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(54) Diagnostic system for cam phasers of a dohc internal combustion engine

(57) A method of diagnosis for the oil control valves of the overhead cams for an internal combustion engine.

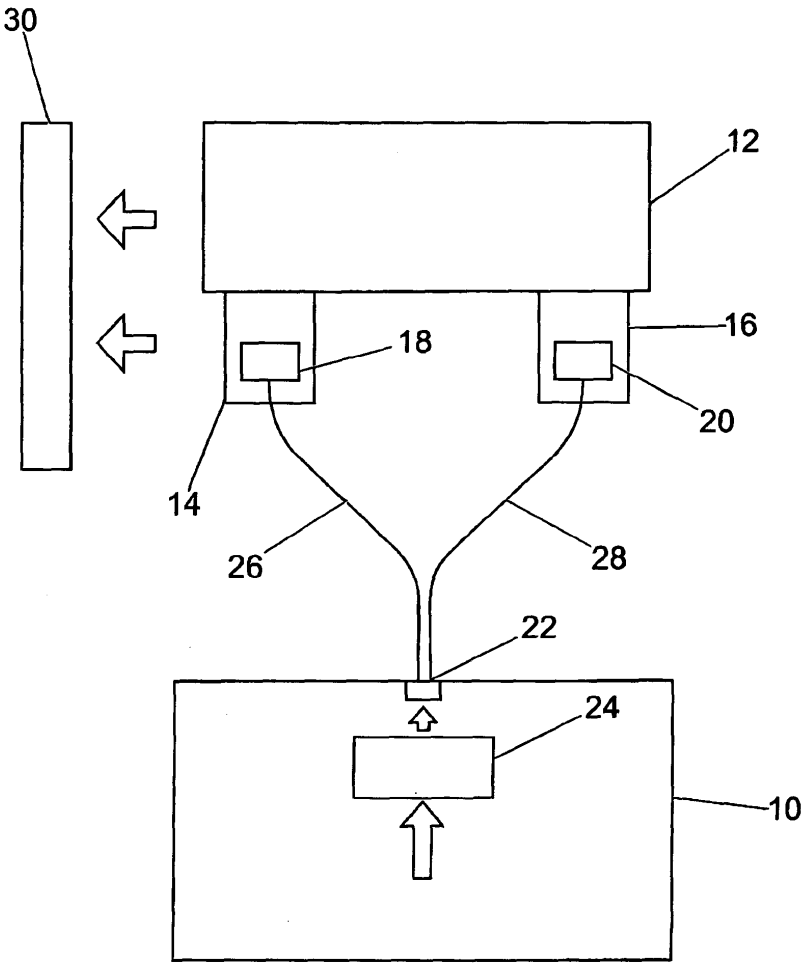

Fig. 2

EP 1 785 596 A1

Description

[0001] The present invention relates to an Engine Control Unit, more particularly to an Engine Control Unit (ECU) which is adapted for being used in a vehicle or which is adapted for being used in connection with a combustion engine. The invention also relates to a method for operating such an ECU.

[0002] In automotive applications, i.e. when the ECU is an ECU for use in a vehicle or in connection with a combustion engine, one task of the ECU is controlling the variable cam phasing system. A cam phasing system comprises at least one oil control valve (OCV) for controlling the oil flow to the different ports entering a cam phaser, thus controlling the angular position of the cam shaft relative to pulley or sprocket.

[0003] There is an increasing number of applications with Dual Independent Cam Phasing, which require intake and exhaust cam phasing, and thus two OCVs.

[0004] One problem which might arise from dual independent cam phasing is that the relevant units and devices are not properly connected. Specifically with dual cam phasing and subsequently dual OCVs respectively, a first OCV and a second or complementary OCV, the OCVs might not be correctly connected, e.g. the OCV connectors can potentially be misconnected during engine assembly, resulting in an exhaust OCV connector on an intake OCV and vice versa, causing the first OCV to react on signals received from the ECU when in fact the complementary OCV was meant to be affected. Thus, a wrong connection would result in the control unit affecting the wrong device or unit.

