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(54) **Title:** DEVICE AND METHOD FOR MEASURING A CONSTRUCTION

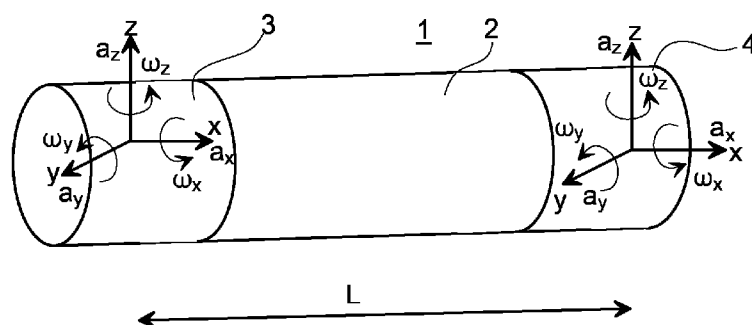


Fig. 1

(57) **Abstract:** A measuring device 1 for measuring structures is provided, wherein the measuring device including two inertial measuring units 3, 4 arranged at a distance from each other. The measuring device can be provided with means for engaging the constructions that are measured. Also, an arrangement including a measuring device and a base station 21 providing a reference point for the measuring device is provided. Moreover, a kit including the measuring device and adaptors are provided, wherein the adaptors can provide an interface between the measuring device and a measured construction. A method for measuring a stationary construction is also provided, using a measuring device, preferably a measuring kit.

Description**Device and method for measuring a construction****Technical Field**

[0001] The invention relates to measuring devices and methods for measuring a construction, such as determining the extension and dimensions of a building or of a vehicle. Especially, it relates to a measuring device including gyroscopes and accelerometers.

Background Art

- [0002] A problem with measuring objects or structures, such as buildings or vehicles, is that the accuracy of the measuring requires skill and often involves tedious handling of the measuring device.
- [0003] US 5,852,241 describes a measurement system for measuring vehicles, especially the wheel angles and directions of axles on a large vehicle, like a truck. The system comprises measuring units that are arranged on a vehicle and angles and dimensions of different parts of the vehicle are measured. The results of the measurements are fed to a computer that computes the geometric data of the vehicle, and display these data on a monitor. The system uses lasers that need free line of sight and use equipment requiring precise operations performed manually by an operator.

Disclosure of Invention

- [0004] It is an object of the present invention to provide measuring equipment that is easy to handle and provides reliable measurements.
- [0005] For this purpose the invention provides a measuring device, for measuring a stationary construction or structure, comprising two inertial measuring units for measuring accelerations in the same directions. Inertial measuring units, so called IMUs, are measuring units comprising motion sensing means, accelerometers and gyroscopes, that have been developed and used to track positions, inclinations and velocities of moving vehicles, for example airplanes and submarines. The sensed accelerations and angular velocities are then integrated with time twice and once, respectively, to provide lengths and angles, respectively. The measuring device of the present invention comprises a body and each inertial measuring unit is fixed to the body. The inertial measuring units are

fixed at a distance (L) from each other and each unit comprises means for sensing accelerations and for sensing rotations. Having two inertial measuring units provides redundancy and can be used to detect measuring faults.

- [0006] A measuring device 1 for measuring structures is thus provided, and the measuring device includes two inertial measuring units arranged at a distance from each other. This measuring device can also be provided with means for engaging the constructions that are measured. Moreover, an arrangement including a measuring device and a base station providing a reference point for the measuring device is provided. Further, a kit including the measuring device and adaptors are provided, wherein the adaptors provide an interface between the measuring device and a measured construction. The invention also provides a method for measuring a stationary construction, the method uses a measuring device, preferably a measuring kit.
- [0007] In one embodiment the two inertial measuring units have different ranges, and the first one of the units can have a greater resolution than the other, and provide more exact measuring data. The other, having a greater range, can still provide measuring data when the measuring device is subjected to large accelerations putting the first one out of range.
- [0008] Preferably, one of the inertial measuring units comprises three accelerometers arranged in first, second and third coordinate directions and the other inertial measuring unit also comprises three accelerometers in the same first, second and third coordinate directions.
- [0009] In one embodiment the measuring device comprises at least one roller, wherein the, or each, roller is adapted to rotate freely in relation to the measuring unit and provide an interface between the unit and a surface that is measured. In one preferred embodiment the housing is elongated having two ends and the roller is arranged at one of the ends.
- [0010] The invention also provide a measuring kit comprising a measuring device as described above and an adaptor for interfacing the structure to be measured, wherein the adapter and device is adapted to be attached to each other in a releasable way so that they also are detachable from each other. The adaptor can have a wheel or roller as interfacing means. Other

