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(54) Title: METHOD AND DEVICE FOR DETERMINING SERVICEABILITY OF AN AUXILIARY UNIT USED AT OPERATION OF AN INTERNAL COMBUSTION ENGINE

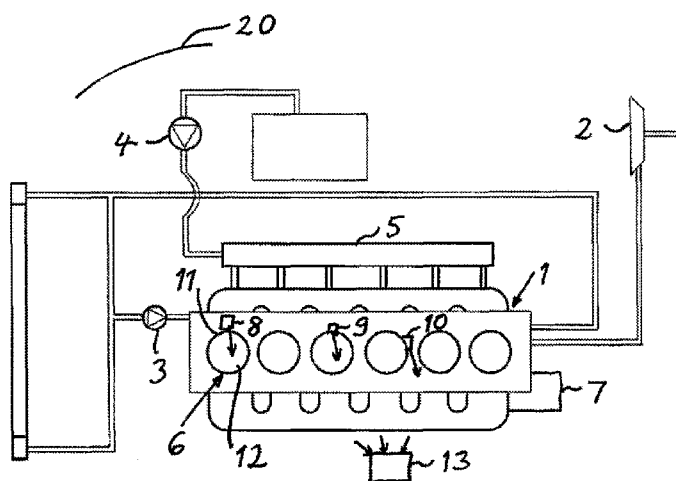


Fig. 1a

(57) Abstract: In a method for the determination of the functionality of an auxiliary aggregate (2-4, 7) used at the operation of a combustion engine (1), movements generated in parts (11) of the combustion engine by the function of the auxiliary aggregate are detected. These movements are compared with stored information about possible such movements when the auxiliary aggregate is functioning properly, and the functionality of the auxiliary aggregate is determined, based on the result of such comparison.

Method and device for determining serviceability of an auxiliary unit used at operation of an internal combustion engine

5

FIELD OF THE INVENTION

The present invention relates to a method and a device for determination of the functionality of an auxiliary aggregate used at the operation of a combustion engine.

10

BACKGROUND

At the operation of a combustion engine a number of so-called auxiliary aggregates are used, such as for example one or several compressors for supply of pressurised air to the combustion engine's cylinder chamber, a fuel pump arranged in the fuel's route from a tank to the injector of the combustion engine, a water pump for cooling of the engine and a starter motor. Naturally, having knowledge, all the time, of the functionality of these auxiliary aggregates is of great importance for ensuring that the combustion engine functions optimally, i.e. that fuel used therein is burned in the engine's cylinders with a maximum amount of energy/fuel mass being generated out of the engine, and a resulting minimum amount of emissions, and that this is done with minimum wear of the component parts in the combustion engine and said auxiliary aggregates, avoiding that unwanted stops of the combustion engine become necessary. It is usually difficult to reliably diagnose, i.e. determine the functionality of such auxiliary aggregates of combustion engines.

25

US 2012/0330575 A1 describes a method for diagnosis of auxiliary aggregates of a combustion engine by assessing the pressure detected by the pressure sensor that reaches into said cylinder chamber of the combustion engine's cylinders, via holes
5 bored through the engine walls.

SUMMARY OF THE INVENTION

The objective of the present invention is to provide a method and a device for the determination of the functionality of an auxiliary
10 aggregate used at the operation of a combustion engine, which is improved in at least one respect in relation to prior art such methods and devices.

This objective is achieved with the invention as defined in the
15 enclosed claims.

According to one embodiment, a method is achieved for determination of the functionality of an auxiliary aggregate used at the operation of a combustion engine. The method includes

- 20 • detecting movements generated in parts of the combustion engine through the auxiliary aggregate's function,
- comparing said movements with stored information about possible movements when the auxiliary aggregate is functioning properly, and
- 25 • determining the functionality of the auxiliary aggregate based on the result of said comparison.

