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(54) Title: A DEVICE AND A METHOD FOR MONITORING AN APPARATUS

(57) Abstract: A device (1) and a method for monitoring an apparatus (3) with an operative state and a non-operative state. The device (1) comprises a sensor (7) adapted to measure a quantity with respect to the apparatus, a storage unit (11), a control unit (9) adapted to receive information on the measured quantity from the sensor and store the information on the storage unit, and interface (13) for retrieving stored information from the storage unit. The stored information is adapted to be used for determining if a prescribed handling condition regarding said quantity of the apparatus has not been complied with when the apparatus was in the non-operative state.

Reference: 401039PCT/JA
Applicant: ABB Research Ltd

A DEVICE AND A METHOD FOR MONITORING AN APPARATUS

FIELD OF THE INVENTION

The present invention relates to a device for monitoring an apparatus. The apparatus has an operative state and a non-operative state.

PRIOR ART

An apparatus, such as industrial equipment, a robot unit, rotating machinery, field instrument, analyzer, switchgear, etcetera, may be improperly handled in respect to the prescribed handling condition set for example by the manufacturer. The prescribed handling condition may require that a quantity, such as temperature, acceleration, mechanical stress or strain, apparatus orientation, concentration of dust or particles, concentration of a chemical substance, in respect to the apparatus does not exceed certain value.

Apparatuses, in particular industrial equipment, often contain mechanically and electrically sensitive parts. In case the prescribed handling condition is not complied with the apparatus may be damaged even though the damage may not be immediately recognizable. Such damage may degrade the function and the accuracy of the apparatus and may result in a failure of the apparatus. Accordingly, it is desired to use a device for monitoring the apparatus, wherein the misuse of the apparatus can be detected.

There are known devices for monitoring an apparatus during the apparatus is in the operative state. For example, industrial robots

can detect a collision while they are operating; however, not while being in the non-operative state. Hard drives for computers have accelerometers or shock sensors, wherein in case the hard drive is dropped the arm of the hard drive is moved to a parked position. Such device is monitoring the handling of the apparatus only when the apparatus is in the operative state. However, the prescribed handling condition of the apparatus may also not be complied with when the apparatus is in the non-operative state.

OBJECTS AND SUMMARY OF THE INVENTION

The objective of the present invention is to provide a device and a method for monitoring a prescribed handling condition of an apparatus while the apparatus is in a non-operative state.

This objective is obtained by the previous mentioned device that is characterized in that the device comprises:
at least one sensor adapted to measure a quantity with respect to the apparatus, a storage unit adapted to store information on the measured quantity, a control unit adapted to, when the apparatus is in the non-operative state, receive information on the measured quantity from the sensor and store said information on the storage unit, wherein the stored information is adapted to be used for determining if a prescribed handling condition regarding said quantity of the apparatus has not been complied with when the apparatus was in the non-operative state, and an interface for retrieving stored information from the storage unit.

The sensor is adapted to measure the quantity with respect to the apparatus. The sensor is mounted on or located in vicinity of the apparatus, wherein the sensor is adapted to sense the handling condition of the apparatus.

The control unit adapted to receive the information on the measured quantity from the sensor and store the information on

the storage unit. The control unit comprises logical means for receiving, handling and storing the information.

The storage unit is adapted to store information on the measured quantity for future analysis. The stored information is retrievable by means of the interface.

The term "operative state" refers to a situation where the apparatus is in operation.

The term "non-operative state" refers to a situation where the apparatus is switched off, wherein the control unit of the device is adapted to monitor the condition of the apparatus in the non-operative state.

The device is adapted to measure and store information on the measured quantity during the apparatus is in the non-operative state. The information is adapted to be used for determining if the prescribed handling condition regarding the quantity of the apparatus has not been complied with when the apparatus was in the non-operative state. Such non compliance of the prescribed handling condition may result in damage or reduction in the performance of the apparatus. The information may be used for determining the cause of the failure or reduction in performance of the apparatus. The customer may demand warranty even if the equipment was not handled according to prescribed handling conditions. Accordingly, the information may be used for determining if warranty is applicable. Furthermore, the information regarding the handling of the apparatus may be used as a basis for scheduling maintenance of the apparatus and as a basis for future design of the apparatus, for improving storage, safeguarding or shipment means of the apparatus.

