(54) A method and apparatus for locating inclusions in a diamond stone

(57) A method and apparatus to localizing inclusions in a diamond, wherein said diamond is fixed on a holder, said diamond on the holder is observed under a predetermined angle to obtain an image, further a second measurement is carried out to obtain two data to be calculated in a computer, said second data can be obtained by a depth measurement, or by changing the direction of observation to said diamond, in order to localize the inclusion with respect to the outer surface of said diamond.

FIG.1
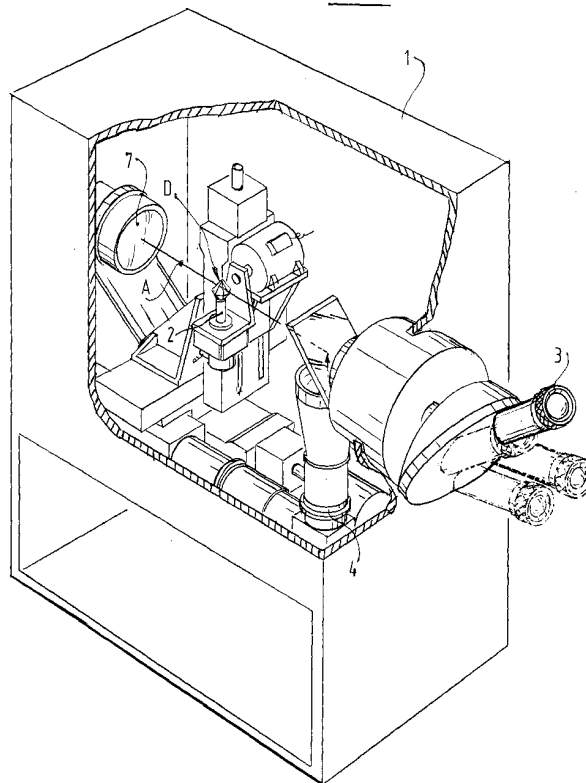
EP 1 211 503 A1

Description

[0001] The invention is related to a method and appartus to localizing inclusions in a diamond.

[0002] Up to now several methods are used to determine inclusions in diamonds, all of which have the disadvantage that the inclusions are difficult to locate with respect to the outer surface of the diamond. Mostly two-dimensional images of the diamond will be obtained, what leads to an inaccurate location of such inclusion.

[0003] The invention has for its object to avoid abovementioned disadvantages, and the method according to the invention is distinguished in that said diamond is fixed on a holder, said diamond on the holder is observed under a predetermined angle to obtain an image, further a second measurement is carried out to obtain two data to be calculated in a computer in order to localize the inclusion with respect to the outer surface of said diamond. According to a first embodiment of the invention the method is further distinguished in that, said diamond is fixed on a holder, said diamond on the holder is detected under a predetermined angle to obtain a reference image, further the direction of observation is at least changed one time, to obtain just as much as changes, wherein the image-data are fed into a computer to calculate a tridimensional image including the or each inclusion with respect thereof.

[0004] Once the inclusion is clearly located with respect to the outer surface of the diamond, said diamond can easily be cut through the most optimal plane, calculated by the computer. This optimal plane leads through the inclusion, so when cutting the diamond the inclusion is disappeared.

[0005] Although the viewing direction with respect to the diamond can be carried out by repositioning the scanner and so on, it is according to the invention easier to rotate and/or translate the holder with the diamond with respect to a fixed direction of observation.

[0006] Further it is one of the objectives of the invention to introduce a correction factor, related to the refractive index of the diamond material to be taken up in the calculation when the scanning direction is deviating from a direction of observation, perpendicular to the diamond surface.

[0007] To easily create a correct location and/or largeness of the inclusion in the diamond, an optical cylinder will be used, the diameter and the detecting direction is used for the calculation by the computer.

[0008] According to a further embodiment the inclusion can be localized by using a scanner having focussing means to obtain a depth position along said direction of observation by focusing said inclusion.

[0009] The invention will be elucidated by the following description of an embodiment to localize inclusions in the diamond.