Thus, the invention is based on the knowledge that the auxiliary aggregates of a combustion engine generate movement in parts
30 of the combustion engine when they function properly, and that

an analysis of such movements may lead, with good reliability, to a determination of the functionality of an auxiliary aggregate.

5 A method according to the invention facilitates diagnosis of a greater number of auxiliary aggregates with a greater reliability, than what is possible with the method according to the above mentioned document, and additionally the innovative method may be carried out without any holes having to be bored in the combustion chamber, which results in a cost saving, and in addition
10 disruptions, which may be caused by pressure sensors introduced in the cylinder chamber are also avoided thanks to the invention.

According to one embodiment of the invention, movements in the
15 form of vibrations are detected. Auxiliary aggregates of a combustion engine, when functioning properly, normally generate vibrations in parts of the combustion engine, such as the cylinder heads or engine blocks or other parts, and such vibrations have an appearance that is dependent on the auxiliary aggregate's
20 function, so that by comparing these vibrations with stored information about such vibrations, it is possible to determine whether or not the auxiliary aggregate functions in the expected manner.

According to another embodiment of the invention, movements in
25 an engine block part or in a cylinder head in the combustion engine are detected. According to an additional embodiment of the invention, movements in the form of strains on screws in the engine are detected, such as screws in main bearings, in connecting rod bearings and in cylinder head bolts. The appearance of
30 such movements depends on the function of auxiliary aggregates

of a combustion engine, and may for example be detected by applying strain-sensors on such screws.

5 According to another embodiment of the invention, movements in the form of strains on injector- and glow plug fixings are detected, which constitutes another possibility of determining the functionality of an auxiliary aggregate.

10 According to another embodiment of the invention, the detection of said movements is carried out partly before and partly after the activation or deactivation of said auxiliary aggregates, said movements before and after said activation or deactivation are compared with each other, and the functionality of the auxiliary aggregate is determined, based on the result of such comparison.
15 Such differential diagnoses may advantageously be carried out to determine the functionality of a said auxiliary aggregate.

20 According to another embodiment of the invention, the functionality of a compressor arranged in an air inlet conduit to the combustion engine is determined. Other embodiments of the invention relate to the determination of the functionality of a water pump for cooling of the combustion engine, and of a fuel pump connected to an aggregate for injection of fuel into the cylinders of the combustion engine. In the case of a determination of the
25 functionality of a fuel pump, the development of the pressure in at least one cylinder of the combustion engine may be measured over time, the measured pressure development is compared with stored information about such pressure development, and also the result of such comparison is used to determine the fuel
30 pump's functionality. Thus, it may be reliably determined whether

the fuel pump is functioning properly. The method may in this case be carried out for a fuel pump comprising several pump elements, and it is then determined that a pump element has failed, when said movement expected to be generated by such
5 pump element disappears.

According to another embodiment of the invention, the functionality of a starter motor is determined, by detecting movements propagated in a cylinder head of the engine or in adjacent parts
10 in the engine, generated by pressure changes in a cylinder chamber of the engine, , a development over time of the gas pressure in the cylinder chamber is calculated, based on information in said detected movements, and the duration on a curve showing said development is compared with stored information
15 about such a curve, in order to determine the functionality of the starter motor. It has been shown that the development over time of the gas pressure in the cylinder chamber of a combustion engine may reliably be derived by detecting movements generated in a cylinder head of the engine or in adjacent parts in the engine, i.e. without the requirement of boring any holes in the combustion chamber. Thus, it becomes possible to determine
20 whether the combustion engine's starter motor functions properly.

25 The invention also relates to a device, adapted to determine the functionality of an auxiliary aggregate in a combustion engine according to the enclosed independent device claims. The function of such a device and embodiments thereof defined in non-independent claims, and the possibilities which they offer, are
30 explained in the discussion above of the innovative method.

The invention also relates to a computer program, a computer program product, an electronic control device, a combustion engine and a motor vehicle which uses the above.

5

The invention is not limited to any specific type of combustion engine, but encompasses otto engines as well as compression ignited engines, nor to any specific fuel, non-exhaustive examples of which may comprise fuel in the form of petrol, ethanol,
10 diesel and gas.