adaptors in accordance with the invention are sleeves for surrounding protruding parts of a structure providing a fix measuring point when engaging the protruding part, like a bolt head. Other adaptors are designed for mating holes in the measured object, e.g. conical adaptors of different sizes. Still others are provided for reaching a measuring point and provide an extension for the measuring device, for example, an elongated rod attached to one end of the measuring device.

- [0011] The invention also provides a base unit for the measuring device, wherein the base unit is adapted to receive the measuring device in a predefined position, and preferably also direction, to provide a reference position, and preferably also a reference direction, for the measuring device. Thus, an origin of coordinates is provided for the measurements.

Brief Description of Drawings

- [0012] Figure 1 illustrates a measuring device in accordance with the invention.

- [0013] Figure 2 illustrates a measuring device provided with a surface engaging wheel.

- [0014] Figure 3 illustrates a measuring device provided with a sleeve for engaging a protrusion of an object that is measured.

- [0015] Figure 4 illustrates an elongated rod for reaching measuring points on a structure, for example into narrow passages or locations that are hard to reach, e.g. a ceiling inside a room.

Mode(s) for Carrying Out the Invention

- [0016] Figure 1 illustrates a measuring device 1 comprising a housing 2 and at least two inertial measuring units 3, 4 arranged in the housing 2. The housing is elongated like a rod and the size is suitably for easy handling, a size like a hand held mobile phone or a pen. Each inertial measuring unit (IMU) comprises at least two, and preferably three, accelerometers, sensing accelerations a_x , a_y , a_z in perpendicular directions, preferably three perpendicular directions x , y , z . Each IMU 3,4 also comprises at least two, and preferably three, gyroscopes, sensing rotations, i.e. angular velocities ω_x , ω_y , ω_z , around perpendicular directions, preferably three perpendicular directions x , y , z . The IMUs 3, 4 are arranged at a fixed distance L from each other; one at each end of the measuring device 1. Both IMUs 3, 4 measure in the same directions, so that they independently

can provide two independent measurements of the motion of the measuring device 1. The measuring device can preferably be adapted to alarm when the measurements deviate too much, i.e. more than the nominal measuring accuracy of the units, which indicates a faulty measurement.

- [0017] The measuring device also includes powering means, such as a battery (not shown), and preferably also communication means (not shown), such as wireless communication means, e.g. a radio transceiver, for communicating with an external computer unit. An example of an external computer unit is illustrated in figure 6, showing a laptop (see fig. 6) provided with a display, which is suitably adapted for providing a user interface for an operator during a measuring session. The IMU can suitably be provided with computing means to calculate distances, like the length, height and width of objects, and angles from the sensed accelerations and angular velocities. Alternatively, an external computing unit (e.g. the laptop in figure 6) to which measuring data is transferred from the IMU's performs, such calculations.
- [0018] Moving the measuring device 1 in the x-axle direction provides two measurements of the acceleration in this direction. The IMUs 3, 4 are preferably of different types, e.g. one is more sensitive than the other. For example, the first IMU 3 can be provided with accelerometers with a measuring range from 0-1g ($g = \text{constant of gravity, } 9.8\text{m/s}^2$), while the second IMU 4 has accelerometers having a measuring range from 0-5 g, is less sensitive, but is also less accurate than the first IMU 3. In such an arrangement, two complete measurements will normally be provided for the movement of the measuring device 1, but if the measuring device is subjected to accelerations between 1 and 5 g, the first IMU 3 will be "out of range" and only one measurement will be provided. The device 1 is preferably adapted to alarm when one of the IMUs, in his case the first IMU 3, is out of range, i.e. do not provide a reliable signal or measurement.
- [0019] The measuring device preferably also includes wireless communication means and is adapted for communication with an external device, such as a computer 14, illustrated in Figure 6. The figure illustrates a measuring

arrangement using a measuring device in accordance with the invention during measuring of a stationary structure, illustrated by a truck. The truck has a body 11 and front and rear wheels 13, 15, and is positioned on rollers 16, 17 so that the wheels can be rotated during the measuring. The arrangement also includes a base station 21 and the laptop computer 14. The laptop computer 14 is provided with radio communication means 18 for communicating with the measuring device 1. The base station 21 is provided with a recess 20 for receiving the measuring device. Preferably, the recess is formed to receive the measuring device in a certain position as well as direction.

