in accordance with claim 24 wherein:

the adjusting means (22, 65) adjusts the energy level of the laser beam to inscribe an indicium which is imperceptible to the naked eye.

30. Apparatus in accordance with claim 24 wherein:

said control means (2, 6) provides an expanse



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of said laser beam (3) having sufficient intensity to inscribe said surface (4) which is equal to or less than approximately 100 microns at said surface.

31. Apparatus in accordance with claim 30 wherein:

said control means (2, 6) provides an expanse of said laser beam (3) having sufficient intensity to inscribe said surface (4) which is equal to or greater than approximately 1 micron at said surface.

32. Apparatus in accordance with claim 30 wherein:

said control means (2, 6) includes a lens means (66) for focusing said beam (3) onto said surface.

33. Apparatus in accordance with claim 24 wherein:

said adjusting means (22, 65) provides a laser beam (3) of sufficient power such that the power of said beam is within a range of approximately 0.5 to 5 kW at said surface (4).

34. Apparatus in accordance with claim 24 wherein:

said adjusting means includes a Q-switch (22).

35. Apparatus in accordance with claim 24 wherein:

said adjusting means includes a continuous laser source (21).

36. Apparatus in accordance with claim 24 wherein:

said moving means further includes:

means (61) for deflecting said beam in a first direction;

and means (63) for deflecting said beam in a second direction transverse to said first direction.

37. Apparatus in accordance with claim 36 wherein:

said deflecting means (61, 63) each include a digital deflector.

38. Apparatus in accordance with claim 24 wherein:

said beam is controlled to inscribe a plurality of further indicia on said surface (4).

39. Apparatus in accordance with claim 38 further including:

means (7) for maintaining said diamond (5) stationary during inscription of each said indicium and moving said diamond (5) subsequent to inscription of the next successive indicium to bring a non-inscribed area of said surface into confronting relationship with said beam.

40. Apparatus in accordance with claim 39 wherein:

said diamond moving means includes:

a first table means (71) for translating said diamond (5) in a first direction;

a second table means (72) for translating said diamond (5) in a second direction;

a third table means (73) supporting said first and second table means (71, 72) for rotating said diamond (5);

and a fourth table means (74) for supporting said third table means (73) and translating said diamond (5) in said first direction.

41. Apparatus in accordance with claim 39 further including:

computer means (8) for sequentially controlling the operation of said applying means (2), beam moving means (6) and said diamond moving means (7).

42. Apparatus in accordance with claim 30 wherein:

said control means (2, 6) provides an expanse of said laser beam (3) having sufficient intensity to inscribe said surface (4) which is equal to or greater than approximately 10 microns at said surface.

Patentansprüche

1. Verfahren zum Anbringen einer identifizierenden Kennzeichnung auf einer Fläche eines Diamanten (5), umfassend

Beaufschlagen der Fläche (4) des Diamanten mit einem Laserstrahl (3);

Bewegen des Laserstrahls (3) schrittweise in anschließende Positionen längs einer Bahn, die der Kennzeichnung auf der Diamantfläche (4) entspricht;

dadurch gekennzeichnet, daß

der Strahl in jeder folgenden Position ein Diamant-Flächenelement ($A_2, \dots$) bedeckt, welches ein Diamant-Flächenelement ($A_1, \dots$) überlappt, das von dem Strahl in der unmittelbar vorausgehenden Position auf der der Kennzeichnung entsprechenden Bahn bedeckt war;

der Energiepegel des Laserstrahls (3) auf einen höheren Wert eingestellt wird, um ein erstes Diamant-Flächenelement (A_1), das einer ersten Position auf der Bahn entspricht, zu graphitieren und zu beschriften; und daß

der Energiepegel des Laserstrahls (3) auf einen niedrigeren Wert eingestellt wird, um jedes darauffolgende Diamant-Flächenelement ($A_2, \dots$) zu graphitieren und zu beschriften, das der jeweils folgenden Position auf der Bahn entspricht.