Likewise, the invention comprises combustion engines intended for all types of use, such as in industrial applications, in crushing machines and various types of motor vehicles, wheeled motor
15 vehicles as well as trucks and buses, and boats and crawlers or similar vehicles.

Other advantageous features and advantages with the invention are set out in the description below.

20

BRIEF DESCRIPTION OF THE DRAWINGS

Below are descriptions of example embodiments of the invention, with reference to the enclosed drawings, in which:

25 Fig 1a is a schematic view illustrating a combustion engine with associated auxiliary aggregates and sensors, arranged in different possible positions for the detection of movements generated through the auxiliary aggregates' function,

30

Fig. 1b shows a possible location of a sensor element,

Fig 2 is a flow chart showing a method according to one
5 embodiment of the invention, and

Fig. 3 is a diagram of an electronic control device for the implementation of a method according to the invention.

10 DETAILED DESCRIPTION OF EMBODIMENTS ACCORDING TO THE INVENTION

Fig 1a illustrates very schematically a combustion engine 1 with auxiliary aggregates, connected in a prior art manner, in the form of a compressor 2, a water pump 3 and a fuel pump 4 in the form of a high pressure pump, arranged to pump fuel at a high pressure to an accumulator volume 5 with nozzles for injection of fuel into the cylinders 6 of the combustion engine. An additional auxiliary aggregate in the form of a starter motor 7 is also indicated. The combustion engine is here arranged in a schematically indicated motor vehicle 20, for example a truck.

It is illustrated how sensors 8-10 may be arranged to detect movements generated in parts of the combustion engine, through the function of the different auxiliary aggregates. By arranging such a sensor 8 on a part of a cylinder head 11 or on parts in the engine adjacent thereto, pressure changes in the relevant cylinder chamber 12 may be detected through movements generated thereby where the sensor is arranged. Such a sensor may, for example, detect such movements optically or via piezo electricity or piezo resistivity, and be used to produce a pressure curve

generated by the starter motor 7, which may be compared with stored information about such a curve, for the determination of the functionality of the starter motor.

- 5 Other sensors 9, 10 may be arranged to detect vibrations or strains, for example in screws of the engine, such as screws in main bearings, in connecting rod bearings, and in cylinder head bolts, or in an engine block part.
- 10 Information about the detected movements is sent to a unit 13, which may consist of an electronic control device for the combustion engine and the vehicle, in cases where the combustion engine is arranged in a vehicle. The unit 13 is adapted to compare the appearance of the detected movements with stored information about possible such movements when the respective auxiliary aggregates function properly, and to determine, based on
- 15 the result of such comparison, the functionality of the auxiliary aggregate.
- 20 Fig. 1b shows another placement of a sensor element 8. The sensor element is here placed on a section adjacent to the cylinder head. In this example, the sensor element is placed on the engine, specifically on the engine block. The sensor elements/sensors 8 may be of a suitable type, e.g. piezo resistive or piezo electrical elements or optical sensors. The sensor element
- 25 may here be placed on the engine, in an area adjacent to the outlet of the exhaust channel from a cylinder. For example on a surface on the engine block next to the outlet, on the engine, of the exhaust channel from a cylinder. The surface where the sensor 8 is placed may be substantially vertical. The sensor may be
- 30

arranged to detect movements, which are perpendicular to the movements of the piston. The sensor may also be arranged to detect movements, which are perpendicular both in relation to the piston's direction of movement and in relation to the engine's longitudinal direction. In one embodiment, the sensor is located on the engine's long side. The sensor may be arranged to detect movements in a direction, which is perpendicular in relation to the surface on which it is placed.

10 In another embodiment (not displayed) the sensor element 8 may be placed in a corresponding manner as when placed on the engine at the outlet of the exhaust channel from a cylinder, but instead placed in a corresponding location on the engine, at the inlet channel's inlet to a cylinder.