[0005] To this end, the term "targeted device (unit, OCV, etc.)" is hereinafter used to describe the device which would normally be affected by the control unit, provided that all the connections thereto are correct. That means, the targeted device is the device which is meant to be affected. However, in case of a "wrong" connection, signals sent out by the control unit to the targeted device will not arrive at the targeted device and therefore will have no effect on the targeted device. Instead, the signals will in fact arrive at the complementary device and will subsequently cause an effect at the complementary device. In order to distinguish this device from the targeted device, this device will be subsequently termed as "affected device (unit, OCV, etc.)". It should be noted that in case of a correct connection, the targeted device and the affected device will coincide. Furthermore, once the invention rectifies the effects of the wrong connection, the targeted device and the effected device will also coincide. However, the phrase "targeting a device" will generally be used as a generic term for the engine control unit addressing, activating, triggering, etc. the relevant device, while the phrase "affecting a device" will in contrast be used as a generic term for both targeting a device and causing an effect by having targeted the device. The effect will occur either at the targeted device or at a device connected to, or combined with, either electrically, mechanically, or functionally, the targeted device.

[0006] Some engines have their OCVs remote from each other; one next to the exhaust manifold, and the other next to the intake manifold. In this situation a remedy for the possibility of misconnection can be providing the relevant cables at different lengths; the smaller length being sufficient to reach one OCV only. However, in many applications the OCVs are situated together in the middle of the cylinder head, which does not allow for error proof by cable length. A potential solution here would typically involve different colours or key features in the connector or both. Both require proliferation in OCV part number, driving OCV (and harness/connector) cost. Also, even with colour and/or key coding it would still be possible for the OCVs themselves to become placed in the wrong position, in which case the correctly paired connector still does not help.

[0007] It is an object of the present invention to overcome problems and drawbacks described above. More particularly the object of the invention is to propose a method, and an apparatus capable of and provided for performing said method, for rectifying the effects of a wrong connection. One preferred example for a wrong connection is where a connection which was meant to go to a first device in effect goes to a complementary or second device, and where a connection which was meant to go to the second device in effect goes to the complementary or first device. One preferred example for the device is an OCV in a dual cam phasing system.

[0008] The above object is achieved by carrying out the method having the features defined in claim 1, according to which the method for operating an engine control unit for use in a motor vehicle, or for use in connection with a combustion engine, involves affecting a first or a second device - targeted device - on account of a status of a toggle means, observing an effect of having targeted the targeted device, whereby, in operation, if said effect is not observed in a predetermined or predeterminable amount of time, said status of said toggle means is toggled.

[0009] The above object is also achieved by an apparatus provided for and capable of performing this method. To this end, an engine control unit for use in a motor vehicle or for use in connection with a combustion engine is proposed, which is capable of and provided for performing the method steps of any one of the preceding claims. More particularly, the engine control unit comprises means - affecting means - for affecting a first and a second device, toggle means and observation means, whereby a status of said toggle means is provided to influence which of said first and second device is affected by the engine control unit, whereby said observation means are provided for observing an effect of the affected devices, and whereby the engine control unit is provided for, if in operation said effect is not observed in a predetermined or predeterminable amount of time, toggling said status of said toggle means.

[0010] The invention foresees an addition to the ECU

algorithm to check OCV position on initial engine key up and define their position by S/W flags. This would allow for a totally random positioning of OCVs and connectors at engine assembly without any impact.

[0011] The essential advantage of the invention is that a potential misconnection of the connections or connectors for the relevant device is rectified by the engine control unit and/or the method steps performed by the engine control unit automatically. Thus, with the invention no human interference is required and the connectors or connections can remain in place.

[0012] It should be noted that in order to implement the functionality defined by the method steps above in the engine control unit, the method steps can be implemented in software and/or in hardware or in a mixture of both software and hardware.

[0013] The dependent claims outline advantageous forms of embodiment of the method according to the invention.

[0014] Preferably the first and second device is a first and second oil control valve, since the possibility for incorrectly connecting OCV is specifically present during engine assembly for dual cam phasing systems comprising two OCVs.