[0010] In the drawing:

Figure 1 is a perspective view of an scanning-embodiment according to the invention for scanning a diamond upon a holder.

Figure 2 A,B,C,D, indicates the sequential steps of the preferred method according to the invention.

[0011] In figure 1 a housing 1 contains a holder 2, upon which a diamond D is fixed. By means of arbitrary and suitable motor means, it is possible to rotate the holder and/or to translate the holder, in order to position the diamond in an optical axis a, being the optical axis of a projecting light-beam 7, projected through the diamond unto a half permeable mirror, refuting in a diamond-image at a microscope and/or camera 3 and to a scanner 4.

[0012] When projecting the light it is possible to bring the holder 2 in the correct position with respect to the microscope crosswires in a manual way carried out by an operator. The scanner 4 is used to obtain the data necessary for this particular image and to use this data in a calculation by a computer.

[0013] The several steps for carrying out the method according to the invention is explained in figure 2.

a) Fix the diamond on the table, and take a scan 4 of the outer surface of the stone at an arbitrary initial position. The coordinates of this position are $X_0, Y_0, Z_0, \alpha_0, \beta_0, \gamma_0$.

i) rotate the stone to make the necessary inclusion visible through the microscope (with the measuring ocular)

b) Move the inclusion in front of the crosswire 9 of the microscope. The operator looking through the microscope does this by controlling the table. The translations X_1, Y_1, Z_1 and rotations α_1, β_1, γ_1 the diamond on the table has performed, starting from its initial position, are registered. A facet is determined (its normal is (α_1, β_1, γ_1), through which the inclusion is seen. A cylinder (or line) is determined so that the inclusion is inside said cylinder (or is crossed by said line). The same procedure (steps a and b) is carried out from several different positions "n".

c) Different positions are understood as either viewing through different facets of the diamond, or viewing through the same facets but from different directions. The different set of translations and rotations are registered: $X_2...X_n$, $Y_2...Y_n$, $Z_2...Z_n$, $\alpha_2...\alpha_n$, $\beta_2...\beta_n$, $\gamma_2...\gamma_n$.

d) The position of the inclusions inside the diamond is calculated out from the registered translations and rotations, the scan of the outer surface and knowledge of the refractive index of the diamond. The position of an inclusion is determined as the nearest cross-centres of the lines or cylinders created on step b. A symbol of the inclusion 8 is projected into the scan.