15

The signal detected by the sensor element 8 may be treated in various ways. For example, the following signal treatment steps may be carried out. First the sensor's electrical signal is entered into a control device/signal treatment device. The signal is filtered with a bandpass filter in order to remove superfluous information, which does not belong to the frequency range around which information is required. The signal is evened out by way of filtering, averaging or by being replaced with one or several continuous function(s) with good likeness. Subsequently, the signal is scaled, e.g. with the help of the correlation between pressure and volume at compression. Subsequently, (a) suitable part(s) of the signal is/are transformed to the pressure domain. Supplemental modelling closes gaps in the signal's reliability, in order to form a pressure curve. The thus formed pressure curve is used to

calculate different values at engine control. In some embodiments one or several of the steps above may be omitted.

Fig 2 shows a flow chart illustrating an embodiment of a method according to the present invention, for determination of the functionality of an auxiliary aggregate used at the operation of a combustion engine. In a first step S_1 movements generated in a part of the combustion engine by the function of an auxiliary aggregate are detected. In a second step S_2 the detected movements are compared with stored information about such movements, and in a third step S_3 the functionality of the auxiliary aggregate is determined, based on the result of such comparison.

A computer program code for the implementation of a method according to the invention is suitably included in a computer program, loadable into the internal memory of a computer, such as the internal memory of an electronic control device of a combustion engine. Such a computer program is suitably provided via a computer program product, comprising a data storage medium readable by an electronic control device, which data storage medium has the computer program stored thereon. Said data storage medium is e.g. an optical data storage medium in the form of a CD-ROM, a DVD, etc., a magnetic data storage medium in the form of a hard disk drive, a diskette, a cassette, etc., or a Flash memory or a ROM, PROM, EPROM or EEPROM type memory.

Fig. 3 very schematically illustrates an electronic control device 13 comprising execution means 14, such as a central processor unit (CPU), for the execution of computer software. The execution means 14 communicates with a memory 15, e.g. a RAM

memory, via a data bus 16. The control device 13 also comprises a data storage medium 17, e.g. in the form of a Flash memory or a ROM, PROM, EPROM or EEPROM type memory. The execution means 14 communicates with the data storage means 17 via the data bus 16. A computer program comprising computer program code for the implementation of a method according to the invention is stored on the data storage medium 17.

The invention is obviously not limited in any way to the embodiments described above, but numerous possible modifications thereof should be obvious to a person skilled in the area, without such person departing from the spirit of the invention as defined by the appended claims.

The innovative method could be used for the determination of the functionality of auxiliary aggregates other than those mentioned above.

It would also be possible to use signal strength and time delay between several different sensors to identify auxiliary aggregates, which generate "noise" or which move in an abnormal manner, if indicated.

Claims

1. Method for the determination of the functionality of an auxiliary aggregate (2-4, 7), used at the operation of a combustion engine (1), **characterised** in
 - detecting movements generated in parts (11) of the combustion engine through the auxiliary aggregate's function,
 - comparing said movements with stored information about possible movements when the auxiliary aggregate is functioning properly, and
 - determining the functionality of the auxiliary aggregate, based on the result of said comparison.
2. Method according to claim 1, **characterised** in that movements in the form of vibrations are detected.
3. Method according to claim 1 or 2, **characterised** in that movements in an engine block part or in a cylinder head (11) of the combustion engine are detected.
4. Method according to claim 1 or 2, **characterised** in that movements in the form of strains on screws of the engine (1) are detected, such as screws in main bearings, in connecting rod bearings, and in cylinder head bolts.
5. Method according to claim 1 or 2, **characterised** in that movements in the form of strains on injector- or glow plug fixings are detected.

