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- (54) Title:** CONTACTLESS SENSOR AND DETECTING ASSEMBLY COMPRISING SUCH A CONTACTLESS SENSOR

(57) Abstract: This contactless sensor (4) of the displacement of a mobile magnetic target (2), comprises: - a mechanical magnetic receptor (10), adapted for being moved by the magnetic target, without contact between said magnetic target and said receptor, - detecting means (12), adapted for detecting the mechanical displacement of the receptor.

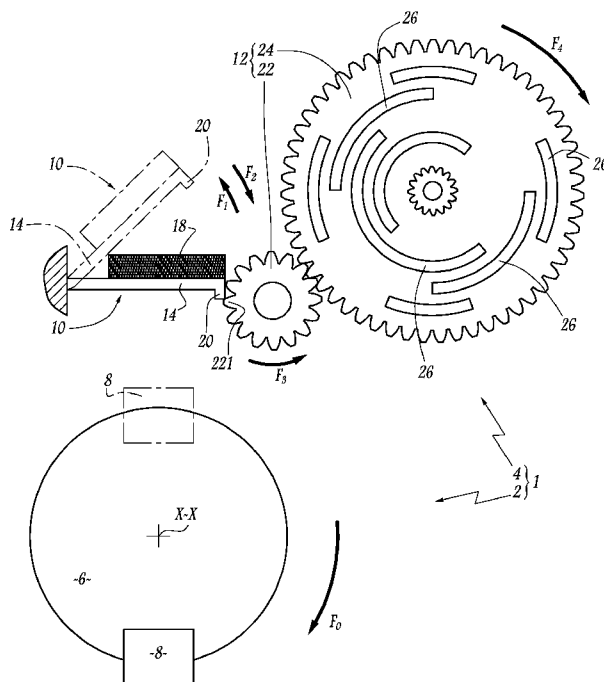


Fig. 1

CONTACTLESS SENSOR AND DETECTING ASSEMBLY COMPRISING SUCH A CONTACTLESS SENSOR

5 **TECHNICAL FIELD OF THE INVENTION**

The present invention relates to a contactless sensor of the displacement of a mobile magnetic target. Furthermore, the present invention relates to a detecting assembly comprising such a mobile magnetic target.

10 **BACKGROUND OF THE INVENTION**

In the field of the contactless sensors adapted, for instance, for counting a revolution number done by a magnetic target comprising a permanent magnet, it is known to use Hall-effect cells. Each cell generates an output voltage which varies according to the magnetic field generated by the magnet and sensed by the Hall-effect cell. However, such sensors need a constant supply voltage to be operated.

Another kind of contactless sensors is also known, which implements electrostatic interactions. Such sensors need to be supplied by a specific voltage of about 10 Volts or even about 100 Volts. Furthermore, the interaction between the sensor and the target is limited regarding the size of the target.

20 **BRIEF DESCRIPTION OF THE INVENTION**

One object of the present invention is to solve the here-above listed drawbacks by providing a contactless sensor which is self-contained, that is to say which does not need an external electric supply.

25 This object is achieved by a contactless sensor of the displacement of a mobile magnetic target, comprising:

- a mechanical magnetic receptor, adapted for being moved by the magnetic target, without contact between said magnetic target and said receptor,
 - detecting means, adapted for detecting the mechanical displacement of the
- 30 receptor.

Thanks to the present invention, the contactless sensor operates only in a mechanical way. Furthermore, the functioning of such a contactless sensor requires insignificant amount of energy compared to the amount of energy

necessary to move the mobile magnetic target. In other words, the sensor removes minimum energy from the target to operate.

According to further aspects of the invention which are advantageous but not compulsory, a contactless sensor might incorporate one or several of the following features:

- The mechanical magnetic receptor comprises an actuating part, adapted for mechanically driving the detecting means.

- The dimension of the receptor and/or the detecting means is sub-millimetric, preferably micron-scale.

- The detecting means are located on a silicon substrate.