[0015] Beneficially the observation means are provided for observing an effect of the affected oil control valve comprised in a dual cam phaser with an intake cam phaser and an exhaust cam phaser either at the intake cam phaser or the exhaust cam phaser or directly at the cam shaft by means of cam shaft sensors. That means, the intake or exhaust cam phaser is, in the sense of the definition above, a device connected to, or combined with, either electrically, mechanically, or functionally, the targeted device, i.e. the first or second OCV. Further, beneficially the intake or exhaust cam phasers are easy to observe on account of the cam phaser's position. Still further, beneficially the cam phaser's position is a control value which is supervised by the ECU on account of the cam phaser reaching its set position by means of a control scheme. Thus the cam phaser's position, or a variable representative of the cam phaser's position, is already available in or accessible by the ECU. When observing an effect of the affected oil control valve the ECU can reflect to the cam phaser's position and its representation. Ion regards the availability of position information the same basically applies to the position of the cam shaft. Accordingly the observation means could alternatively relay on observing the cam shaft.

[0016] In further accord with the invention, once the status of the toggle means is toggled, and the other of said first or a second device is affected on account of the toggled status of said toggle means, an effect of having targeted the other device - targeted device - is again observed. However, if said effect is not observed in a predetermined or predeterminable amount of time, an exception handling is initiated._This accounts for the possibility of a more severe error in the system, where both the devices will not react to being affected and/or will not cause an effect due to having been affected. Once this is established, i.e. once, prior to the toggle means being toggled, the predetermined amount of time passes without an observable effect, and once, after the toggle means being toggled and the complementary device being affected without causing an observable effect in the observation time, and exception handling, e.g. toggling an error flag, etc., is initiated.

[0017] In still further accord with the invention, initiating an exception handling comprises triggering an engine diagnostics system, where the engine diagnosis system deals with maintaining and evaluating error signals or error flags and initiating or signalling to the vehicle drive appropriate measures where applicable.

[0018] Other features and advantages of the present invention will appear from the following description of a preferred embodiment of the invention, given as a non-limiting example, illustrated in the drawings. All the elements which are not required for the immediate understanding of the invention are omitted. In the drawings, the same elements are provided with the same reference numerals in the various figures, and in which:

- Fig. 1 is a simplified block diagram of an engine control unit 10 adapted for use in automotive applications,
- Fig. 2 is a simplified block diagram of the invention implemented in the automotive system of Fig. 1, and
- Fig. 3 is a simplified flowchart illustrating the steps of the method according to the invention

[0019] In the following description for purposes of explanation, but not limitation, specific details are set forth, such as particular embodiments, data flows, signalling implementations, interfaces, techniques, etc., in-order to provide a thorough understanding of the present invention. However, it will be apparent to one skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. For example, while the present invention is described in the context of an engine control unit for use in a vehicle or in connection with a combustion engine, those skilled in the art will appreciate that the present invention can be implemented in different systems also, using a variety of methods for implementing the relevant method steps.

[0020] In other instances, detailed descriptions of well-known methods, interfaces, devices and signalling techniques are omitted so as not to obscure the description of the present invention with unnecessary detail. Moreover, individual function blocks are shown in some of the figures. Those skilled in the art will appreciate that the functions may be implemented using individual hardware circuits, using software functioning in conjunction with a suitably programmed digital microprocessor or general purpose computer, using an application specific integrated circuit (ASIC).

[0021] Fig. 1 is a simplified block diagram of an engine

control unit 10 adapted for use in automotive applications. The engine control unit (ECU) 10 is provided for controlling, amongst other units and devices in a vehicle, a combustion engine 12 and more particularly, a first and a second cam phasing system 14, 16 associated with the combustion engine 12 in per se known manner. Each cam phasing system 14, 16 comprises an oil control valve (OCV) 18, 20 and each cam phasing system 14, 16 together with the relevant OCV 18, 20 is provided for controlling the angular position of a cam shaft of the combustion engine 12 relative to pully and/or sprocket.

