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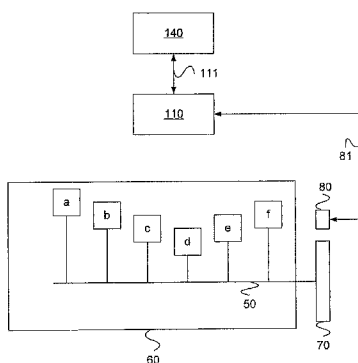


Fig. 1b

(57) Abstract: The invention relates to a method for identifying a malfunctioning fuel injector (150a, 150b, 150c, 150d, 150e, 150f) associated with an individual cylinder (Ca, Cb, Cc, Cd, Ce, Cf) of a multicylinder combustion engine (60). The method comprises the steps of: -generating a plurality of engine-speed values (r(t)) corresponding to at least one engine cycle of said engine; -transforming said engine-speed values (r(t)) so as to generate transformed engine-speed values (FT(r(t))); -processing said transformed engine-speed values (FT(r(t))) so as to facilitate a subsequent identification step; -correlate said processed values (abs(FT(r(t)))) to at least one ordinal number; -comparing said processed values (abs(FT(r(t)))) associated with the at least one ordinal number with a predetermined threshold value (K); -identifying at least one malfunctioning fuel injector depending upon said comparison.



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Method and computer program product for identifying a malfunctioning cylinder of a multi-cylinder combustion engine

Technical field

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The present invention relates to a method for identifying a malfunctioning fuel injector/cylinder of a multi-cylinder combustion engine. The invention also relates to a computer program product comprising computer program code for implementing a method according to the invention. The invention further relates to a computer and a platform having a computer on-board.

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Background of the invention

When a multi-cylinder combustion engine fails to deliver its rated power, this may be due to the malfunctioning of any of the cylinders of the engine. In the case of a diesel engine, the malfunctioning of a cylinder may be due to overfuelling caused by a faulty fuel injector or to excessive fuel pressure within a fuel supply system of the engine.

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US 5095742 discloses a method for diagnosis of faulty ignition in individual cylinders by calculating power loss. According to the method of US 5095742 accelerations of the engine speed for each of the cylinders are measured.

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Subsequently an acceleration value of a measurement associated with a particular cylinder of the engine is compared with a median acceleration and the resulting difference is used for a normalized calculation of power loss.

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US 6223120 relates to a method for estimating torque contribution of each cylinder of the engine. The method involves engine speed measurements and frequency analysis.

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Today, there exists a need to identify a malfunctioning fuel injector out of a plurality of properly functioning fuel injectors of an engine.

Summary of the invention

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An object of the invention is to provide a new and advantageous manner of identifying a malfunctioning fuel injector associated with an individual cylinder of a multicylinder combustion engine.

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An object of the invention according to an aspect of the invention is to provide an improved method for diagnosing a multi-cylinder combustion engine.

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According to an aspect of the invention there is provided a method for identifying a malfunctioning fuel injector associated with an individual cylinder of a multicylinder combustion engine, comprising the steps of:

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- generating a plurality of engine-speed values corresponding to at least one engine cycle of said engine;

- transforming said engine-speed values so as to generate transformed engine-speed values;

- processing said transformed engine-speed values so as to facilitate a subsequent identification step;

- correlating said processed values to at least one ordinal number;

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- comparing said processed values associated with the at least one ordinal number with a predetermined threshold value;

- identifying at least one malfunctioning fuel injector based upon said comparison.

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An advantage of the present invention is that the derivative of the engine speed values does not need to be taken into consideration. This thus means that the torque of the crank shaft also does not need to be taken into consideration. An advantage is that the noise reduction is improved.

An advantage of the present invention is also that the number of erroneous detections is reduced.

5 The present invention further provides an improved ability to at an early stage detect a malfunctioning cylinder of a multi-cylinder engine, which is highly desirable, not least for the operators of the vehicle, such as a driver of a heavy vehicle.