According to one embodiment of the invention, the control unit is adapted, based on the stored information, to make a determination if the prescribed handling condition regarding said

quantity of the apparatus has been complied with or not. Based on the determination if the prescribed handling condition has been complied with or not, the operator may decide if the apparatus shall be maintained, such as replacing components of the apparatus, performing recalibration, etc., prior to further use of the apparatus.

According to one embodiment of the invention, the control unit comprises indication means adapted to indicate if the prescribed handling condition regarding said quantity of the apparatus has been complied with or not based on said determination. The indication means provide information to the operator if the prescribed handling condition has been complied with or not.

According to one embodiment of the invention, the device comprises a first power unit adapted to provide electrical power for the operation of the device. The first power unit comprises an energy storage, such as a battery, a capacitor, a fuel cell, or a power generator from harvested ambient energy, or other known means for supplying local electrical power.

According to one embodiment of the invention, the device comprises a clock unit, wherein the control unit is adapted to receive information on the time from the clock unit and time stamp the information on the measured quantity from the sensor.

By means of the clock unit the time of the non compliance of the prescribed handling condition of the apparatus may be determined. Such time information may be useful in order to determine liability of the apparatus.

According to one embodiment of the invention, the quantity is at least one of a temperature, an acceleration, a mechanical stress or strain, an apparatus orientation, concentration of dust or particles, concentration of a chemical substance.

According to one embodiment of the invention, the apparatus comprises one or more electrical motors, each motor having an orientation transmitter adapted to provide information on the rotational orientation of the motor, and a second power unit adapted to provide power to the one or more orientation transmitter during the apparatus is in the non-operative state, wherein the device is adapted to receive power from the second power unit for the operation of the device.

According to one embodiment of the invention, the device is adapted to monitor an industrial robot unit.

According to one embodiment of the invention, the control unit is adapted to perform data analysis on the stored information.

According to one embodiment of the invention, the control unit is adapted to, when the apparatus is in the operative state, receive information on the measured quantity from the sensor and store said information on the storage unit, wherein said stored information is adapted to be used for determining if the prescribed handling condition regarding said quantity of the apparatus has not been complied with when the apparatus was in the operative state.

Accordingly, the device is adapted to monitor the apparatus both during the non-operative state and the operative state. Thereby a single device is used for the monitoring of the apparatus.

The object is further achieved by a method for monitoring an apparatus, wherein the method comprises
measuring a quantity with respect to the apparatus,
receiving and storing information on the measured quantity when the apparatus is in the non-operative state, and
determining if a prescribed handling condition regarding said quantity of the apparatus has not been complied with based on the stored information.

According to one embodiment of the invention, the method comprises:
receiving information on the time, and time stamping the information on the measured quantity.

The time stamping of the information enables the time of a non compliance of the prescribed handling condition to be determined. Based on the time of the non compliance of the prescribed handling condition the liability to the non compliance may be determined.

According to one embodiment of the invention, the method comprises:
indicating that the prescribed handling condition regarding said quantity of the apparatus has not been complied with when a non compliance of the prescribed handling condition has been determined.

The indicating of the non compliance of the prescribed handling condition provides information to the operator that the apparatus may not be suitable for operation. Thereby, potential further damage to the apparatus and to machines and products subjected to the apparatus may be avoided.

According to one embodiment of the invention, the method comprises:
determining a recommended corrective action based on the stored information when a non compliance of the prescribed handling condition has been determined, and
presenting the recommended corrective action.

The recommended corrective action prevents further damages to the apparatus and to machines and products subjected to the apparatus is avoided. The corrective action is for example,

calibration, maintenance, restrictions in operation parameters, etcetera.

According to one embodiment of the invention, the method comprises:
receiving and storing information on the measured quantity when the apparatus is in the operative state.

Accordingly the method comprises receiving and storing information both when the apparatus is in the non-operative state and the operative state. Thereby, the apparatus is being fully monitored for non compliance of the prescribed handling condition.

According to one embodiment of the invention, the method comprises:
receiving and storing information on the measured quantity from a plurality of apparatuses when the apparatuses are in the non-operative state, and
statistically analyzing the stored information.

By means of storing information on the measured quantity from a plurality of apparatuses and analyzing the stored information the condition of the apparatuses, a characteristic non-operational condition can be established. Based on the characteristic non-operational condition the plurality of apparatuses the design of the apparatus can be modified in order to improve operational stability, useful life, etcetera.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be explained more closely by the description of different embodiments of the invention and with reference to the appended figures.

Fig. 1 shows a device for monitoring an apparatus.