6. Method according to claim 3, characterised in that the detection is carried out in or on said cylinder head (11).
7. Method according to claim 3, characterised in that the detection is carried out on the engine, in an area adjacent to the outlet of the exhaust channel from a cylinder.
8. Method according to claim 3, characterised in that the detection is carried out on the engine, in an area adjacent to the inlet of the inlet channel to a cylinder.
9. Method according to any of the previous claims, characterised in that the detection of said movements is carried out partly before, and partly after the activation or deactivation of said auxiliary aggregate, in that said movements before and after said activation or deactivation are compared with each other, and in that the functionality of the auxiliary aggregate is determined, based on the result of such comparison.
10. Method according to any of the previous claims, characterised in that the functionality of a compressor (2) arranged inside an air inlet conduit to the combustion engine (1) is determined.
11. Method according to any of claims 1-9, characterised in that the functionality of a water pump (3) for cooling of the combustion engine (1), or of an oil pump for lubrication of the engine's moveable parts, is determined.

12. Method according to any of claims 1-9, **characterised** in that the functionality of a fuel pump (4) connected to an aggregate for injection of fuel into cylinders of the combustion engine (1) is determined.
- 5
13. Method according to claim 12, **characterised** in that the development of the pressure in at least one cylinder (6) of the combustion engine over time is measured, in that the measured pressure development is compared with stored information about such pressure development, and in that the result of this comparison is also used to determine the fuel pump's functionality.
- 10
14. Method according to claim 12 or 13, **characterised** in that it is carried out for a fuel pump (4) comprising several pump elements, and in that it is determined that a pump element has failed when said movements expected to be generated by such pump element disappear.
- 15
15. Method according to any of claims 1-9, **characterised** in that the functionality of a starter motor (7) is determined, in that movements propagated in a cylinder head (11) of the engine or in parts of the engine adjacent thereto, generated by pressure changes in a cylinder chamber (12) of the engine, are detected, in that a development over time of the gas pressure in the cylinder chamber is calculated based upon information in said detected movements, and in that the duration in time of a curve showing said development is compared with stored information about such curve, in order to determine the functionality of the starter motor.
- 20
- 25
- 30

16. Device adapted to determine the functionality of an auxiliary aggregate (2-4, 7) of a combustion engine (1), characterised in that it comprises a sensor (8-10), arranged on a part of the combustion engine and adapted to detect movements generated in this part (11) through the function of the auxiliary aggregate, and a unit (13), adapted to compare the appearance of said detected movements with stored information about possible such movements when the auxiliary aggregate is functioning properly, and, based upon the result of said comparison, to determine the functionality of the auxiliary aggregate.
17. Device according to claim 16, characterised in that said sensor (9, 10) is adapted to detect movements in the form of vibrations.
18. Device according to claim 16 or 17, characterised in that said sensor (9, 10) is a strain sensor.
19. Device according to any of claims 16-18, characterised in that it is adapted to determine the functionality of an auxiliary aggregate in the form of a compressor (2), a water pump (3), a fuel pump (4) and/or a starter motor (7).
20. Device according to any of claims 16-19, characterised in that a sensor element (8) is arranged in or on said cylinder head.

21. Device according to any of claims 16 - 19, characterised in that said sensor element (8) is placed on the engine, in an area adjacent to the outlet of the exhaust channel from a cylinder.
- 5
22. Device according to any of claims 16 - 19, characterised in that a sensor element (8) is placed on the engine, in an area adjacent to the inlet of the inlet channel to a cylinder.
- 10
23. Computer program which may be downloaded directly to the internal memory of a computer, which computer program comprises a computer program code in order to make the computer control the steps according to any of claims 1-15 when said computer program is executed in the computer.
- 15
24. Computer program product comprising a data storage medium (17) which is readable by a computer, the computer program code of a computer program according to claim 23 being stored on the data storage medium.
- 20
25. Electronic control device for a combustion engine, comprising an execution means (14), a memory (15) connected to the execution means and a data storage medium (17) connected to the execution means, the computer program code in a computer program according to claim 23 being stored on said data storage medium.
- 25
26. Combustion engine comprising a device according to any of claims 16-22.
- 30

27. Motor vehicle, characterised in that it comprises a device according to any of claims 16-22.
28. Motor vehicle according to claim 27, characterised in that it
5 is a wheeled motor vehicle, such as a truck or a bus, or a boat or a crawler.