[0022] The engine control unit 10 affects the cam phasing systems 14, 16 by sending the relevant control signals to the relevant systems 14, 16, more particularly, by sending the relevant control signals to the relevant OCVs 18, 20 as visualised by the block arrows directed towards the cam phasing systems 14, 16 and/or the OCVs 18, 20.

[0023] The block arrows in Fig. 1 denote a signal path to the relevant targeted device, more particularly, to the relevant OCV 18, 20. However, in practise, the ECU 10 and the OCVs 18, 20 are hardwired with a connector at least on the OCVs' side. This involves the possibility for the wiring leading to the first OCV, for means of distinction hereinafter termed as intake OCV, and second OCV, for means of distinction hereinafter termed as exhaust OCV, 18, 20 to be misconnected during engine assembly. Misconnection of the connectors will result in the intake OCV reacting on signals received from the ECU 10 when in fact the exhaust OCV was meant to be affected and vice versa.

[0024] Fig. 2 is a simplified block diagram of the invention implemented in the automotive system of Fig. 1. As a means for affecting a first and a second device, whereby in the example depicted in Fig. 2 said first and second device is the first and second OCV 18, 20, the engine control unit 10 comprises an output 22. The output 22 is connected both with the first OCV 18 and the second OCV 20. The output 22, in the following also more broadly termed as affecting means 22, is accessible via a toggle means 24. The control signals destined for either the first or the second OCV 18, 20 originating inside the ECU 10 are transmitted via the toggle means 24 to the affecting means 22 and from there, via cables 26, 28 to either the first OCV 18 or the second OCV 20. The status of the toggle means 24 is provided to influence which of the first or second OCV 18, 20 is affected by the signals originating from the ECU 10. Once a signal from the ECU 10 arrives at either the first or second OCV 18, 20 normally an effect is caused at the relevant OCV 18, 20 or the cam phasing system 14, 16 or the combustion engine 12. To this end, an observation means 30 is provided for observing an effect of the device having affected, i.e. controlled, triggered et cetera. If in operation said effect is not observed in a predetermined or pre-determinable amount of time the status of the toggle means 24 is toggled causing the signals originating in the ECU 10 which so far have arrived via the toggle means 24, the affecting means 22, for example at the first OCV 18 now arriving with the toggled status of the toggle means 24 at the second OCV 20.

[0025] Without the toggle means 24, signals originating in the ECU 10 destined for the first OCV 18 would normally be delivered to the output 22 and from there, via the relevant contacts directly to the first OCV. The same applies for signals destined to the second OCV 20. If the cables 26, 28 are misconnected, e.g. cable 26 which is normally supposed to be connected to the first OCV 18 is in fact connected to the second OCV 20, and the cable 28 which normally is supposed to be connected to the second OCV 20 is in fact connected to the first OCV 18, then the signals destined for the first OCV 18 (targeted device) will arrive at the second OCV 20 and cause an effect at the second OCV 20 in time (affected device). With the invention, once a signal destined for a specific device, e.g. the first or second OCV 18, 20, has been sent out, the targeted device, e.g. the relevant OCV 18, 20, and/or devices or units mechanically, electrically or functionally connected to or associated with that device, are observed by the observing means 30 during a predetermined or pre-determinable amount of time for an occurrence of an effect of the transmitted signals. Once that effect is not determined during the observation time, it is at first assumed that the targeted device is not properly connected. Therefore, the toggle means 24 is toggled, causing signals which as yet have arrived at e.g. the first OCV 18 will now arrive at the second OCV 20, while signals which as yet have arrived at e.g. the second OCV 20 will now arrive at the first OCV 18. The toggle means 24 is preferably implemented in software. In case of a misconnection, once the toggle means 24 has been toggled, the targeted device and the affected device will normally coincide. However, if during observation of the targeted device an effect is still not determinable, it is assumed that a more severe situation is present in the system and exception handling is initiated, where in the case of an automotive application exception handling normally comprises steps such as triggering and engine diagnostics system.