Fig. 2 shows block diagram on a method for monitoring an apparatus.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Fig. 1 shows a device 1 for monitoring an apparatus 3, such as industrial equipment, a robot unit, etcetera. In the displayed embodiment the apparatus 3 is a robot unit with four joints, wherein each joint has an electric motor 5.

The apparatus 3 is adapted to be in an operative state and a non-operative state. The apparatus 3 is in the operative state when the apparatus 3 is being operated. The apparatus 3 is in the non-operative state when the apparatus 3 is being shut down, for example during stopped operation, transportation, storage, etcetera.

The device 1 comprises one or more sensors 7 for measuring a quantity with respect to the apparatus 3. The quantity is for example temperature, acceleration, mechanical stress or strain, apparatus orientation, concentration of dust or particles, concentration of a chemical substance, etcetera.

The sensors 7 are positioned in vicinity to the apparatus 3 in order to measure the quantity. The sensors 7 may be located inside the apparatus 3, wherein the sensors are not visible from the exterior of the apparatus 3. In the shown embodiment the device 1 comprises four sensors 7, one sensor 7 for each electric motor 5 of the apparatus 3. The sensors 7 are positioned in vicinity to each electric motor 5. Thereby, the sensors 7 sense the operational condition of the motors 5.

The device 1 further comprises a control unit 9, a storage unit 11, an interface 13, a clock unit 15, indication means 17 and a first power unit 19.

The control unit 9 is adapted to receive information on the measured quantity from the sensor 7 and store said information on the storage unit 11. Furthermore, the control unit 9 is adapted to receive information on the time from the clock unit 15.

The control unit 9 comprises logical means for receiving, handling and storing the information from the sensors 7. The control unit 9 may, if necessary, convert the information on the measured quantity to a suitable format for storing on the storage unit 11. The control unit 9 comprises for example a central processing unit (CPU), a microprocessor, a logic unit, etcetera.

The storage unit 11 is storage adapted to store the information from the sensors 7, preferably a computer memory such as a Random-Access Memory (RAM), a flash memory, a magnetic storage memory for example a hard drives, etcetera.

The stored information on the measured quantity from the sensors 7 are adapted to be used for determining if a prescribed handling condition regarding said quantity of the apparatus 3 has not been complied with when the apparatus 3 was in the operative state and the non-operative state.

The interface 13 is adapted to allow the stored information to be retrieved from the storage unit 11. The interface 13 is for example a computer bus for connecting a computer, a connection socket, a USB memory, a display, etcetera, wherein the stored information is retrievable for determining if a prescribed handling condition regarding said quantity of the apparatus 3 has not been complied with.

In an embodiment of the invention the control unit 9 is adapted to make a determination if the prescribed handling condition regarding said quantity of the apparatus 3 has been complied with or not based on the stored information on the measured quantity.

In the determination, the stored information on the measured quantity is compared with a predetermined value.

The indication means 17 is adapted indicates if the prescribed handling condition regarding said quantity of the apparatus 3 has been complied with or not based on said determination. Thereby, the operator of the apparatus 3 is informed if the prescribed handling condition has been complied with or not, wherein the operator has information to make a decision if the apparatus 3 is in operative condition. The indication means 17 is for example a lamp, an indicator, a display, etc.

In an embodiment the control unit 9 is adapted to time stamp the information from the sensors 7. Thereby, the time of the non compliance of the prescribed handling condition may be determined. For example, liability may be dependent on if the non-compliance with the prescribed handling condition occurred during transportation or during storage of the apparatus 3.

The first power unit 19 is adapted to provide power to the components of the device 1, wherein the device 1 is arranged to monitor the apparatus 3 while the apparatus 3 is both in the operative state and the non-operative state.

In an embodiment the apparatus 3 comprises a second power unit 21 and one or more orientation transmitter for the electrical motors 5, wherein the device 1 is adapted to receive power for the operation of the device 1 from the second power unit 21. In an embodiment the second power unit 21 is adapted to power both orientation transmitter for the electrical motors 5 of the apparatus 3 and the device 1.

Fig. 2 presents a block diagram on a method for monitoring an apparatus 3. By means of the method the apparatus 3 is monitored for a non compliance of the prescribed handling condition.

In block 30 the method comprises measuring a quantity with respect to at least one apparatus 3. The measuring of the quantity may originate from one or more sensors 7. The measurements on the quantity are preferably performed continuously both during the apparatus 3 is in the non-operative state and the operative state.