- [0020] The arrangement can be specifically adapted to measure a vehicle like a car, for example, by storing a database in the computer 14 with geometric data for a large number of different car models. The computer can suitably be adapted to provide an image of the measured vehicle on the display with the measuring points marked up.
- [0021] Another example is to measure a building. The computer can be adapted to provide a 3-dimensional model of the building, both the inside and the outside.
- [0022] Figures 2 to 5 illustrate embodiments of the measuring device in figure 1. The illustrated embodiments can be provided for by adaptors. As an example, a measuring kit comprising one measuring device 1 and four different connectable adapters 5-8, each for a specific purpose, can be provided.
- [0023] Figure 2 illustrates an embodiment of a measuring device 1 provided with a wheel or roller 5. This embodiment is useful for measuring surfaces, for example the curvature of a chassis part. During use, the wheel of the device 1 is placed on a surface, e.g. a deformed body part of a car, and it is subsequently rolled along the surface with the wheel held against the surface and following the surface. In this way a contour line of the surface is provided. Thus, the measuring device 1 with a wheel 5 is adapted to provide coordinates continuously, i.e. at a high rate. The wheel 5 can be an integrated part of the measuring device. Alternatively, the wheel 5 is a part of an adaptor having means for fastening to the measuring device 1. This wheel adaptor can comprise a sleeve or tubular cover for enclosing

an end section of the measuring device and connect the adaptor to the device.

[0024] Figures 3 to 5 illustrate embodiments for determining coordinates for different types of measuring points, wherein a measuring device is provided with adaptors for the measuring points. Preferably, each adaptor is releasably connectable to the measuring device. The measuring device and the adaptors can be provided as a measuring kit.

[0025] Figure 3 illustrates an embodiment of the measuring device 1 provided with a sleeve 6 for centring the measuring device on protruding parts, like a handle or an axle end. The sleeve 6 has an opening and a narrowing channel for enclosing the protruding part. Preferably, a set of sleeves 6 of different sizes can be provided for adapting the measuring device to centre on protrusions of different sizes.

[0026] Figure 4 illustrates an embodiment of the measuring device 1 provided with a extension rod 7 for reaching measuring positions in places that are different to reach like into small and narrow compartments.

[0027] Figure 5 illustrates an embodiment of the measuring device 1 is provided with a cone 8 for centring the measuring device in circular holes.

Claims

1. Measuring device (1) for measuring a structure comprising a body (2) comprising a first and a second inertial measuring units (3, 4), each inertial measuring unit being fixed to the body and fixed at a distance (L) in relation to the other inertial measuring unit (3, 4), each inertial measuring unit comprising at least two accelerometers for sensing accelerations (a_x , a_y , a_z) and at least two gyroscopes for sensing rotations (ω_x , ω_y , ω_z), and wherein the first (3) and second inertial measuring unit (4) is arranged to measure in the same directions.
2. Measuring device according to claim 1, wherein the first inertial measuring unit (3, 4) includes three accelerometers and is adapted to sense accelerations in three perpendicular coordinate directions (x, y, z), and the second inertial measuring unit (3, 4) includes three accelerometers and is adapted to sense accelerations in three perpendicular coordinate directions (x, y, z).
3. Measuring device according to claim 1 or 2, comprising a roller (5) arranged to rotate freely in relation to the measuring unit and provide an interface between the unit and a surface that is measured.
4. Measuring device according to claim 2, wherein the body is elongated having two ends and the roller (5) is arranged at one of the ends.
5. Measuring device according to any of claims 1-4, wherein the two inertial measuring units (3, 4) have different ranges.
6. Measuring kit comprising a measuring device according to any of claims 1-5 and an adaptor (5 - 9) for interfacing the structure to be measured, the adapter and device is releasably connectable.
7. Measuring kit according to claim 6, wherein the adaptor comprises an opening for centring on a protrusion.
8. Measuring kit according to claim 6, wherein the adaptor is conical for a centring in a hole.
9. Measuring kit according to claim 6, wherein the adaptor is elongated for reaching a measuring point.
10. Measuring system comprising a measuring device (1) according to any of the preceding claims and a base unit (21) for the measuring device, wherein the base unit is adapted to receive the measuring device in a predefined position to provide a reference position for the measuring device.