- The detecting means and the mechanical magnetic receptor are located on the same silicon substrate.

- The detecting means comprise polycrystalline or monocrystalline silicon.

- The mechanical magnetic receptor comprises polycrystalline or monocrystalline silicon.

- The mechanical magnetic receptor comprises a blade including at least one layer of a magnetic material.

- The blade comprises a fixed end and a free end opposite to the fixed end.

- The contactless sensor is further adapted for counting the number of revolutions done by the magnetic target around a central axis and the magnetic target holds at least one permanent magnet.

- The detecting means comprise at least one gear, such as a cog wheel.

- The detecting means comprise a driving gear cooperating with an encoding gear, the driving gear being adapted for being driven mechanically by the receptor.

- The detecting means comprise optical encoding means, adapted for being read out by optical external means to recover the information from the displacement of the magnetic target.

- The optical encoding means comprise a plurality of annular trenches located in the detecting means.

The various above aspects, embodiments or objects of the invention may be combined in various ways with each others provided the combined aspects, embodiments or objects are not incompatible or mutually exclusive.

Another object of the present invention is to provide a detecting assembly comprising:

- a contactless sensor, such as described above, and
- a mobile magnetic target.

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BRIEF DESCRIPTION OF THE DRAWINGS

The present invention and its advantages will be well understood on the basis of the following description, which is only given as an illustrative example, without restricting the scope of the invention, in relation with the annexed drawings among

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- figure 1 is a schematic view of a detecting assembly comprising a contactless sensor according to the present invention;
- figure 2 is a schematic view of a second embodiment of the mobile magnetic target.

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Other aspects and advantages of the present invention will be apparent from the following detailed description made in conjunction with the accompanying drawings illustrating schematically some non-limitative embodiments of the invention.

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DETAILED DESCRIPTION OF SOME EMBODIMENTS

Figure 1 illustrates a detecting assembly 1, which comprises a mobile magnetic target 2 and a contactless sensor 4 of the displacement of the target. The magnetic target 2 is schematically illustrated by a ring 6 defining a central axis X-X. This axis is the rotation axis of the target 2. A permanent magnet 8 is arranged on the periphery of the ring 6. The magnet 8 is fastened to the ring 6.

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The sensor 4 comprises a mechanical magnetic receptor 10 and detecting means 12. The receptor 10 comprises a blade 14 with a fixed end fastened to a non-mobile support and a free end opposite to the fixed end. The blade, forming a cantilever beam, is flexible so that it is capable to be distorted. The free end of the blade 14 comprises an actuating part 20, adapted for mechanically driving the detecting means 12.

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According to an alternative embodiment (not shown), a blade fitted at its both ends to a support can be used in order to improve its stability.

The blade 14 comprises magnetic material 18. Advantageously, it is a soft magnetic material such as permalloy (NiFe), with a saturation value of its magnetic flux density as high as possible, so that the quantity of such a material can be minimized, and therefore the size of the blade can be minimized. Thus, once magnetized, the blade is able to interact magnetically with the magnetic target 2. The magnetic material 18 is arranged in the form of a layer and can be obtained by an electroplating process for example. It has to be noticed that the magnetic layer has to be of a sufficient thickness to be able to generate a magnetic field sufficient to actually interact with the magnetic target.

The thickness value of the layer can be for instance between 1 μm and 200 μm , preferably between 50 μm and 200 μm . The magnetic layer can include materials such as iron, cobalt, nickel, rhenium, tungsten or platinum, this list being non-restrictive.

The detecting means 12 comprise a driving gear 22 cooperating with an encoding gear 24. These two gears are cog wheels. The radius of the driving gear 22 is lower than the radius of the encoding gear 24. Thanks to this feature, it is easier for the blade 14 to drive the detecting means since the blade cooperates with the smallest gear 22 in term of radius.

The encoding gear 24 comprises optical encoding means 26, adapted for being read out by optical external means not illustrated in figure 1. The optical external means are provided for recovering information from the rotation of the encoding gear 24. The optical encoding means 26 comprise a plurality of annular trenches located in all the surface of the encoding gear 24.