[0014] The invention is not limited to the method ac-

cording to the lines above. For example the miroscope crosswire may be replaced by a "coordinate map", so avoiding a translation of the holder in each viewing direction.
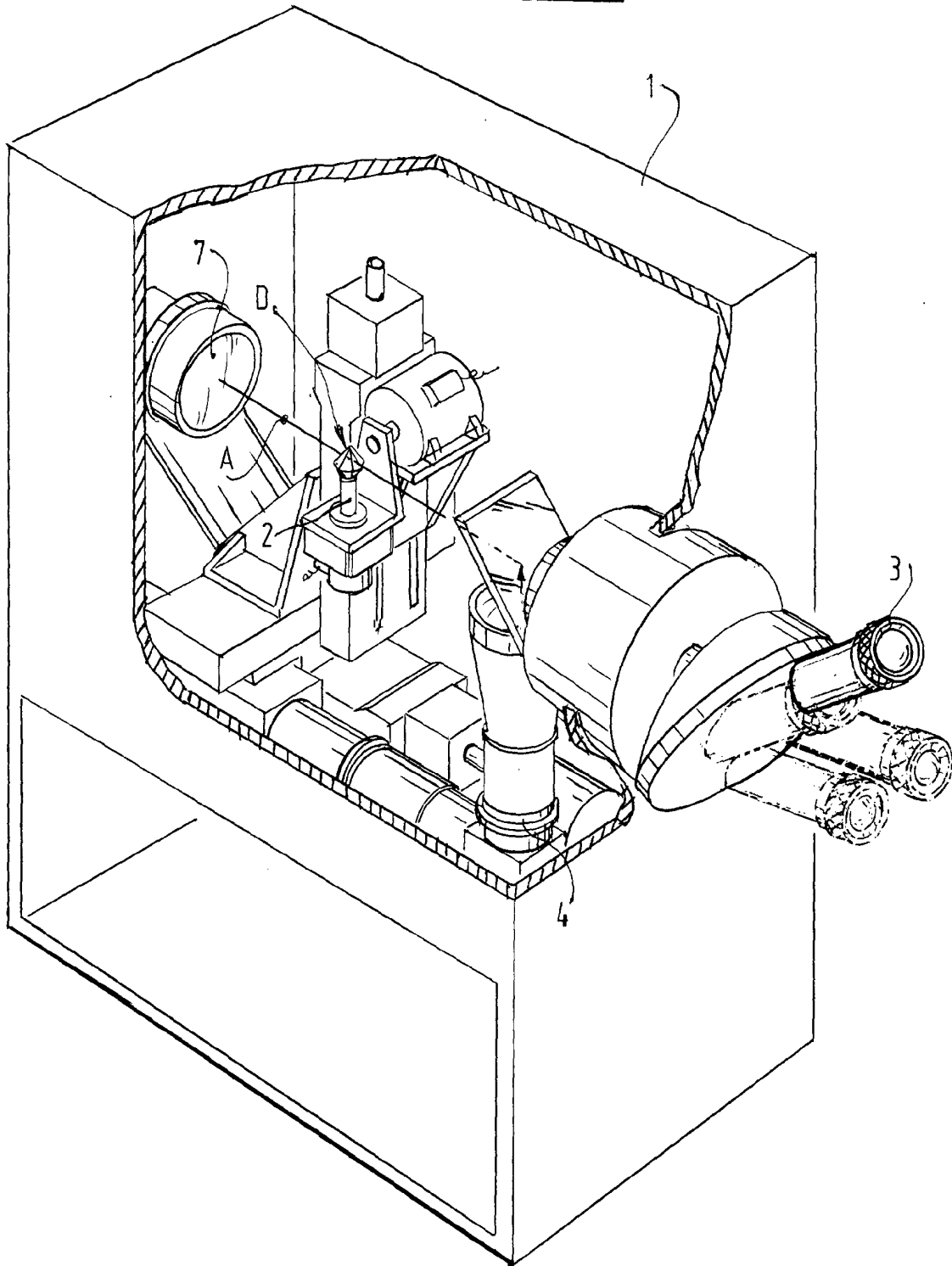
Claims

1. A method to localizing inclusions in a diamond, **characterized in that** said diamond is fixed on a holder, said diamond on the holder is observed under a predetermined angle to obtain an image, further a second measurement is carried out to obtain two data to be calculated in a computer in order to localize the inclusion with respect to the outer surface of said diamond.

2. A method according to claim 1, **characterized in that** said direction of observation is at least changed one time in order, to obtain image-data just as much as changes, wherein the image-data are fed into a computer to calculate a tridimensional image wherein the location of the or each inclusion is calculated out of image data, corresponding with at least two images.

3. A method according to claim 2, **characterized in that** the holder with diamond is rotated and/or translated.

4. A method according to claim 2 or 3, **characterized in that** an observation direction, deviating from 90° with respect to the diamond surface, a correction factor being a function of the refractive index of the diamond material is used in the calculation of said computer.

5. A method according to any of the previous claims, **characterized in that**, the or each inclusion is contained in an optical cylinder, the diameter and the detecting direction of which is used for the calculation by the computer.

6. A method as claimed in claim 1, **characterized in that** a scanner having a focusing means is used to obtain a depth position along said direction of observation by focusing said inclusion.

7. An appartus, comprising a holder for supporting a diamond, a light source, a scanning means and/or microscope, suitable to carry out the method according to each of the previous claims 1-6.