In block 32 the method comprises receiving information on the measured quantity when the apparatus 3 is in the non-operative state. In a preferable embodiment the method comprises receiving information on the measured quantity both when the apparatus 3 is in the non-operative state and the operative state.

In block 34 the method comprises receiving information on time and time stamping the received information on the measured quantity prior to storing the time stamped information.

In block 36 the method comprises storing information on the received information. Thereby, the information is retrievable for further analysis.

In block 38 the method comprises determining if a prescribed handling condition regarding said quantity of the apparatus 3 has not been complied with based on the stored information.

In block 39 the method comprises statistically analyzing the stored information from a plurality of apparatuses 3. Thereby, a typical condition of the apparatuses 3 is determined.

In block 40 the method comprises indicating that the prescribed handling condition regarding said quantity of the apparatus 3 has not been complied with when a non compliance of the prescribed handling condition has been determined. Thereby, the operator is informed on the determined non compliance of the prescribed handling condition of the apparatus 3.

In block 42 the method comprises determining a recommended corrective action of the apparatus 3, such a recalibration, maintenance, etcetera, based on the stored information when a non compliance of the prescribed handling condition has been determined, and presenting the recommended corrective action. The information on a corrective action may be important for the operator in order to avoid damage to the apparatus 3 and to machines and products in contact with the apparatus 3.

The invention is not limited to the disclosed embodiment but may be varied and modified within the scope of the following claims.

For example the device 1 may comprise any number of sensors 7. The sensors 7 may measure one or more quantity. The device 1 may be arranged to monitor one or more apparatuses 3. The control unit 9 may be adapted to transform the measured information prior to storage, such as removing signal noise, performing statistical calculation, etcetera.

CLAIMS

1. A device (1) for monitoring an apparatus (3), wherein the apparatus (3) has an operative state and a non-operative state, characterized in that the device (1) comprises:
- at least one sensor (7) adapted to measure a quantity with respect to the apparatus (3),
- a storage unit (11) adapted to store information on the measured quantity,
- a control unit (9) adapted to, when the apparatus (3) is in the non-operative state, receive information on the measured quantity from the sensor (7) and store said information on the storage unit (11), wherein the stored information is adapted to be used for determining if a prescribed handling condition regarding said quantity of the apparatus (3) has not been complied with when the apparatus (3) was in the non-operative state, and
- an interface (13) for retrieving stored information from the storage unit (11).

2. A device (1) according to claim 1, characterized in that the control unit (9) is adapted, based on the stored information, to make a determination if the prescribed handling condition regarding said quantity of the apparatus (3) has been complied with or not.

3. A device (1) according to claim 1, characterized in that the control unit (9) comprises indication means adapted to indicate if the prescribed handling condition regarding said quantity of the apparatus (3) has been complied with or not based on said determination.

4. A device (1) according to any of the previous claims, characterized in that the device (1) comprises a first power (19) unit adapted to provide power for the operation of the device (1).

5. A device (1) according to any of the previous claims, characterized in that the device (1) comprises a clock unit (15), wherein the control unit (9) is adapted to receive information on the time from the clock unit (15) and time stamp the information on the measured quantity from the sensor (7).

6. A device (1) according to any of the previous claims, characterized in that the quantity is at least one of a temperature, an acceleration, a mechanical stress or strain, an apparatus orientation, concentration of dust or particles, concentration of a chemical substance.

7. A device (1) according to any of the previous claims, characterized in that the apparatus (3) comprises one or more electrical motors (5), each motor having an orientation transmitter adapted to provide information on the rotational orientation of the motor (5), and a second power unit (21) adapted to provide power to the one or more orientation transmitter during the apparatus (3) is in the non-operative state, wherein the device (1) is adapted to receive power from the second power unit (21) for the operation of the device (1).

8. A device (1) according to any of the previous claims, characterized in that the device (1) is adapted to monitor an industrial robot unit.

9. A device (1) according to any of the previous claims, characterized in that the control unit (9) is adapted to, when the apparatus (3) is in the operative state, receive information on the measured quantity from the sensor (7) and store said information on the storage unit (11), wherein said stored information is adapted to be used for determining if the prescribed handling condition regarding said quantity of the apparatus (3) has not been complied with when the apparatus (3) was in the operative state.

10. A method for monitoring an apparatus (3), wherein the apparatus (3) has an operative state and a non-operative state, characterized in that the method comprises:
- measuring a quantity with respect to the apparatus (3),
- receiving and storing information on the measured quantity when the apparatus (3) is in the non-operative state, and
- determining if a prescribed handling condition regarding said quantity of the apparatus (3) has not been complied with based on the stored information.