2. Verfahren nach Anspruch 1, worin der Angriff des Laserstrahls an der Diamantfläche gesteuert wird, um ein untilgbares Kennzeichen auf die Diamantfläche aufzubringen.

3. Verfahren nach Anspruch 1, worin der Angriff des Laserstrahls an der Diamantfläche gesteuert wird, um eine Kennzeichnung auf diese Diamantfläche aufzubringen, wobei der Wert des Diamanten praktisch erhalten wird.

4. Verfahren nach Anspruch 1, worin der Angriff des Laserstrahls an der Diamantfläche gesteuert wird, um eine Kennzeichnung auf die Diamantfläche aufzubringen, die ohne erhebliche Herabsetzung des Wertes des Diamanten nicht entfernt werden kann.

5. Verfahren nach Anspruch 1, worin der Angriff des Laserstrahls an der Diamantfläche gesteuert wird, um auf die Diamantfläche eine Kennzeichnung aufzubringen, die für das menschliche Auge nicht wahrnehmbar ist.

6. Verfahren nach Anspruch 1, worin die Intensität, die Breite und die Zeitdauer des Angriffs des Laserstrahls gesteuert werden, um die Kennzeichnung aufzubringen.



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7. Verfahren nach Anspruch 1, worin die Ausdehnung des Laserstrahls, der ausreichend Intensität hat, um den Diamanten zu beschriften, so gesteuert wird, daß sie an der Fläche etwa 100 µm oder weniger beträgt.

8. Verfahren nach Anspruch 7, worin die Ausdehnung des Laserstrahls, der ausreichend Intensität hat, um den Diamanten zu beschriften, so gesteuert wird, daß sie an der Fläche etwa 1 µm oder mehr beträgt.

9. Verfahren nach Anspruch 1, worin die Leistung des Laserstrahls so gesteuert wird, daß sie an der Fläche etwa 0,5 bis 5 kW beträgt.

10. Verfahren nach Anspruch 1, worin für das Bewegen des Strahls dieser in einer ersten Richtung und in einer quer zu der ersten Richtung verlaufenden zweiten Richtung abgelenkt wird.

11. Verfahren nach Anspruch 10, worin der Grad der Ablenkung des Strahls in der ersten und der zweiten Richtung intermittierend geändert wird.

12. Verfahren nach Anspruch 1, worin zum Steuern des Strahls das Fokussieren des Strahls auf die Fläche des Diamanten gehört.

13. Verfahren nach Anspruch 1, worin der Strahl so gesteuert wird, daß er eine Mehrzahl von weiteren Kennzeichnungen auf die Fläche aufbringt.

14. Verfahren nach Anspruch 13, ferner umfassend das stationäre Festhalten des Diamanten während des Aufbringens jeder Kennzeichnung und das Bewegen des Diamanten im Anschluß an das Aufbringen einer Kennzeichnung und vor dem Aufbringen der nächstfolgenden Kennzeichnung, um einen nicht beschrifteten Bereich der Fläche dem Strahl gegenüberzustellen.

15. Verfahren nach Anspruch 14, worin das Verfahren ausserdem umfaßt, anfangs den Diamanten zu orientieren, um den Drehungsmittelpunkt der Fläche an einen Punkt zu bringen, der auf der Achse des Strahls liegt und der von dem Fokussierungspunkt des Strahls um eine Strecke entfernt ist, die gleich dem Krümmungsradius der Fläche ist;

und worin das Bewegen des Diamanten das Drehen des Diamanten um diesen Punkt umfaßt, um jeden nicht-beschrifteten Bereich dem Strahl gegenüberzustellen, wodurch der Strahl in Fokussierungslage gegenüber aufeinanderfolgenden Bereichen der zu beschriftenden Fläche gehalten wird.

16. Verfahren nach Anspruch 12, ferner umfassend, vor dem ersten Ausrichten des Diamanten diesen in mindestens drei Positionen zu bringen, für welche die Fläche sich an dem Fokussierungspunkt des Strahls befindet, und aus diesen Positionen den Drehungsmittelpunkt und den Krümmungsradius der Fläche zu berechnen.