[0026] Fig. 3 is a simplified flowchart illustrating the steps of the method according to the invention. In step 100, which is preferably executed at the very first engine start, one of the OCVs 18, 20 is targeted on account of the current status of the toggle means 24. An effect caused at the targeted OCV is subsequently observed via the observation means 30 in order to obtain a default status for the toggle means 24. The status of the toggle means 24 is influenced on account of the decision in step 102, where, if an effect is observed in due time at the targeted OCV, the status of the toggle means 24 remains unchanged (branch 104). However, if the effect is not observed at the targeted device, the status of the toggle means 24 is toggled by following branch 106. The decision in step 102 involves evaluation of information received from the observation means 30, where the information provided by the observation means 30 in case of an automotive system and in case of a first and second

OCV 18, 20 as targeted device normally involves feedback from cam sensors at the combustion engine 12 and/or the relevant cam phasing system 14, 16. In step 108, which is only executed if the decision in step 102 is positive, i.e. if the targeted device and the affected device coincide, the status of the toggle means 24 is maintained, and normal operation of the automotive system is resumed. In step 110, which is only executed if the decision in step 102 is negative, i.e. if the targeted device and the affected device are found not to coincide, the toggle means 24 is toggled, which preferably is accomplished by reversing relevant flags maintained in the toggle means if the toggle means 24 is implemented in software. The branch invoked at step 110 commences with a consecutive step 112 which is provided for targeting the targeted device, e.g. the first OCV 18 again this time with the toggled status of the toggle means 24. Normally once the status of the toggle means 24 has been toggled the targeted device and the affected device will coincide. To this end, a further decision is executed in step 114, which is basically analogue to the decision in step 102, where the targeted device is observed for an effect caused by the relevant signals sent to the targeted device. If at step 114 the targeted device and the affected device are found to coincide, the algorithm will commence via branch 116 with step 108, which was already described above and which was provided for maintaining the status of the toggle means 24 unchanged. However, if there is still no effect to be observed at the targeted device then the method will commence via branch 118 at step 120 which involves exception handling such as triggering an engine diagnostic system, since, if toggling the toggling means 24 at step 110 has not caused the targeted and the affected device to coincide this is normally assumed to be an indication for a more severe problem in the system.

[0027] The method can be executed at the very first engine start only, causing the method to provide a default setting for the toggle means. However, the method can be executed after every engine start to monitor whether targeted and affected device still coincide. Executing the method at every engine start is specifically beneficial on account of the possibility of misconnection, not only occurring during engine assembly, but during engine maintenance also. Normally, there is no need to invoke the algorithm in Fig. 3 when the engine is running.

[0028] Although a preferred embodiment of the invention has been illustrated and described herein, it is recognized that changes and variations may be made without departing from the invention as set forth in the claims. More specifically, while the particular engine control method and the corresponding apparatus as herein shown and described in detail is fully capable of attaining the above-described objects of the invention, it is to be understood that it is the presently preferred embodiment of the invention and thus, is representative of the subject matter which is broadly contemplated by the present invention. However, the scope of the present invention fully encompasses other embodiments which may become obvious to those skilled in the art. Accordingly, the scope of the present invention is to be limited by nothing other than the appended claims, in which, for example, reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather "one or more". All structural and functional equivalents to the elements of the above-described preferred embodiment that are known, or later come to be known, to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the present claims. Moreover, it is not necessary for a device or method to address each and every problem sought to be solved by the present invention, in order to be regarded as being encompassed by the present claims.

[0029] Summarising the invention described above it can briefly be described as proposing a method and an apparatus implementing said method which solves the problem of misconnected devices in an application where the devices which are subject to potential misconnection are always present in at least dual form.

Reference List

[0030]

10	Engine Control Unit
12	Combustion Engine
14	First Cam Phasing System
16	Second Cam Phasing System
18	Oil Control Valve
20	Oil Control Valve
22	Ouput
24	Toggle Means
26	Cable
28	Cable
30	Observing Means
100	Step
102	Step
104	Branch
106	Branch
108	Step
110	Step
112	Step
114	Step
116	Branch
118	Branch
120	Step

Claims

1. A Method for operating an Engine Control Unit for use in a motor vehicle or for use in connection with a combustion engine,
said method comprising the steps of:

affecting a first or a second device (18, 20) -

targeted device (18, 20) - on account of a status of a toggle means (24),
observing an effect of having targeted the targeted device (18, 20),
whereby, in operation, if said effect is not observed in a predetermined or predeterminable amount of time said status of said toggle means (24) is toggled.