10 A beneficial contribution of the invention is that a cost effective solution to the above stated problems is achieved. Existing vehicles may easily be upgraded with relevant software so as to achieve the positive effects of the present invention.

15 Yet another beneficial contribution of the invention is that the method for identifying a malfunctioning cylinder of a multi-cylinder engine is robust.

The transforming step may be a Fourier transforming step. The Fourier transform highlights periodicity and hence makes a detection procedure more robust.

20 Absolute values may be generated during the step of processing said values. The magnitude provides information about the intensity of the periodicity/malfunctioning injector. In this way the identification step is facilitated.

25 The step of identifying at least one malfunctioning fuel injector may involve determining the argument of said processed values. Based upon the argument there can be identified witch fuel injector is malfunctioning.

30 The step of determining the argument may be dependant upon a predetermined interval. The 360 degrees of the argument is divided into 6 intervals (of a 6 cylinder engine) and the phase is compared with these intervals and thereby associated with one specific cylinder.

The ordinal number may be associated with a number of strokes per engine cycle.
The ordinal number may be 0.5, corresponding to one malfunctioning fuel injector.

- 5 The method may be performed on-line, i.e. in real time during operation of the engine. Thus, possible malfunction may be detected at an early stage. This facilitates for the operator to shut off the injector or attend to the problem by replacing the malfunctioning fuel injector.
- 10 Additional objects, advantages and novel features of the present invention will become apparent to those skilled in the art from the following details, as well as by practice of the invention. While the invention is described below, it should be understood that the invention is not limited to the specific details disclosed. A person skilled in the art having access to the teachings herein will recognise
- 15 additional applications, modifications and embodiments, which are within the scope of the invention.

Brief description of the drawings

- 20 For a more complete understanding of the present invention and further objects and advantages thereof, reference is now made to the examples shown in the accompanying drawings, in which:

Figure 1a schematically illustrates a fuel injection system for a combustion engine according to an aspect of the present invention;

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Figure 1b schematically illustrates a combustion engine and an electronic control unit therefore according to an aspect of the present invention;

- 30 Figure 2 schematically illustrates a flywheel of an engine according to an aspect of the present invention;

Figure 3a-e schematically illustrates graphs according to different aspects of the present invention;

- 5 Figure 4 schematically illustrates a flow chart depicting a method for identifying a malfunctioning cylinder/fuel injector according to an aspect of the present invention;

- 10 Figure 5 schematically illustrates an electronic control unit according to an aspect of the invention.

Detailed description of the drawings

- 15 With reference to Figure 1a, a sub-system of a platform 10 is shown. The platform 10 is preferably a heavy vehicle, such as a truck or lorry. It should be noted that the platform 10 alternatively can be a water craft or underwater craft, e.g. a ship or submarine. Alternatively the platform 10 can be a power plant.

- 20 Hereinafter the term “link” refers to a communication link which may be a physical connector, such as an optoelectronic communication wire, or a non-physical connector such as a wireless connection, for example a radio or microwave link.

- 25 Fig. 1a shows a fuel injection system for a combustion engine 60 (shown in figure 1b) in the form of a schematically represented diesel engine having six cylinders. The fuel injection system and the diesel engine are with advantage fitted to a heavy vehicle, such as truck, lorry or bus, for propelling the vehicle. The fuel injection system is a so-called Common Rail system and comprises a fuel line for supply of fuel from a fuel tank 115 to the cylinders of the diesel engine. A fuel pump 116 is arranged in the fuel line to convey fuel from the fuel tank via a filter 117 to a high-
30 pressure pump 118. The high pressure pump 118 is adapted to pressurize the fuel so that it enters at high pressure an accumulator tank 120 which takes the form of a so-

called Common Rail. The high fuel pressure in the accumulator tank 120 constitutes a power source making it possible for fuel to be injected at high pressure into the respective cylinders of the diesel engine. The fuel in the accumulator tank 120 is intended to be distributed to all the cylinders of the combustion engine 60.