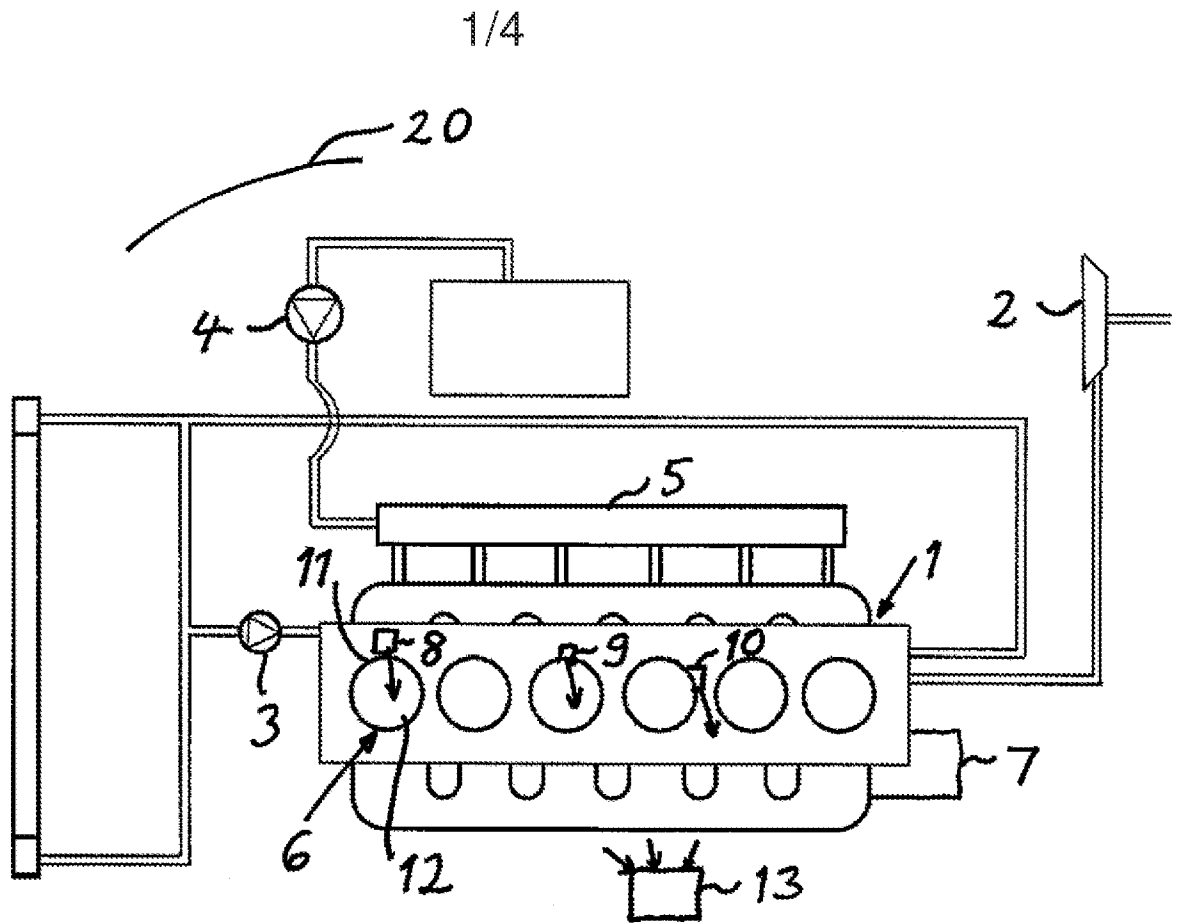


Fig. 1a