11. A method according to claim 10, characterized in that the method comprises:
- receiving information on the time, and
- time stamping the information on the measured quantity.

12. A method according to any of claim 10 and 11, characterized in that the method comprises:
- indicating that the prescribed handling condition regarding said quantity of the apparatus (3) has not been complied with when a non compliance of the prescribed handling condition has been determined.

13. A method according to any of claim 10-12, characterized in that the method comprises:
- determining a recommended corrective action based on the stored information when a non compliance of the prescribed handling condition has been determined, and
- presenting the recommended corrective action.

14. A method according to any of claim 10 and 13, characterized in that the method comprises:
- receiving and storing information on the measured quantity when the apparatus (3) is in the operative state.

15. A method according to any of claim 10-14, characterized in that the method comprises:

- receiving and storing information on the measured quantity from a plurality of apparatuses (3) when the apparatuses (3) are in the non-operative state, and
- statistically analyzing the stored information.

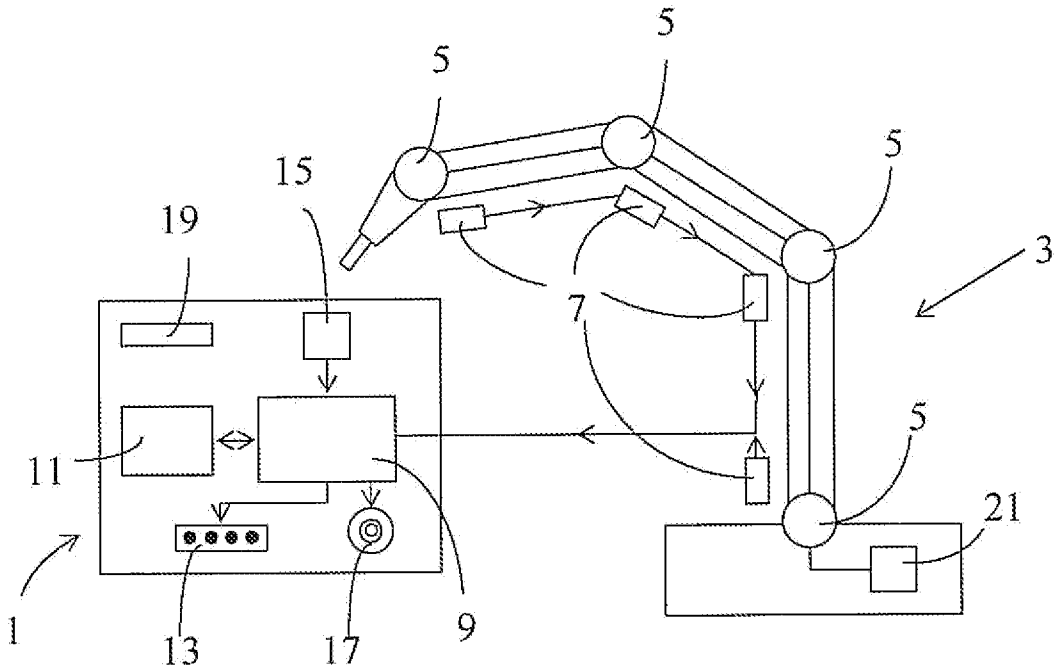

Figure 1

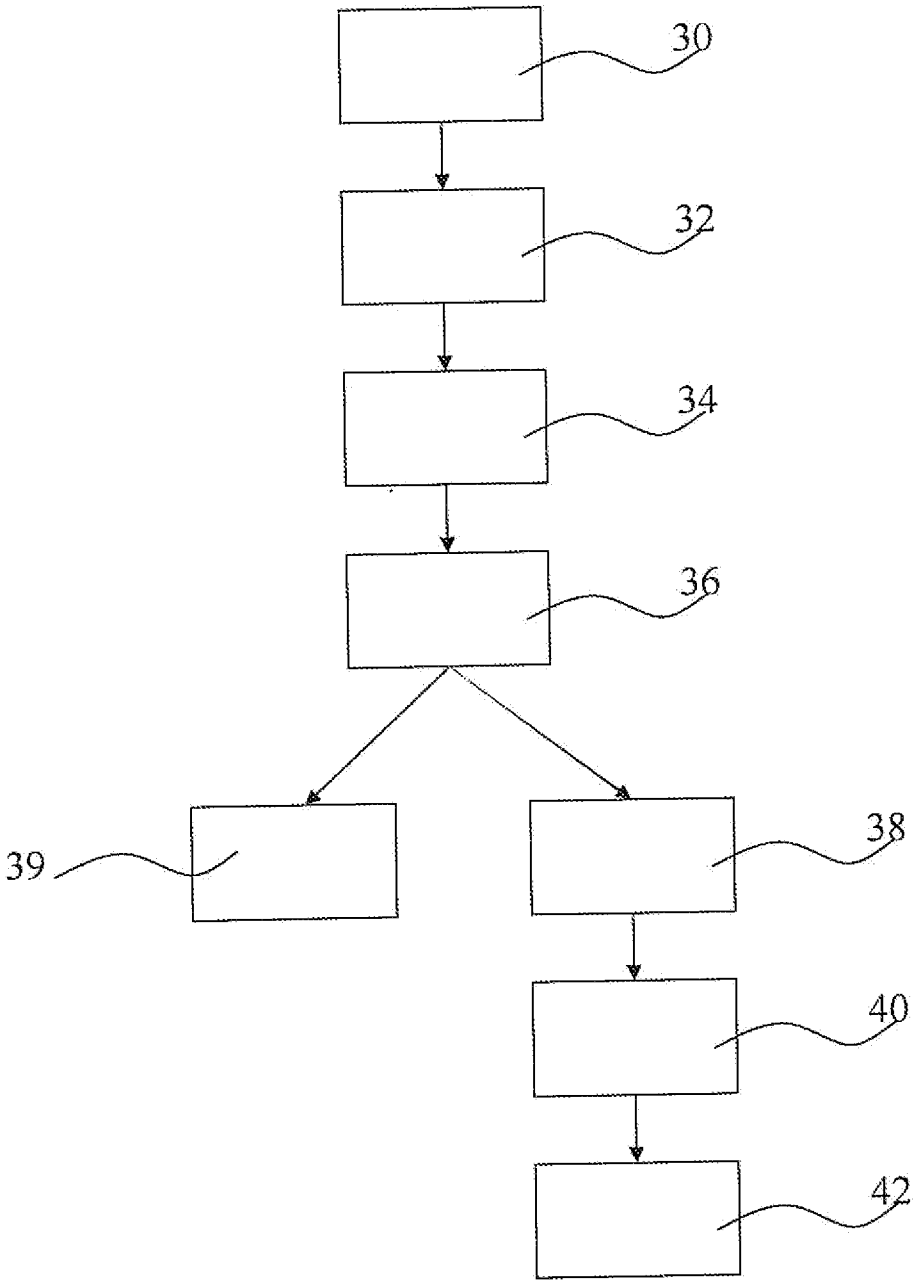

Figure 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/055823