According to another embodiment of the invention which is not shown, the detecting means can only comprise one gear.

In a first configuration, in which there is weak magnetic interaction between the target 2 and the sensor 4, the mechanical magnetic receptor 10 is in a rest position. The receptor 10 cooperates with the driving gear 22. More accurately, the actuating part 20 leans on one tooth 221 of the gear 22. In this first configuration, illustrated in full lines in figure 1, the magnet 8 is in the position in which the distance between the magnet and the receptor is the greatest. This means that the magnetic interaction between the magnetic layer 18 and the magnet 8 is the lowest.

In a second configuration, in which the magnet 8 and the magnetic receptor 10 are illustrated in chain dotted lines, the magnetic target 2 carries out an half turn around the central axis X-X according to the direction of the arrow F_0 . This rotation has for consequence to decrease the distance between the magnet 8 and the actuator 10. The magnet 8 comes into the position represented in chain dotted lines on figure 1. This means that the magnetic interaction between the magnetic layer 18 and the magnet 8 is the greatest. Consequently, the flexible blade 14 is pushed away according to the direction of the arrow F_1 , in such a way that the distance between the blade and the magnet increases, once the magnet is next to the sensor 4.

In a third configuration, in which the target 2 goes on turning of a half turn according to the direction of arrow F_0 , the magnet 8 recovers its position corresponding to the first configuration. This has for consequence that the magnetic interaction between the receptor 10 and the magnet 8 decreases. The receptor 10 recovers then its position described in the first configuration and the blade 14 moves from the configuration in chain dotted lines to the configuration in full lines, in the direction of the arrow F_2 .

The receptor 10 is an actuator since its movement drives the driving gear 22 in a rotating movement according to the arrow F_3 . Indeed, the actuating part 20 abuts against the tooth 221 with a significant force, which causes the rotation of the gear 22. The encoding gear 24 is then driven in a rotating movement in the direction of the arrow F_4 .

Each time the mobile magnetic target 2 carries out one revolution around its central axis X-X, the driving gear 22 carries out a rotation according to the arrow F_3 , this movement being able to be considered as an unitary movement. This has for consequence to drive the encoding gear 24 in a movement of one unitary element. This means that the encoding means 26 moves also of one unitary element. By using adapted optical external means, it is possible to recover the information from the movement of the target 2 by analyzing the rotation of the encoding gear 24. It is then possible to deduce the revolution numbers done by the target.

This counting is done without any contact between the target 2 and the sensor 4. This enables to keep wear of the detecting assembly 1 very low since

there is no mechanical stress between the sensor and the target. Moreover, no electrical power is necessary to operate the sensor. Thanks to the magnetic interaction between the sensor and the target, the energy removed from the target to operate the sensor is very low in comparison to the energy necessary to operate the target.

The manufacturing of the sensor 4 can be carried out by using the processes available in the semi-conductor industry. This enables to get a device of micron-scale dimensions, that is to say of sub-millimetric dimensions, with a good processing repeatability. Such a device is called a MEMS (MicroElectroMechanical System). In the context of the invention, the use of the term "micron-scale" encompasses both a micron-scale device defined by a micron-scale and a submicron-scale device defined by a nanometer scale.

Both gears 22 and 24 can be manufactured in polycrystalline or monocrystalline silicon on the same silicon substrate. Similarly, the blade 14 of the receptor 10 can be manufactured in polycrystalline or monocrystalline silicon by using for instance the SON (Silicon On Nothing) process.

If the gear 24 is made of polycrystalline or monocrystalline silicon, the trenches of the optical encoding means 26 can be carried out by patterning and etching processes used in the semi-conductor industry.

To optimize integration of the sensor 4, it is possible to manufacture the receptor 10 and both gears 22 and 24 on the same silicon substrate.

The embodiment illustrated in figure 1 is a sensor adapted for counting a revolution number done by the magnetic target comprising a rotating shaft defining the central axis X-X. It can be also planned to measure the translation movement of a mobile magnetic target. The contactless sensor used in this configuration can be similar to the sensor 4.