17. Verfahren nach Anspruch 14, worin das Verfahren außerdem das anfängliche Ausrichten des Diamanten umfaßt, um die Fläche orthogonal zu der Achse des Strahls auszurichten, und das Bewegen des Diamanten die Translationsbewegung des Diamanten umfaßt, um jeden nicht-beschrifteten Bereich dem Strahl gegenüber-

zustellen, wodurch der Strahl weiterhin in Fokussierungsstellung gegenüber den nachfolgenden Bereichen der zu beschriftenden Fläche verbleibt.

18. Verfahren nach Anspruch 17, ferner umfassend, vor dem erstmaligen Ausrichten des Diamanten, den Diamanten in eine Anzahl von Positionen zu bringen, für welche die Fläche sich an dem Punkt befindet, auf den der Strahl zu fokussieren ist, und aus diesen Positionen den Schnittwinkel der Flächen zu berechnen.

19. Verfahren nach Anspruch 1, weiter umfassend, zunächst ein energieabsorbierendes Material auf die Fläche des Diamanten zu bringen, bevor der Laserstrahl auf die Diamantfläche gerichtet wird.

20. Verfahren nach Anspruch 19, worin es sich bei dem Material um Ruß handelt.

21. Verfahren nach Anspruch 1, worin das Auftreffenlassen des Laserstrahls das Schalten des Ausgangs einer kontinuierlichen Laserquelle mittels Güteschalter umfaßt.

22. Verfahren nach Anspruch 7, worin die Ausdehnung des Laserstrahls (3) mit für das Beschriften des Diamanten (5) ausreichender Intensität so gesteuert wird, daß sie an der Oberfläche mindestens etwa 10 µm beträgt.

23. Verfahren nach Anspruch 1, worin die Fläche (4) sich auf der Fassungskante des Diamanten (5) befindet.

24. Vorrichtung zur Ausübung des Verfahrens nach Anspruch 1, zum Beaufschlagen einer Fläche (4) eines Diamanten (5) mit einem Laserstrahl (3), um auf die Diamantfläche (4) eine Kennzeichnung aufzubringen, mit einer Einrichtung (6) zum intermittierenden Bewegen des Laserstrahls (3) in aufeinanderfolgende Positionen längs einer Bahn, die der Kennzeichnung auf der Diamantfläche (4) entspricht

gekennzeichnet dadurch, daß die Bewegungseinrichtung (6) den Laserstrahl (3) in der Weise bewegt, daß der Strahl in jeder folgenden Stellung ein Diamantflächenelement ($A_2, \dots$) bedeckt, das ein Diamantflächenelement ($A_1, \dots$) überlappt, das von dem Strahl in der unmittelbar vorausgehenden Stellung auf der der Kennzeichnung entsprechenden Bahn bedeckt war; und

durch eine Einrichtung (22, 65) zum Einstellen des Energiepegels des Laserstrahls (3) auf einen höheren Wert, um ein erstes Diamant-Flächenelement (A_1) zu graphitieren und zu beschriften, das einer ersten Position auf der Bahn entspricht, und zum Einstellen des Energiepegels des Laserstrahls (3) auf einen niedrigeren Wert, um jedes nachfolgende Diamant-Flächenelement ($A_2, \dots$) zu graphitieren und zu beschriften, das jeder nachfolgenden Position auf der Bahn entspricht.

25. Vorrichtung nach Anspruch 24, worin die Fläche (4) auf der Fassungskante des Diamanten (5) liegt.

26. Vorrichtung nach Anspruch 24, worin die Einstelleinrichtung (22, 65) den Energiepegel des Laserstrahls (3) einstellt, um eine unutilgbare Kennzeichnung auf die Diamantfläche (4) aufzubringen.



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27. Vorrichtung nach Anspruch 24, worin die Einstelleinrichtung (22, 65) den Energiepegel des Laserstrahls (3) einstellt, um eine Kennzeichnung auf die Diamantfläche (4) aufzubringen, während der Wert des Diamanten praktisch erhalten bleibt.