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To control the injection of fuel injection means 150a-150f is arranged in each of the connections between the accumulator tank 120 and the respective cylinders of the diesel engine. When an injection means is in an open state, it injects fuel at high pressure into the cylinder concerned. Thus, fuel from the accumulator tank 120 is injected into the combustion spaces of the respective cylinder by means of the injection means which is in the form of electronic injectors which injectors can open and close very quickly. A control unit 110 in the form of an electronic control unit (ECU) is adapted to control the operation of the fuel pump 116, the high pressure pump 118 and the injection means 150a, 150b, 150c, 150d, 150e, and 150f. A pressure sensor 122 is fitted in the accumulator tank 120 to detect the prevailing pressure therein and to send to the control unit 110 a signal S122 conveying information about the pressure values detected. On the basis of knowing the pressure in the accumulator tank, the electronic control unit 110 controls the on-time or opening times of each individual electronic injector so that the calculated amount of fuel is supplied with good accuracy to the combustion spaces of the respective cylinders.

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In this description, the term “on-time” refers to the opening time of an injector, i.e. the duration of the time period during which the injector is kept open in order to inject fuel into the associated cylinder in connection with a single stroke of the engine. The quantity of fuel injected into a cylinder in connection with a stroke of the engine depends on the length of the on-time and the pressure of the fuel supplied to the injector.

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Here, the inventive method is initiated and controlled by means of the electronic control unit. Alternatively, the inventive method is initiated and controlled by

means of an external PC 112. The external computer may be directly connected to the electronic control unit via a link 114, but may also be indirectly connected to the electronic control unit in any suitable manner, such as through an internal vehicle internal network. The communication between the external computer and the engine control unit may be partly or entirely wireless. The inventive method could also be initiated and controlled by the electronic control unit itself or by another electronic control unit, such as an electronic gear box control unit connected to the fuel injection system via a vehicle internal network.

Figure 1b shows the engine 60 having six cylinders, each cylinder Ca, Cb, Cc, Cd, Ce, and Cf (not shown) being provided with a piston a, b, c, d, e, f, respectively. It should be noted that the invention is applicable to any multicylinder combustion engine with an arbitrary number of cylinders. The six pistons are attached to a crank shaft 50. The crank shaft 50 is attached to a fly wheel 70 being arranged to rotate with the same speed as the crank shaft 50. A sensor unit 80 is provided at a close proximity to the fly wheel 70. The sensor unit 80 is arranged to measure engine speed by detecting points of time corresponding to detections of markers equidistantly provided on the fly wheel 70 as depicted in greater detail below. The sensor unit 80 is arranged for communication with the electronic control unit 110 via a link 81. The sensor unit 80 is arranged to continuously transmit detected discrete points of time. Alternatively, the sensor unit 80 is arranged to, on a regular basis, send signals comprising a plurality of detected discrete time points.

Thus, the electronic control unit is arranged to receive sensed engine data in the form of e.g. a toothed fly wheel signal (TF-signal). The TF-signal is received on a data communications port from the engine-speed sensor unit 80 which senses rotation of the engine's toothed fly wheel 70. The engine-speed sensor 80 may be e.g. an inductive type sensor or a Hall-effect sensor. Of course there may be more than one engine-speed sensor unit and other positions for measuring engine speed, such as measuring the engine's camshaft speed, or the speed of an alternator connected to the engine.

The electronic control unit 110 is arranged to perform a diagnosis test based upon transmitted discrete points of time from the sensor unit 80, so as to determine if one or more injectors associated with a unique cylinder of the engine is malfunctioning.

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Figure 2 schematically illustrates a side view of the fly wheel of the engine. There is also shown the engine-speed sensor unit 80 arranged for communication with the electronic control unit 110 via the link 81.

10 The flywheel 70 is provided with 60 markers denoted #1, #2, ... , #60, such as teeth or holes. However, since there are four strokes in an engine cycle two turns of the flywheel give that each marker is calculated twice and therefore 120 markers are sensed by the engine-speed sensor unit 80 during an engine cycle. The measurements are denoted #1, #2, ... , #120, wherein #1 and #61 corresponds to the
15 same marker. The engine-speed sensor unit 80 is arranged to detect a time point corresponding to a marker passing by a predetermined location, e.g. a location schematically indicated at marker #60 (and #120).