Figure 2 illustrates a ring 30 defining a central axis Y-Y. Such a ring 30 can be adapted for example for a bearing. This bearing can be a rolling bearing with rolling bodies such as balls or rollers interposed between the rotatable rings, or a plain bearing without any rolling bodies. Traditionally, in a bearing, there is a non-rotating ring and a rotating ring. Advantageously, the ring 30 is made integral in rotation with the rotating ring by any means such as force fitting or gluing. The sensor 4 is placed on or embedded within the non-rotating ring of the bearing, in

the neighbourhood of the ring 30, so as to obtain a very compact so-called rotational or speed sensor bearing. Furthermore, the usage of MEMS technology to obtain the sensor according to the invention makes it possible to fit such a sensor inside bearings of the smallest dimensions without affecting the overall standardized dimensions of the bearing.

The ring 30 comprises four north poles and four south poles alternatively and regularly arranged all around the periphery of the ring. This means that by using such a ring for the mobile magnetic target 2, the gear 24 carries out a rotation comprising four unitary movements when the ring 30 carries out one complete revolution around its axis Y-Y.

Instead of using cog wheels, one can use wheels without teeth able to cooperate for instance by friction.

While the invention has been shown and described with reference to certain embodiments thereof, it would be understood by those skilled in the art that changes in form and details may be made therein without departing from the spirit and scope of the invention as defined in the appended claims.

CLAIMS

1. A contactless sensor (4) of the displacement of a mobile magnetic target (2), comprising:

5 - a mechanical magnetic receptor (10), adapted for being moved by the magnetic target, without contact between said magnetic target and said receptor,
 - detecting means (12), adapted for detecting the mechanical displacement of the receptor.

10 2. The contactless sensor according to claim 1, wherein the mechanical magnetic receptor (10) comprises an actuating part (20), adapted for mechanically driving the detecting means (12).

15 3. A contactless sensor according to claim 1 or 2, wherein the dimension of the receptor (10) and/or the detecting means (12) is sub-millimetric, preferably micron-scale.

20 4. The contactless sensor according to any one of the preceding claims, wherein the detecting means (12) are located on a silicon substrate.

 5. The contactless sensor according to claim 4, wherein the detecting means (12) and the mechanical magnetic receptor (10) are located on the same silicon substrate.

25 6. The contactless sensor according to claim 4 or 5, wherein the detecting means (12) comprise polycrystalline or monocrystalline silicon.

30 7. The contactless sensor according to any one of the claims 4 to 6, wherein the mechanical magnetic receptor (10) comprises polycrystalline or monocrystalline silicon.

 8. The contactless sensor according to anyone of the preceding claims, wherein the mechanical magnetic receptor (10) comprises a blade (14) including a layer of a magnetic material (18).

9. The contactless device according to claim 8, wherein the blade (14) comprises a fixed end and a free end (20) opposite to the fixed end.

5 10. The contactless sensor according to any one of the preceding claims, wherein it is further adapted for counting the number of revolutions done by the magnetic target (2) around a central axis (X-X) and the magnetic target holds at least one permanent magnet (8).

10 11. The contactless sensor according to any one of the preceding claims, wherein the detecting means (12) comprise at least one gear (24), such as a cog wheel.

15 12. The contactless sensor according to any one of the preceding claims, wherein the detecting means comprise a driving gear (22) cooperating with an encoding gear (24), the driving gear being adapted for being driven mechanically by the receptor (10).

20 13. The contactless sensor according to any one of the preceding claims, wherein the detecting means (12) comprise optical encoding means (26), adapted for being read out by optical external means to recover the information from the displacement of the magnetic target (2).

25 14. The contactless sensor according to claim 13, wherein the optical encoding means comprise a plurality of annular trenches (26) located in the detecting means (12).

30 15. A detecting assembly (1) comprising:
- a contactless sensor (4), according to any one of the preceding claims, and
- a mobile magnetic target (2).