28. Vorrichtung nach Anspruch 24, worin die Einstelleinrichtung (22, 65) den Energiepegel des Laserstrahls (3) einstellt, um eine Kennzeichnung aufzubringen, die ohne wesentliche Herabsetzung des Wertes des Diamanten nicht entfernt werden kann.

29. Vorrichtung nach Anspruch 24, worin die Einstelleinrichtung (22, 65) den Energiepegel des Laserstrahls (3) einstellt, um eine Kennzeichnung aufzubringen, die für das unbewaffnete Auge nicht wahrnehmbar ist.

30. Vorrichtung nach Anspruch 24, worin die Steuereinrichtung (2, 6) eine Ausdehnung des Laserstrahls (3) mit ausreichender Intensität zum Beschriften der Fläche (4) liefert, welche Ausdehnung an der Fläche höchstens etwa 100 µm beträgt.

31. Vorrichtung nach Anspruch 30, worin die Steuereinrichtung (2, 6) eine Ausdehnung des Laserstrahls (3) mit ausreichender Intensität zum Beschriften der Fläche (4) liefert, welcher Ausdehnung an der Fläche mindestens 1 µm beträgt.

32. Vorrichtung nach Anspruch 30, worin die Steuereinrichtung (2, 6) ein Objektiv (66) zum Fokussieren des Strahls (3) auf die Fläche aufweist.

33. Vorrichtung nach Anspruch 24, worin die Einstelleinrichtung (22, 65) einen Laserstrahl (3) von so hoher Stärke liefert, daß die Stärke des Strahls an der Fläche (4) zwischen etwa 0,5 und 5 kW beträgt.

34. Vorrichtung nach Anspruch 24, worin die Einstelleinrichtung einen Güteschalter (22) enthält.

35. Vorrichtung nach Anspruch 24, worin die Einstelleinrichtung eine kontinuierliche Laserquelle (21) enthält.

36. Vorrichtung nach Anspruch 24, worin die Bewegungseinrichtung außerdem umfaßt:

eine Einrichtung (61) zum Ablenken des Strahls in eine erste Richtung;

und eine Einrichtung (63) zum Ablenken des Strahls in einer quer zu der ersten Richtung liegenden zweiten Richtung.

37. Vorrichtung nach Anspruch 36, worin die Ablenkeinrichtung (61, 63) einen Digitalablenker enthält.

38. Vorrichtung nach Anspruch 24, worin der Strahl gesteuert wird, um eine Mehrzahl weiterer Kenzeichen auf die Fläche (4) aufzubringen.

39. Vorrichtung nach Anspruch 38, ferner eine Einrichtung (7) umfassend zum stationären Halten des Diamanten (5) während des Aufbringens jedes Kennzeichens und zum Bewegen des Diamanten (5) im Anschluß an das Aufbringen des nächstfolgenden Kennzeichens, um einen unbeschrifteten Bereich der Fläche dem Strahl gegenüberzustellen.

40. Vorrichtung nach Anspruch 39, worin die

Einrichtung zum Bewegen des Diamanten umfaßt:

eine erste Tischeinrichtung (71) für die Translationsbewegung des Diamanten (5) in einer ersten Richtung;

eine zweite Tischeinrichtung (72) für die Translationsbewegung des Diamanten (5) in einer zweiten Richtung;

eine dritte Tischeinrichtung (73), die die erste und zweite Tischeinrichtung (71, 72) trägt, um den Diamanten (5) zu drehen;

und eine vierte Tischeinrichtung (74) zum Tragen der dritten Tischeinrichtung (73) und für die Translationsbewegung des Diamanten (5) in der ersten Richtung.

41. Vorrichtung nach Anspruch 39, ferner eine Rechneinrichtung (8) umfassend, um sequentiell die Tätigkeit der Strahlerzeugungs- und zuführungseinrichtung (2), der Strahlbewegungseinrichtung (6) und der Diamant-Bewegungseinrichtung (7) zu steuern.