A person skilled in the art thus realizes that two turns of the flywheel 70 correspond
20 to one engine cycle, which in turn corresponds to two turns of the crankshaft 50. It should be noted that the invention is suitable for various types of flywheels having an arbitrary number of markers.

The electronic control unit 110 is arranged to calculate an engine-speed value $r(t)$
25 corresponding to each of the teeth of the flywheel 70. The calculation of the respective engine-speed value is performed depending upon received time point data, which data is communicated by the engine-speed sensor unit. Herein the parameter t indicates that speed varies with time.

Alternatively, the engine-speed sensor unit 80 is arranged to calculate an engine-speed value $r(t)$ corresponding to each of the teeth of the flywheel 70 and to continuously transmit these values to the electronic control unit 110.

5 Figure 3a is an example graph wherein engine speed is plotted as a function of crankshaft rotation. There is also shown that the engine speed varies depending upon ignitions of subsequent cylinders Ca, Cb, ...Cf. This example illustrates a well functioning engine, with even torque contributions from the cylinders over time. There is also illustrated that the engine during the illustrated engine cycle has a
10 particular mean value M1rpm.

Figure 3b is an example graph associated with the example illustrated with reference to Figure 3a. The graph illustrates a plot of the Fourier transformed engine speed values as a function of ordinal number N. As the fuel injectors of this
15 example are functioning properly, the function substantially constitutes a peak at the ordinal number 3.

It should be noted that ordinal number and frequency are equivalent. Ordinal number 0.5 means that there is a periodicity once every second engine rotation or
20 equivalently once every firing cycle. The advantage of using this ordinal number is that this invention relates to single injector detection, i.e. a periodicity of one event every firing cycle of the engine.

Figure 3c is an example graph wherein engine speed is plotted as a function of
25 crankshaft rotation. There is also shown that engine speed varies depending upon ignitions of subsequent cylinders Ca, Cb, ...Cf. This example illustrates that the fuel injector of the third cylinder Cc is malfunctioning. The malfunctioning fuel injector e.g. suffers from a too long on-time, and thus, a too large amount of fuel is injected in the third cylinder Cc. The power stroke of the third cylinder Cc generates
30 significantly higher engine speed values than desired (see arrows A and B). There are thus uneven torque contributions from the cylinders of the engine over time.

There is also illustrated that the engine during the illustrated engine cycle has a particular mean value $M2_{rpm}$, which is slightly higher than $M1_{rpm}$ during comparable conditions.

5 Figure 3d is an example graph associated with the example illustrated with reference to Figure 3c. The graph illustrates a plot of the Fourier transformed engine speed values as a function of ordinal number N . As one fuel injector of this example is not functioning properly, there is also a peak at the ordinal number 0.5. This indicates that one fuel injector out of the group of six fuel injectors is
10 malfunctioning.

If the amplitude value of the Fourier transformed engine speed values is larger or equal to a predetermined threshold value κ there is identified that one fuel injector is malfunctioning. However, it should be noted that it is not clear which of the fuel
15 injectors is malfunctioning by determining the amplitude of the absolute value of the Fourier transformed engine speed values. κ is a predetermined numerical value. The value of κ may be preset and stored in a memory of the electronic control unit 110. The value of κ can e.g. be in the interval 1-10. According to one embodiment the value of κ is in the interval 1-5. According to one embodiment the value of κ is
20 about 2.

Figure 3e is an example graph associated with the examples illustrated with reference to Figures 3c and 3d. In order to determine which individual fuel injector is malfunctioning the argument of the Fourier transformed engine speed values has
25 to be determined. Figure 3e illustrates the argument of $FT(r(t))$, also denoted $\arg FT(r(t))$ plotted against the ordinal number $N=0.5$.