FIG.1

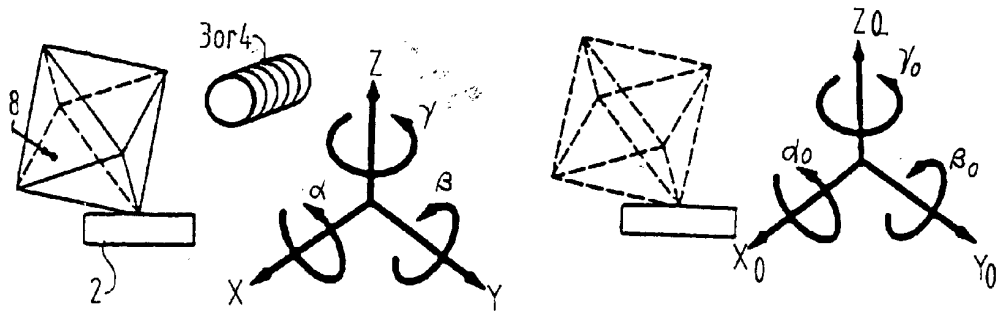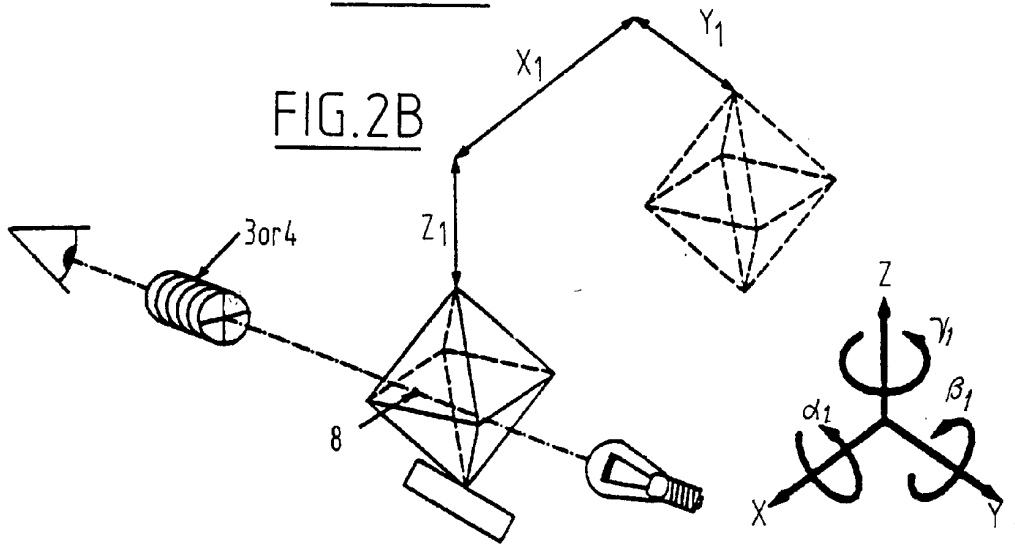FIG.2A