A. CLASSIFICATION OF SUBJECT MATTER
INV. B25J9/16
ADD.

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)
B25J

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.
X	BARRIUSO POY A ET AL: "The detector control system of the ATLAS experiment" JOURNAL OF INSTRUMENTATION, INSTITUTE OF PHYSICS PUBLISHING, BRISTOL, GB, vol. 3, no. 5, 1 May 2008 (2008-05-01), page P05006, XP020140041 ISSN: 1748-0221 sections 3, 4, 5.7, 5.8, 7.1.2, 7.2figure 13	1-15
X	US 2007/136028 A1 (WINTER DUANE [US] ET AL) 14 June 2007 (2007-06-14) * abstract paragraph [0006] - paragraph [0019]	1-15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 September 2010	05/10/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Barriuso Poy, Alex

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HASEMANN J-M ET AL: "An embedded monitoring system for intelligent robots" INTELLIGENT ROBOTS AND SYSTEMS '93, IROS '93. PROCEEDINGS OF THE 1993 IEIEE/RSJ INTERNATIONAL CONFERENCE ON YOKOHAMA, JAPAN 26-30 JULY 1993, NEW YORK, NY, USA,IEEE, US LNKD-DOI:10.1109/IROS.1993.583809, vol. 2, 26 July 1993 (1993-07-26), pages 1431-1438, XP010219299 ISBN: 978-0-7803-0823-7 page 1431 - page 1434 figure 2	1-15
X	EP 2 068 216 A1 (ABB RESEARCH LTD [CH]) 10 June 2009 (2009-06-10) * abstract paragraph [0038]	1-15
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/055823

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