42. Vorrichtung nach Anspruch 30, worin die Steuereinrichtung (2, 6) eine Ausdehnung des Laserstrahls (3) liefert, der eine ausreichende Intensität aufweist, um die Fläche (4) zu beschriften, und welche Ausdehnung an dieser Fläche mindestens etwa 10 µm beträgt.

Revendications

1. Procédé d'apposition d'une marque d'identification sur une surface d'un diamant (5), consistant à appliquer un faisceau de laser (3) sur ladite surface (4) de ce diamant, à déplacer de façon intermittente ledit faisceau de laser (3) jusqu'à des positions successives le long d'un trajet correspondant à ladite marque sur ladite surface du diamant (4), caractérisé en ce que ledit faisceau, dans chaque position successive, couvre une région de surface ($A_2...$) du diamant chevauchant une région de surface ($A_1...$) du diamant couverte par le faisceau à la position qui précède immédiatement sur le trajet correspondant à ladite marque, le niveau d'énergie dudit faisceau de laser (3) étant réglé à un niveau supérieure pour transformer en graphite et marquer une première région de surface (A_1) du diamant correspondant à une première position sur le trajet, et le niveau d'énergie dudit faisceau de laser (3) étant réglé à un niveau inférieur pour transformer en graphite et marquer chaque région de surface ($A_2...$) suivant du diamant correspondant à chaque position successive sur le trajet.

2. Procédé selon la revendication 1, dans lequel l'application dudit faisceau de laser à ladite surface du diamant est contrôlée pour inscrire une marque indélébile sur ladite surface du diamant.

3. Procédé selon la revendication 1, dans lequel l'application dudit faisceau de laser à ladite surface du diamant est contrôlée pour inscrire une marque sur ladite surface du diamant qui préserve la valeur de ce diamant.

4. Procédé selon la revendication 1, dans lequel l'application dudit faisceau de laser à ladite sur-



face du diamant est contrôlée pour inscrire une marque sur ladite surface du diamant qui ne peut être enlevée sans réduire de façon appréciable la valeur de ce diamant.

5. Procédé selon la revendication 1, dans lequel l'application dudit faisceau de laser à ladite surface du diamant est contrôlée pour inscrire une marque sur ladite surface du diamant qui est imperceptible à l'oeil humain.

6. Procédé selon la revendication 1, dans lequel l'intensité, la largeur et la durée d'application dudit faisceau de laser sont contrôlées pour inscrire ladite marque.

7. Procédé selon la revendication 1, dans lequel l'étendue dudit faisceau de laser avec une intensité suffisante pour marquer ledit diamant est contrôlée pour être égale ou inférieure à environ 100 μm à ladite surface.

8. Procédé selon la revendication 7, dans lequel l'étendue dudit faisceau de laser avec une intensité suffisante pour marquer ledit diamant est contrôlée pour être égale ou supérieure à environ 1 μm à ladite surface.

9. Procédé selon la revendication 1, dans lequel la puissance dudit faisceau de laser est contrôlée pour se situer dans une plage d'environ 0,5 à 5 kW à ladite surface.

10. Procédé selon la revendication 1, dans lequel le déplacement dudit faisceau consiste à dévier ledit faisceau dans une première direction et dans une deuxième direction perpendiculaire à ladite première direction.

11. Procédé selon la revendication 10, dans lequel le degré de déviation dudit faisceau dans ladite première et ladite seconde directions est changé par intermittence.

12. Procédé selon la revendication 1, dans lequel le contrôle dudit faisceau consiste à focaliser ledit faisceau sur ladite surface dudit diamant.

13. Procédé selon la revendication 1, dans lequel ledit faisceau est contrôlé pour inscrire plusieurs autres marques sur ladite surface.

14. Procédé selon la revendication 13, caractérisé en ce qu'il consiste en outre à maintenir ledit diamant immobile pendant l'inscription de chacun desdits marquages et à déplacer ensuite ledit diamant pour l'inscription d'un marquage avant l'inscription du marquage qui suit immédiatement pour amener une région non inscrite de ladite surface en regard dudit faisceau.