FIG.2B

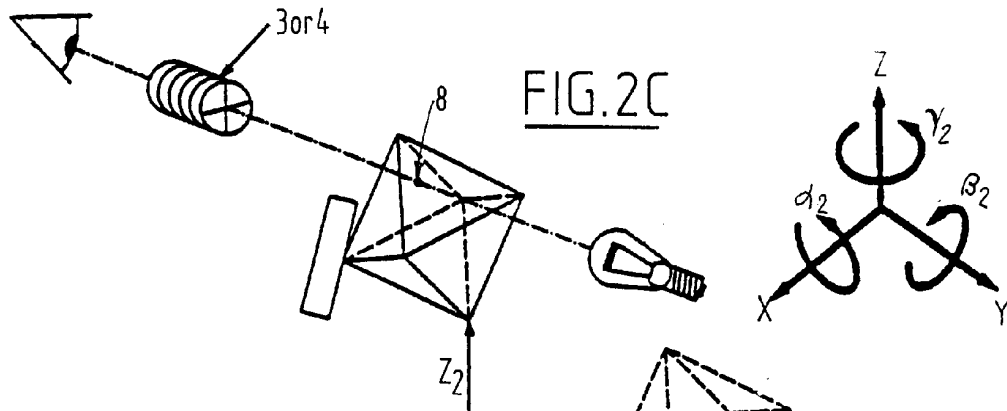FIG.2C

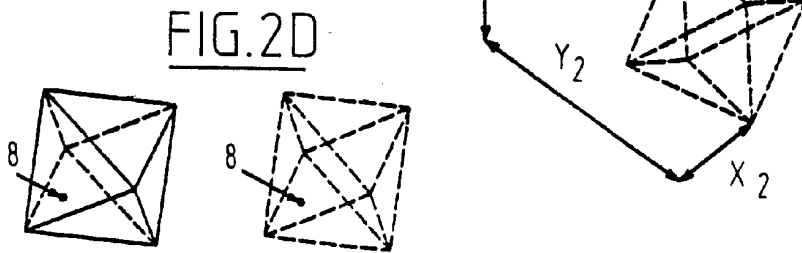FIG.2D

EUROPEAN SEARCH REPORT

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	RU 2 054 656 C (ALTAJSKOE PROIZV OB EDINENIE K) 20 February 1996 (1996-02-20)	1	G01N21/87
Y	* abstract *	2-7	
Y	GB 2 081 439 A (GERSAN ETS) 17 February 1982 (1982-02-17) * page 1, left-hand column, line 51 - line 60 * * page 1, right-hand column, line 81 - line 98 * * page 2, left-hand column, line 12 - line 32 *	2-4	
Y	US 4 152 069 A (BRUCK GERNOT K) 1 May 1979 (1979-05-01) * column 1, line 17 - line 44 * * column 3, line 19 - line 47 *	5-7	
A	SU 408 200 A (STROKOV V.A. ET AL) 10 December 1973 (1973-12-10) * the whole document *	1,6,7	
A	GB 1 416 568 A (WILSON S S) 3 December 1975 (1975-12-03) * page 14, right-hand column, line 101 - line 113 * * page 15, left-hand column, line 29 - line 47 * * page 15, right-hand column, line 113 - page 16, left-hand column, line 4 *	1,3	TECHNICAL FIELDS SEARCHED (Int.Cl.7) G01N G02B
A	US 1 700 496 A (FRANK HEITZLER) 29 January 1929 (1929-01-29) * the whole document *	1,3,6,7	
A	WO 99 61890 A (AGGARWAL LALIT K) 2 December 1999 (1999-12-02) * page 23, line 29 - page 27, line 29 *	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 July 2001	Verdoodt, E

EPO FORM 1503 03 82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 00 20 4323

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-07-2001

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
RU 2054656	C	20-02-1996	NONE		
GB 2081439	A	17-02-1982	BE 889097 A		01-10-1981
			CA 1192995 A		03-09-1985
			DE 3172491 D		07-11-1985
			EP 0041391 A		09-12-1981
			GB 2080712 A,B		10-02-1982
			HK 10085 A		15-02-1985
			IL 63041 A		29-04-1988
			IL 63042 A		29-06-1984
			IL 82552 A		05-11-1990
			JP 1833303 C		29-03-1994
			JP 4070583 B		11-11-1992
			JP 57056736 A		05-04-1982
			MY 5186 A		31-12-1986
			NL 8102686 A,B,		04-01-1982
			SG 84584 G		07-06-1985
			US 4417564 A		29-11-1983
			ZA 8103689 A		28-07-1982
			ZA 8103690 A		28-07-1982
US 4152069	A	01-05-1979	DE 2604410 A		11-08-1977
			DE 2623595 A		08-12-1977
			CA 1086521 A		30-09-1980
			CH 614288 A		15-11-1979
			FR 2340546 A		02-09-1977
			GB 1566325 A		30-04-1980
			IL 51384 A		31-08-1978
			IT 1085202 B		28-05-1985
			JP 52119243 A		06-10-1977
			SE 7701268 A		06-08-1977
			BE 851007 A		31-05-1977
SU 408200	A	10-12-1973	NONE		
GB 1416568	A	03-12-1975	NONE		
US 1700496	A	29-01-1929	NONE		
WO 9961890	A	02-12-1999	US 6020954 A		01-02-2000
			BR 9911207 A		13-02-2001
			EP 1082599 A		14-03-2001
			US 6239867 B		29-05-2001

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82