According to an embodiment of the invention the malfunctioning fuel injector is identified by determining the value $\arg(FT(r(t)))$ corresponding to the ordinal
30 number 0.5. The fuel injectors of each cylinder, respectively, is corresponding to a unique argument of $FT(r(t))$. The fuel injectors of each cylinder, respectively, are

corresponding to a unique argument of $FT(r(t))$ by means of a reference value, i.e. this unique correspondence between the different fuel injectors and the arguments is established by means of a reference value. The reference value is according to this example indicating that the first fuel injector/cylinder corresponds to the argument
5 60° . Thus, as indicated in Figure 3e, the argument 180° is corresponding to the third fuel injector Cc, which is the malfunctioning fuel injector according to this example.

Figure 4 schematically illustrates a method for identifying a malfunctioning fuel
10 injector associated with an individual cylinder of a multicylinder combustion engine.

The method comprises a first method step s410. The method step s410 comprises the step of generating a plurality of engine-speed values corresponding to at least
15 one engine cycle (two revolutions of the crank shaft 50) of said engine. After the method step s410 a subsequent method step s415 is performed. According to a first embodiment the engine speed values are generated in real time, sequentially. As an alternative to generating engine speed values sequentially, engine speed values corresponding to one cylinder, e.g. r_1 - r_{20} , corresponding to the first cylinder, are
20 generated substantially at the same time in a batch. After the method step s410 a subsequent method step s415 is performed.

The method step s415 comprises the step of Fourier transforming said engine-speed values so as to generate transformed engine-speed values $FT(r(t))$. After the method
25 step s415 a subsequent method step s420 is performed.

The method step s420 comprises the step of processing said transformed engine-speed values $FT(r(t))$. The processing step involves determining the absolute value(s) of the Fourier transformed engine speed values $FT(r(t))$. The absolute
30 value(s) of the Fourier transformed engine speed values $FT(r(t))$ is denoted

abs($FT(r(t))$). After the method step s420 a subsequent method step s425 is performed.

The method step s425 comprises the step of correlating said processed values
5 abs($FT(r(t))$) to at least one ordinal number N , where N represents strokes per revolution. Strokes per revolution may also be expressed in engine cycles. After the method step s425 a subsequent method step s430 is performed.

The method step s430 comprises the step of comparing said processed values
10 abs($FT(r(t))$) associated with the at least one ordinal number with a predetermined threshold value κ . According to an embodiment of the present invention the comparison process involves determining whether the processed values
abs($FT(r(t))$) is greater than or equal to a threshold value κ . After the method step s430 a subsequent method step s435 is performed.

15 The method step s435 comprises the step of identifying at least one malfunctioning fuel injector based upon said comparison. If the magnitude associated with the processed values abs($FT(r(t))$) is greater than the threshold value one fuel injector is malfunctioning, see fig. 3d. Which fuel injector is malfunctioning is determined
20 through the following:

Firstly it is, as depicted above, determined whether the magnitude associated with the processed values abs($FT(r(t))$) is greater than the threshold value κ . Secondly it is determined which fuel injector is malfunctioning by determining the argument of
25 the processed values $FT(r(t))$, corresponding to the ordinal number 0.5. The fuel injectors of each cylinder, respectively, are corresponding to a unique argument of $FT(r(t))$. This unique correspondence between the different fuel injectors and the arguments is established by means of a reference value. Thus, it is identified which engine speed values that correlates to the malfunctioning fuel injector. A result of
30 the identification step comprises information about which fuel injector is identified to be malfunctioning, e.g. having a too long on-time, implying that an excessive

amount of fuel is injected. According to one embodiment the result of the identification step is displayed on a display such that the information can be provided to an operator. After the method step s435 the method ends.

5 With reference to Figure 5, a diagram of one embodiment of the electronic control unit 110 is shown. The electronic control unit 110 is also referred to as apparatus. The apparatus comprises a non-volatile memory 520, a data processing device 510 and a read/write memory 550. Non-volatile memory 520 has a first memory portion 530 wherein a computer program, such as an operating system, is stored for
10 controlling the function of the apparatus. Further, the apparatus comprises a bus controller, a serial communication port, I/O-means, an A/D-converter, a time date entry and transmission unit, an event counter and an interrupt controller (not shown). Non-volatile memory 520 also has a second memory portion 540.