15. Procédé selon la revendication 14, consistant en outre à orienter initialement ledit diamant pour situer le centre de rotation de ladite surface en un point qui se trouve sur l'axe dudit faisceau et qui est espacé du point de focalisation dudit faisceau d'une distance égale au rayon de courbure de ladite surface, et ledit déplacement de ledit diamant consiste à faire tourner ledit diamant autour dudit point pour amener chaque région non inscrite en regard dudit faisceau, de manière que ledit faisceau soit maintenu focalisé sur les régions successives de ladite surface marquée.

16. Procédé selon la revendication 12, consistant en outre, avant l'orientation initiale du dia-

mant, à déplacer ledit diamant jusqu'à au moins trois positions dans lesquelles ladite surface se trouve au point auquel ledit faisceau doit être focalisé et à calculer à partir desdites positions, le centre de rotation et le rayon de courbure de ladite surface.

17. Procédé selon la revendication 14, consistant en outre à orienter initialement le diamant pour situer ladite surface orthogonale à l'axe dudit faisceau; et le déplacement dudit diamant consiste en une translation dudit diamant pour amener chaque région non inscrite en regard dudit faisceau de manière que ledit faisceau soit maintenu focalisé sur les régions successives de ladite surface marquée.

18. Procédé selon la revendication 17, consistant en outre, avant l'orientation initiale de ledit diamant à déplacer ledit diamant jusqu'à un certain nombre de positions pour lesquelles ladite surface se trouve au point auquel ledit faisceau doit être focalisé et à calculer à partir desdites positions, l'angle d'intersection desdites surfaces.

19. Procédé selon la revendication 1, consistant en outre à appliquer initialement une matière absorbant l'énergie sur ladite surface de ledit diamant avant l'application dudit faisceau de laser à ladite surface du diamant.

20. Procédé selon la revendication 19, dans lequel ladite matière est du noir de carbone.

21. Procédé selon la revendication 1, dans lequel l'application dudit faisceau de laser consiste à effectuer une commutation Q de la sortie d'une source de laser continue.

22. Procédé selon la revendication 7, dans lequel l'étendue dudit faisceau de laser (3) ayant une intensité suffisante pour marquer ledit diamant (5) est contrôlée pour être égale ou supérieure à environ 10 μm à la surface.

23. Procédé selon la revendication 1, dans lequel ladite surface (4) se trouve sur le feuilletis dudit diamant (5).

24. Appareil destiné à la mise en oeuvre du procédé de la revendication 1, appliquant un faisceau de laser (3) sur une surface (4) d'un diamant (5) pour apposer une marque d'identification sur ladite surface (4) du diamant, comprenant un dispositif (6) pour déplacer par intermittence le faisceau de laser (3) jusqu'à des positions successives le long d'un trajet correspondant audit marquage sur ladite surface (4) du diamant, caractérisé en ce que ledit dispositif de déplacement (6) déplace ledit faisceau de laser (3) de manière que, dans chaque position successive, ledit faisceau couvre une région de surface ($A_2, \dots$) du diamant chevauchant une région de surface ($A_1, \dots$) du diamant couverte par le faisceau dans la position immédiatement précédente sur le trajet correspondant à ladite marque, et en ce qu'un dispositif (22, 65) est prévu pour régler le niveau d'énergie dudit faisceau de laser (3) à un niveau supérieur pour transformer en graphite et marquer une première région de surface (A_1) dudit diamant correspondant à une première position sur le trajet, et pour régler le niveau d'énergie dudit faisceau de laser (3) à un niveau inférieur



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pour transformer en graphite et marquer chaque région de surface ($A_2...$) successive du diamant correspondant à chaque position successive sur le trajet.

25. Appareil selon la revendication 24, dans lequel ladite surface (4) se trouve sur le feuilletis dudit diamant (5).

26. Appareil selon la revendication 24, dans lequel le dispositif de réglage (22, 65) règle le niveau d'énergie du faisceau de laser (3) pour inscrire une marque indélébile sur ladite surface (4) du diamant.