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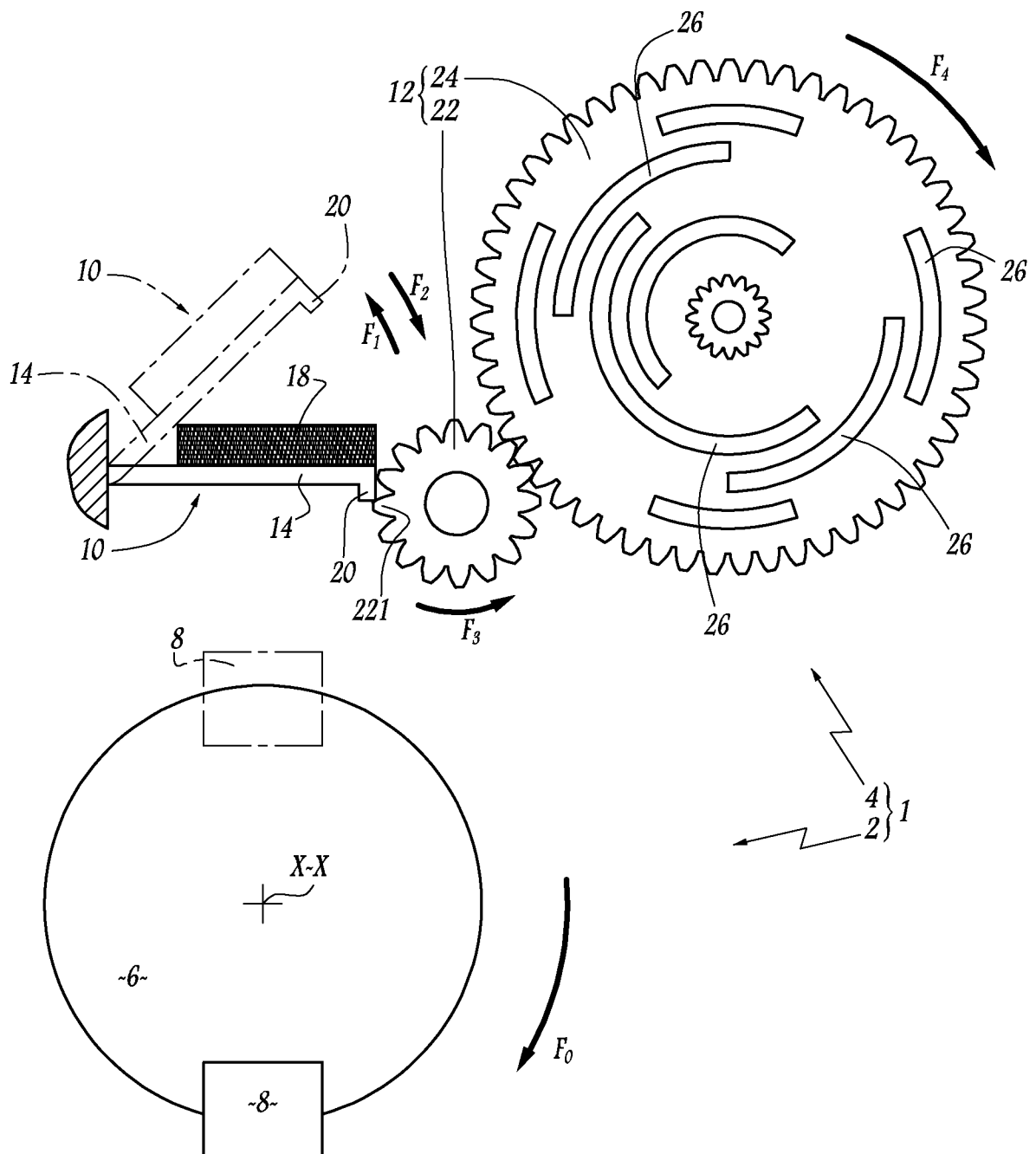