15 A computer program P comprising routines for identifying a malfunctioning injector/cylinder may be stored in an executable manner or in a compressed state in a computer program product in the form of a separate memory 560 and/or in read/write memory 550. The memory 560 is a non-volatile memory, such as a flash memory, an EPROM, an EEPROM or a ROM.

20

When it is stated that the data processing device 510 performs a certain function it should be understood that the data processing device 510 performs a certain part of the program which is stored in the separate memory 560, or a certain part of the program which is stored in the read/write memory 550.

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The data processing device 510 may communicate with a data communications port 599 by means of a data bus 515. The non-volatile memory 520 is adapted for communication with the data processing device 510 via a data bus 512. The separate memory 560 is adapted for communication with the data processing device
30 510 via a data bus 511. The read/write memory 550 is adapted for communication with the data processing device 510 via a data bus 514.

When data is received on the data port 599 from the engine speed sensor unit 80 it is temporarily stored in the second memory portion 540. When the received input data has been temporarily stored, the data processing device 510 is set up to perform execution of code in a manner described above. According to an embodiment of the invention, data received on the data port 599 comprises time information associated with the fly wheel 70. The processing device is arranged to generate engine speed values $r_1(t)$ - $r_{120}(t)$ depending upon the received time information. The generated engine speed values can be used by the apparatus so as to identify which fuel injector/cylinder of the engine 60 onboard the platform is malfunctioning.

Parts of the methods described herein can be performed by the apparatus by means of the data processing device 510 running the program stored in the separate memory 560 or the read/write memory 550. When the apparatus runs the program, parts of the methods described herein are executed.

According to an aspect of the invention the apparatus is arranged to run a computer program for identifying a malfunctioning fuel injector associated with an individual cylinder of a multicylinder combustion engine, comprising computer readable program code means for causing an the apparatus, an electronic control unit or another computer connected to the electronic control unit to perform the steps of:

- generating a plurality of engine-speed values corresponding to at least one cylinder of said engine;
- transforming said engine-speed values so as generate transformed engine-speed values;
- processing said transformed engine-speed values so as to facilitate a subsequent identification step;
- correlating said processed values to at least one ordinal number;
- comparing said processed values associated with the at least one ordinal number with a predetermined value;
- identifying at least one malfunctioning fuel injector based upon said comparison.

According to an aspect of the invention the apparatus is arranged to run a computer program, comprising computer readable means for causing the electronic control unit or another computer connected to the electronic control unit to perform the transforming step as a Fourier transforming step.

According to an aspect of the invention the apparatus is arranged to run a computer program, comprising computer readable means for causing the electronic control unit or another computer connected to the electronic control unit to perform the step of generating absolute values during the step of processing said values.

According to an aspect of the invention the apparatus is arranged to run a computer program, comprising computer readable means for causing the electronic control unit or another computer connected to the electronic control unit to perform the step of determining the argument of said processed values during the step of identifying at least one malfunctioning fuel injector.

According to an aspect of the invention the apparatus is arranged to run a computer program, comprising computer readable means for causing the electronic control unit or another computer connected to the electronic control unit to perform the step of determining the argument, wherein said step is based upon a predetermined reference value.

According to an aspect of the invention the apparatus is arranged to run a computer program, wherein the ordinal number is associated with a number of strokes per engine cycle.

According to an aspect of the invention the apparatus is arranged to run a computer program, wherein the ordinal number is 0.5, corresponding to one malfunctioning fuel injector.

The foregoing description of the preferred embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in the art.

- 5 The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, thereby enabling others skilled in the art to understand the invention for various embodiments and with the various modifications as are suited to the particular use contemplated.