2. The method of claim 1,
wherein the first and second device (18, 20) is a first and second oil control valve (18, 20).

3. The method of claim 2,
whereby the step of observing an effect of having targeted the targeted oil control valve (18, 20) comprised in a dual cam phaser with an intake cam phaser (14) and an exhaust cam phaser (16) involves observing the effect at the intake cam phaser (14) or the exhaust cam phaser (16).

4. The method of claim 1, 2 or 3,
whereby, once the status of the toggle means is toggled, and the other of said first or a second device (18, 20) is affected on account of the toggled status of said toggle means (24), an effect of having targeted the other device (18, 20) - targeted device (18, 20) - is observed,
wherein, if said effect is not observed in a predetermined or predeterminable amount of time, an exception handling is initiated.

5. The method of claim 4,
wherein initiating an exception handling comprises triggering an engine diagnostics system.

6. An Engine Control Unit for use in a motor vehicle or for use in connection with a combustion engine and capable of and provided for performing the method steps of any one of the preceding claims.

7. The engine control unit of claims 6,
said engine control unit having means - affecting means (22) - for affecting a first and a second device (18, 20),
said engine control unit further having toggle means (24) and observation means (30),
whereby a status of said toggle means (24) is provided to influence which of said first and second device (18, 20) is affected by the engine control unit,
whereby said observation means (30) are provided for observing an effect of the affected devices (18, 20), and
whereby the engine control unit is provided for, if in operation said effect is not observed in a predetermined or predeterminable amount of time, toggling said status of said toggle means (24).

8. The Engine Control Unit of claim 7,
wherein the first and second device (18, 20) is a first and second oil control valve (18, 20).

9. The Engine Control Unit of claim 8,
whereby the observation means (30) are provided for observing an effect of the affected oil control valve (18, 20), said oil control valve (18, 20) being comprised in a dual cam phaser with an intake cam phaser (14) and an exhaust cam phaser (16), at the intake cam phaser (14) or the exhaust cam phaser (16) or at a cam shaft.

10. Computer program or computer program product, such as a storage medium, with a computer readable program code for implementing the method according to any one of claims 1 to 5 when the program code is run on a computer.