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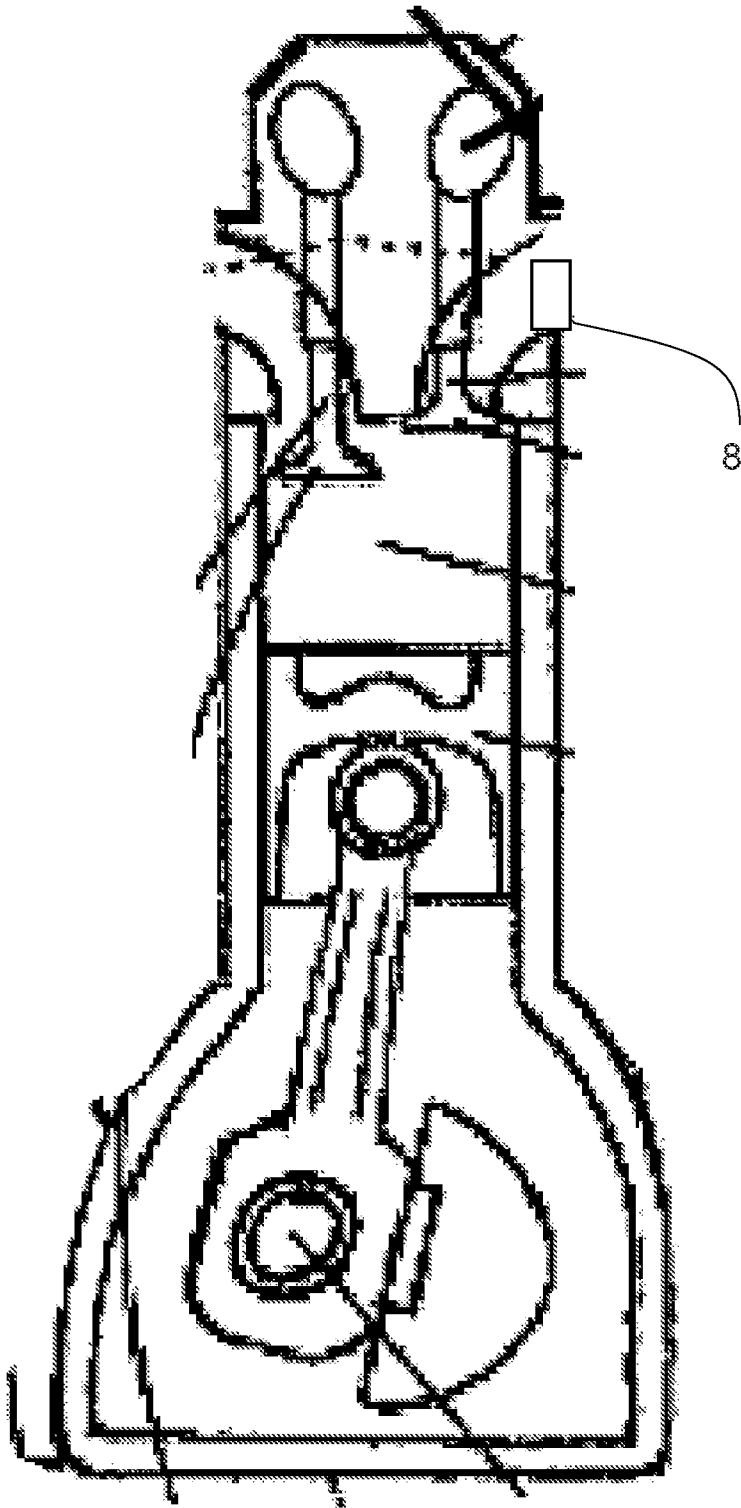