11. Measuring system according to claim 10, wherein the base unit is adapted to receive the measuring device in a predefined direction to provide a reference direction for the measuring device.
12. Measuring system according to claim 10 or 11, comprising a display unit (8) communicatively connected to the measuring device.
13. Method for measuring a stationary construction including the step of moving a measuring device according to any of claims 1-5 in relation to the construction.
14. Method according to claim 13, wherein the measuring device is part of a kit in accordance with any of claims 6-9, and the method includes connecting the adaptor to the measuring device, and the step of moving includes moving the measuring device together with the connected adaptor.

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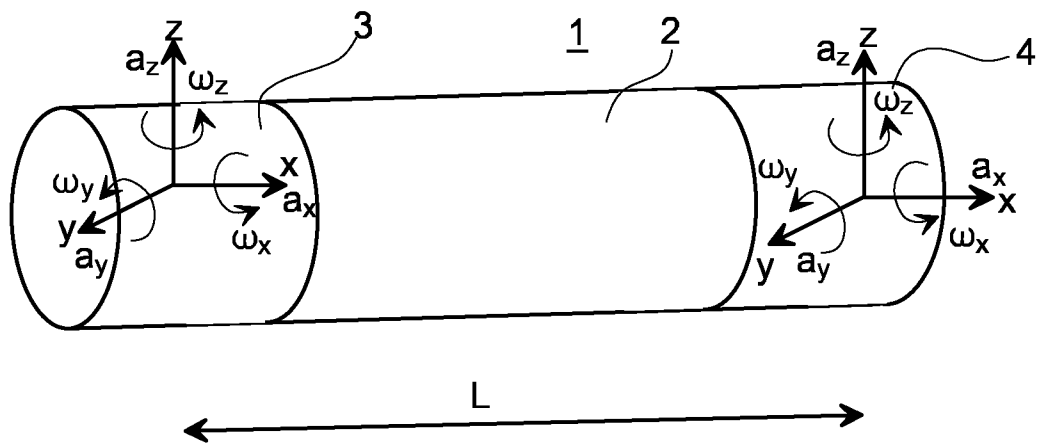


Fig. 1

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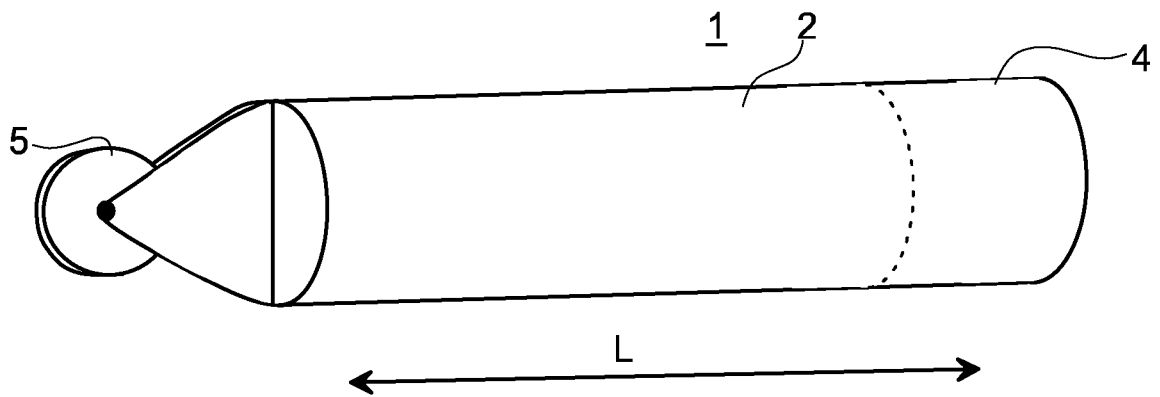