Fig. 1

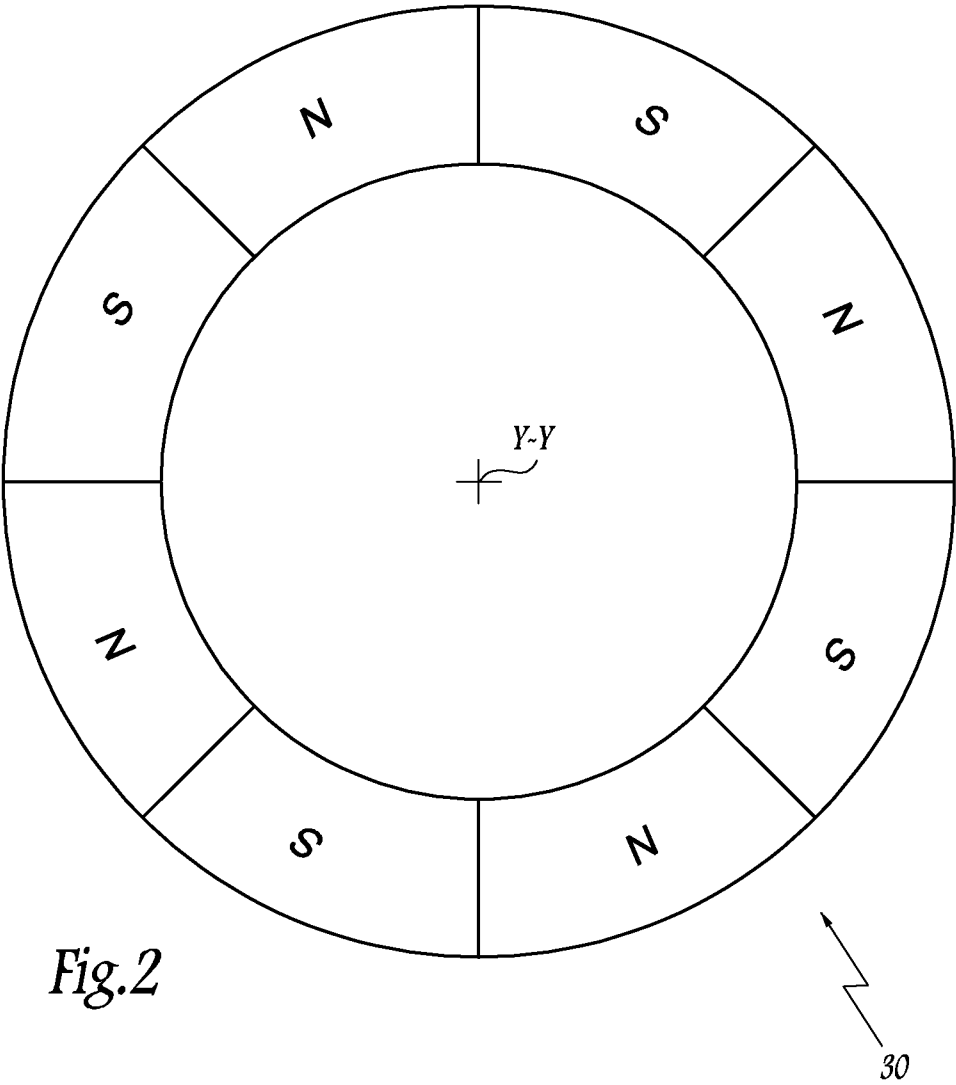


Fig.2

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2009/051320

A. CLASSIFICATION OF SUBJECT MATTER
 INV. G01D5/04 G01D5/06

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)
 G01D

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	the whole document	1-15
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Y	abstract; figures 1,2	1-15
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	figures 1,2	
Y	EP 1 998 144 A2 (FRANCE ETAT [FR]) 3 December 2008 (2008-12-03)	1-15
	the whole document	



Further documents are listed in the continuation of Box C.



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INTERNATIONAL SEARCH REPORT

Information on patent family members

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