Fig. 1b

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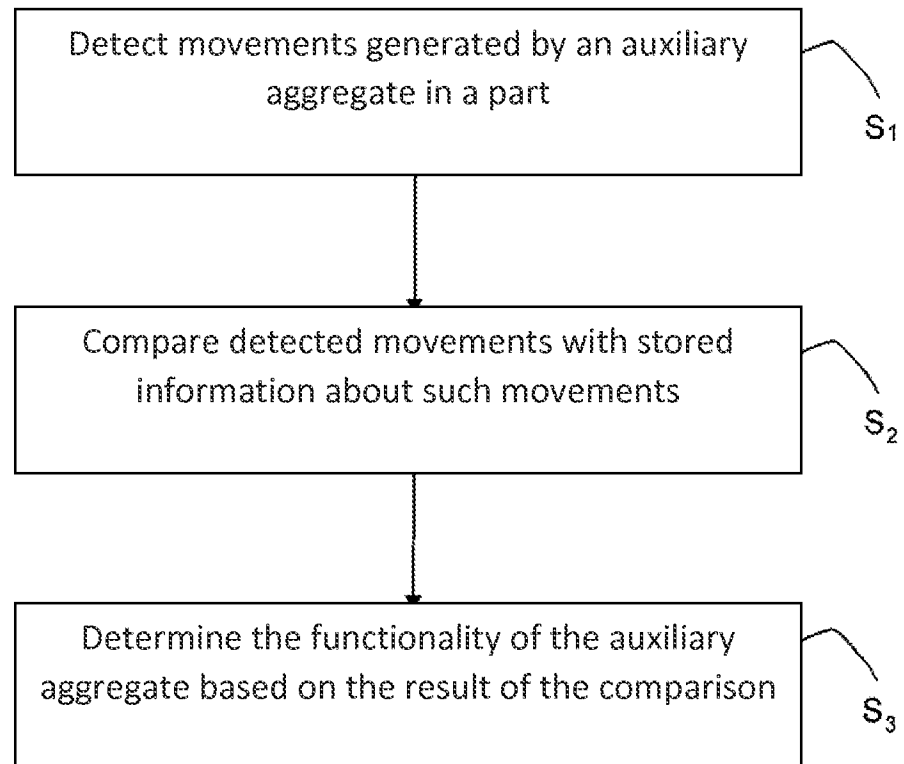


Fig. 2

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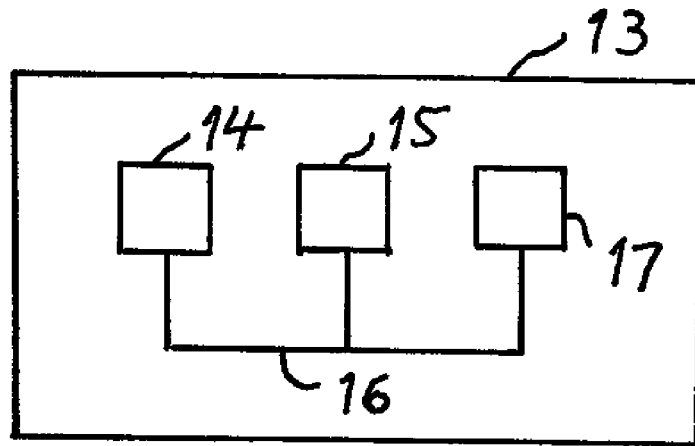


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2015/050702

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: G01M

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, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1972780 A1 (DELPHI TECH INC), 24 September 2008 (2008-09-24); paragraphs [0008], [0018], [0021], [0041]-[0042], [0046]-[0049], [0059]; figures 3,4,9	1-3, 6-9, 12-14, 16-28
A	--	4, 5, 10, 11, 15
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A	--	15



Further documents are listed in the continuation of Box C.



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

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“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

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10-09-2015

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2015/050702

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Yuelel Zhang, Xinping Yan, Chengqing Yuan, Yuelel Zhang, Qingchao Guo, "Study of Optimal Monitoring Point Placement for Marine Power Machinery Using Fault Tree Theory", 2011 Prognostics & System Health Management Conference (PHM2011 Shenzhen). p 1-5. Published 2011-05-24. doi:10.1109/PHM.2011.5939478; figure 5; Section IIIA. --	12-14
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Continuation of: second sheet

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G01M 15/12 (2006.01)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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