Fig. 2

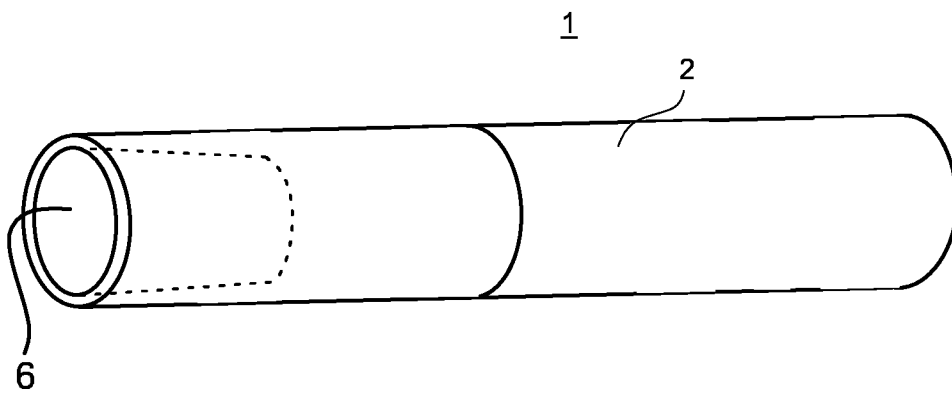


Fig. 3

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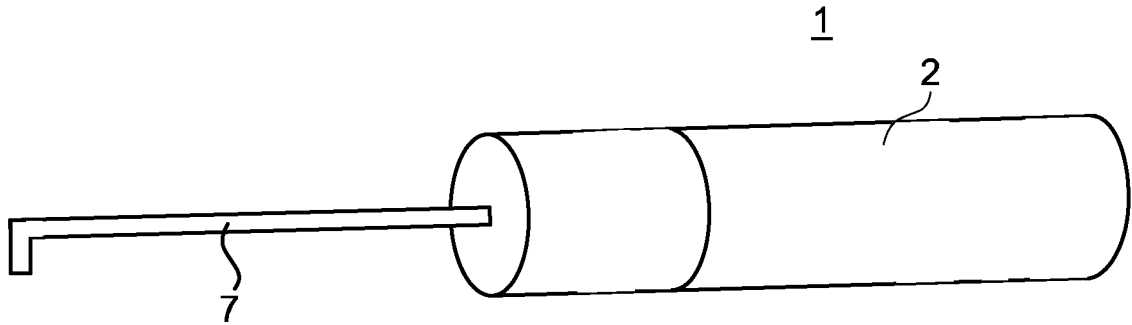