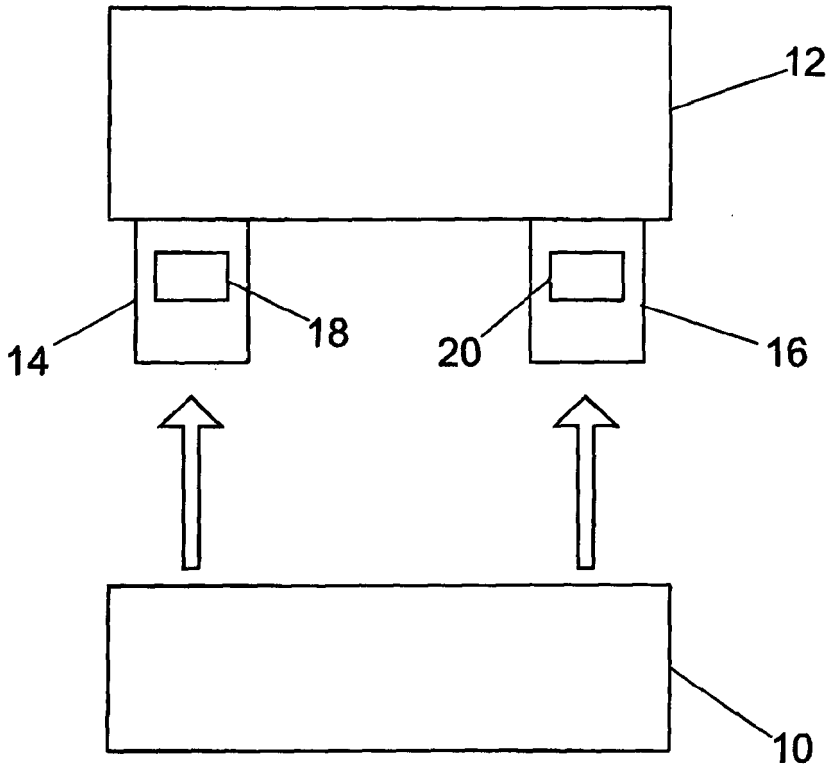

Fig. 1

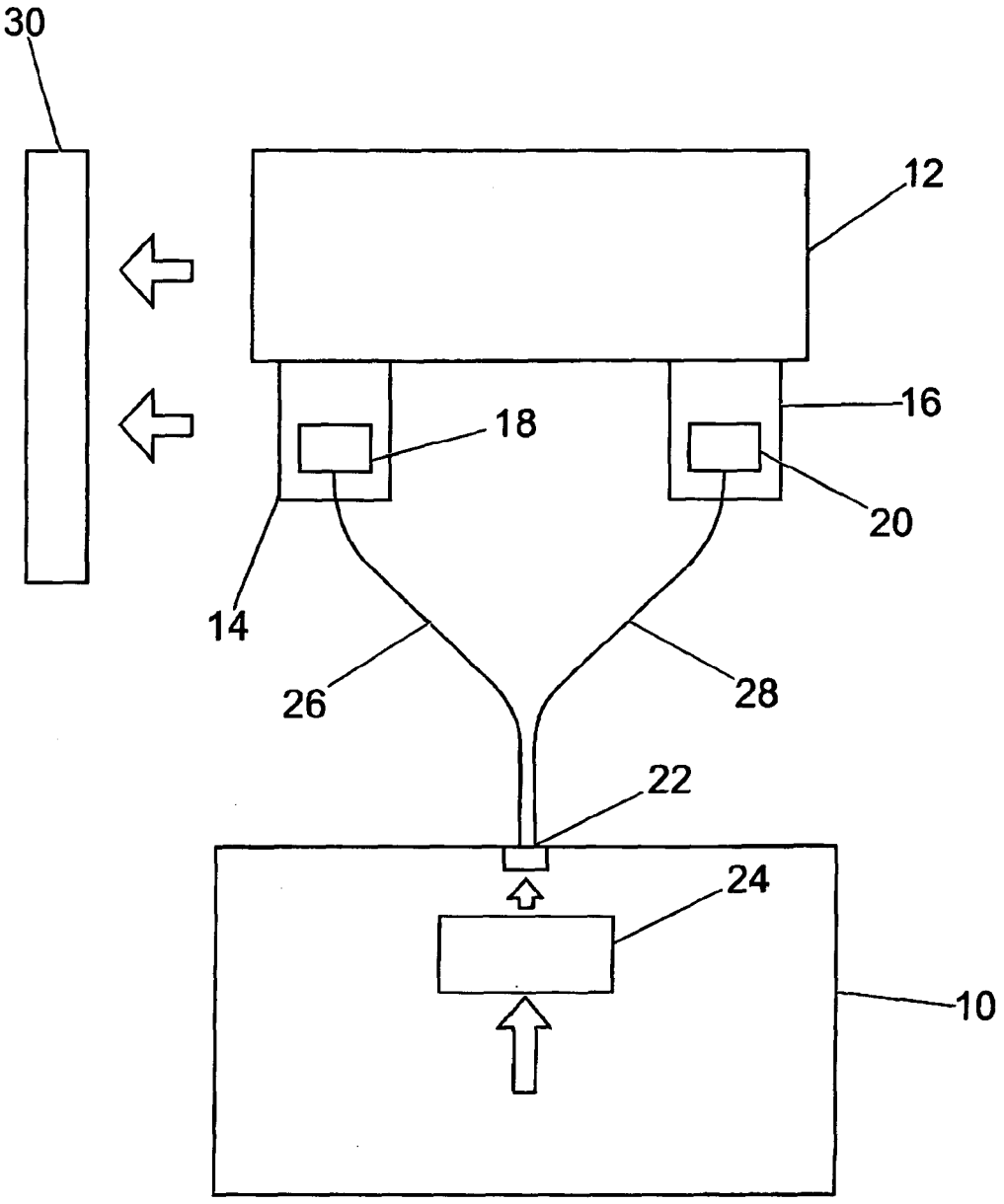

Fig. 2

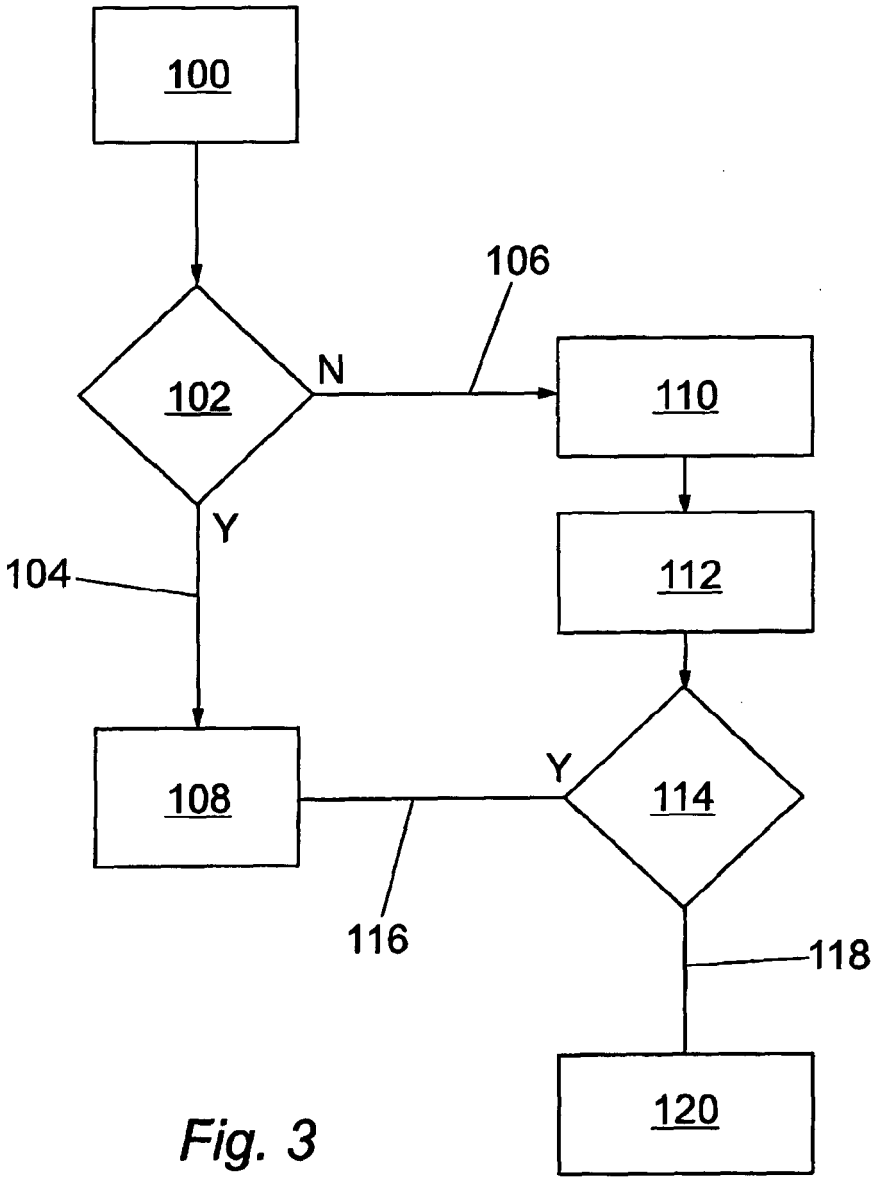

Fig. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
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F01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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CATEGORY OF CITED DOCUMENTS

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