27. Appareil selon la revendication 24, dans lequel le dispositif de réglage (22, 65) règle le niveau d'énergie du faisceau de laser (3) pour inscrire une marque sur ladite surface (4) du diamant tout en préservant la valeur dudit diamant.

28. Appareil selon la revendication 24, dans lequel le dispositif de réglage (22, 65) règle le niveau d'énergie du faisceau de laser (3) pour inscrire une marque qui ne peut être enlevée sans réduire de façon appréciable la valeur dudit diamant.

29. Appareil selon la revendication 24, dans lequel le dispositif de réglage (22, 65) règle le niveau d'énergie du faisceau de laser pour inscrire une marque qui est imperceptible à l'oeil nu.

30. Appareil selon la revendication 24, dans lequel ledit dispositif de commande (2, 6) produit une expansion dudit faisceau de laser (3) avec une intensité suffisante pour marquer ladite surface (4), qui est égale ou inférieure à environ 100 μm à ladite surface.

31. Appareil selon la revendication 30, dans lequel ledit dispositif de commande (2, 6) produit une expansion dudit faisceau de laser (3) avec une intensité suffisante pour marquer ladite surface (4), qui est égale ou supérieure à environ 1 μm à ladite surface.

32. Appareil selon la revendication 30, dans lequel ledit dispositif de commande (2, 6) comporte un dispositif à lentille (66) pour focaliser ledit faisceau (3) sur ladite surface.

33. Appareil selon la revendication 24, dans lequel ledit dispositif de réglage (22, 65) produit un faisceau de laser (3) d'une puissance suffisante pour que la puissance dudit faisceau se situe dans une plage d'environ 0,5 à 5 kW à ladite surface (4).

34. Appareil selon la revendication 24, dans

lequel ledit dispositif de réglage comporte un commutateur (Q 22).

35. Appareil selon la revendication 24, dans lequel ledit dispositif de réglage comporte une source de laser continue (21).

36. Appareil selon la revendication 24, dans lequel ledit dispositif de déplacement comporte en outre un dispositif (61) pour dévier ledit faisceau dans une première direction, et un dispositif (63) pour dévier ledit faisceau dans une seconde direction perpendiculaire à ladite première direction.

37. Appareil selon la revendication 36, dans lequel lesdits dispositifs de déviation (61, 63) comportent chacun un déflecteur numérique.

38. Appareil selon la revendication 24, dans lequel ledit faisceau est contrôlé pour inscrire plusieurs autres marques sur ladite surface (4).

39. Appareil selon la revendication 38, comprenant en outre un dispositif (7) destiné à maintenir ledit diamant (5) immobile pendant l'inscription de chacune desdites marques, et à déplacer ledit diamant (5) après l'inscription de la marque qui suit immédiatement pour amener une région non marquée de ladite surface en regard dudit faisceau.

40. Appareil selon la revendication 39, dans lequel ledit dispositif de déplacement de diamant comporte une première table (71) pour imprimer un mouvement de translation audit diamant (5) dans une première direction, une seconde table (72) pour imprimer un mouvement de translation audit diamant (5) dans une seconde direction, une troisième table (73) supportant ladite première et ladite seconde tables (71, 72) pour faire tourner ledit diamant (5) et une quatrième table (74) destinée à supporter ladite troisième table (73) et à produire un mouvement de translation dudit diamant (5) dans ladite première direction.

41. Appareil selon la revendication 39, comprenant en outre un dispositif à calculateur (8) destiné à commander séquentiellement le fonctionnement dudit dispositif d'application (2), dudit dispositif de déplacement de faisceau (6) et dudit dispositif de déplacement de diamant (7).

42. Appareil selon la revendication 30, dans lequel ledit dispositif de commande (2, 6) produit une expansion dudit faisceau de laser (3) avec une intensité suffisante pour marquer ladite surface (4), qui est égale ou supérieure à environ 10 μm sur ladite surface.



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