Fig. 4

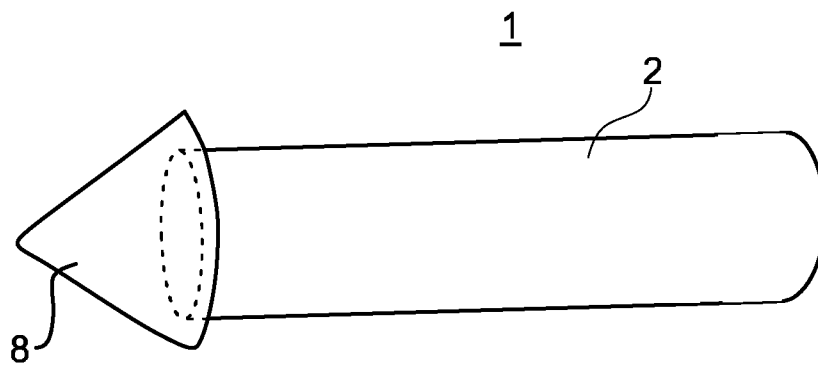


Fig. 5

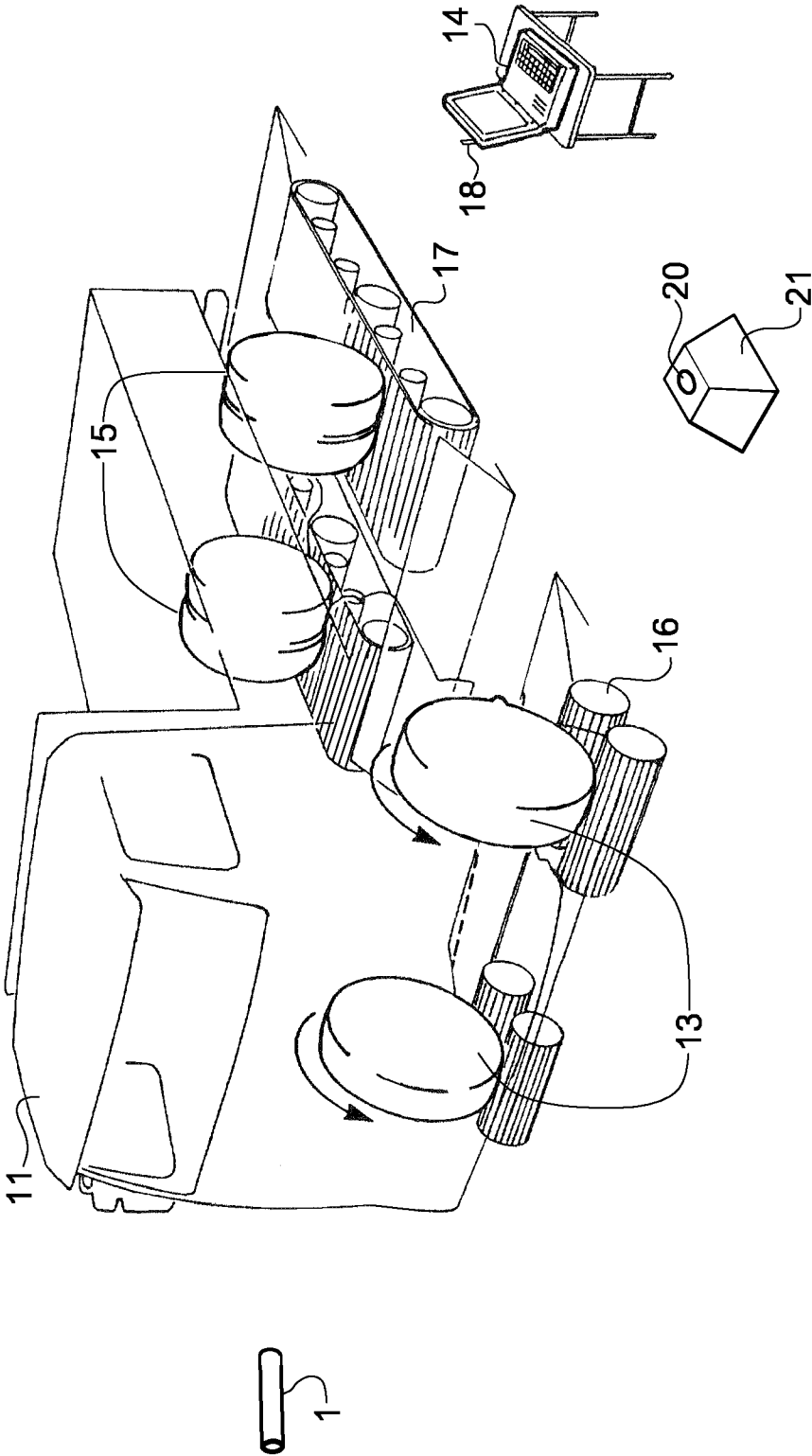


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: G01B, G01C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2045938 A (NEWALL ELECTRONICS LIMITED), 5 November 1980 (05.11.1980), whole document --	1-14
A	EP 1291617 A1 (DAIMLER-CHRYSLER AG), 12 March 2003 (12.03.2003), column 5, line 30 - line 38, figure 1, claim 3 --	1-14
A	WO 0039576 A1 (IMAGE GUIDED TECHNOLOGIES, INC.), 6 July 2000 (06.07.2000), page 9, line 22 - page 10, line 7, claims 6,17, abstract --	1-14

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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International application No.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6427354 B1 (J. VEPSÄLÄINEN), 6 August 2002 (06.08.2002), abstract --	1-14
A	US 6637278 B1 (P. FASANELLA), 28 October 2003 (28.10.2003), abstract -- -----	1-14

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