Claims

1. A method for identifying a malfunctioning fuel injector (150a, 150b, 150c, 150d, 150e, 150f) associated with an individual cylinder (Ca, Cb, Cc, Cd, Ce, Cf) of a multicylinder combustion engine (60), comprising the steps of:

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- generating a set of engine-speed values ($r(t)$) corresponding to at least one engine cycle of said engine;

- transforming said engine-speed values ($r(t)$) so as to generate transformed engine-speed values ($FT(r(t))$);

10

- processing said transformed engine-speed values ($FT(r(t))$) so as to facilitate a subsequent identification step;

- correlating said processed values ($abs(FT(r(t)))$) with at least one ordinal number;

- comparing with a predetermined threshold value (κ) said processed values ($abs(FT(r(t)))$) correlated with at least one ordinal number;

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- identifying at least one malfunctioning fuel injector based upon said comparison, which step of identifying at least one malfunctioning fuel injector involves determining the argument for said processed values.

2. Method according to claim 1 **characterized in that** the transforming step is a Fourier transforming step.

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3. Method according to claim 1 or 2 **characterized in that** during the processing of said values absolute values ($abs(FT(r(t)))$) are generated.

4. Method according to any of claims 1-3 **characterized in that** the step of determining the argument is dependent upon a predetermined reference interval.

25

5. Method according to any of claims 1-4 **characterized in that** the ordinal number is associated with a number of strokes per engine cycle.

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6. Method according to any of claims 1-5 **characterized in that** the ordinal number is 0.5, corresponding to one malfunctioning fuel injector.

7. Computer program for identifying a malfunctioning fuel injector (150a, 150b, 150c, 150d, 150e, 150f) associated with an individual cylinder (Ca, Cb, Cc, Cd, Ce, Cf) of a multicylinder combustion engine (60), provided with computer readable program code means for causing an electronic control unit or another computer connected to the electronic control unit to perform the steps of:

- generating a set of engine-speed values ($r(t)$) corresponding to at least one engine cycle of said engine;
 - transforming said engine-speed values ($r(t)$) so as to generate transformed engine-speed values ($FT(r(t))$);
 - processing said transformed engine-speed values ($FT(r(t))$) so as to facilitate a subsequent identification step;
 - correlating said processed values ($abs(FT(r(t)))$) with at least one ordinal number;
 - comparing with a predetermined threshold value (κ) said processed values ($abs(FT(r(t)))$) correlated with at least one ordinal number;
 - identifying at least one malfunctioning fuel injector based upon said comparison,
- which computer programme has computer readable information for causing the electronic control unit or another computer connected to the electronic control unit to perform the step of determining the argument, wherein said step is based on a predetermined reference interval.

8. Computer program according to claim 7, provided with computer readable information for causing the electronic control unit or another computer connected to the electronic control unit to perform the transforming step as a Fourier transforming step.

9. Computer program according to claim 7 or 8, provided with computer readable information for causing the electronic control unit or another computer connected to

the electronic control unit to perform the step of generating absolute values
($\text{abs}(\text{FT}(\text{r}(\text{t})))$) during the step of processing said values.

10. Computer program according to any of claims 7-9, provided with computer
5 readable information for causing the electronic control unit or another computer
connected to the electronic control unit to perform the step of determining the
argument for said processed values during the step of identifying at least one
malfunctioning fuel injector.

10 11. Computer program according to any of claims 7-10, wherein the ordinal number
is associated with a number of strokes per engine cycle.

12. Computer program according to any of claims 7-11, wherein the ordinal number
is 0.5, corresponding to one malfunctioning fuel injector.

15 13. Computer program product provided with a computer program according to any
of claims 7-12 and a computer readable medium on which the computer program is
stored.

20 14. Computer, such as an embedded electronic control unit or a vehicle external
computer comprising a storage means and a computer program according to any of
claims 7-12 stored in the storage means.

15. Platform provided with a computer according to claim 14.

25 16. Platform according to claim 15 wherein said platform is chosen among a group
comprising road vehicle, water craft and underwater craft, such as truck, ship and
submarine respectively, or a power plant.

1/8

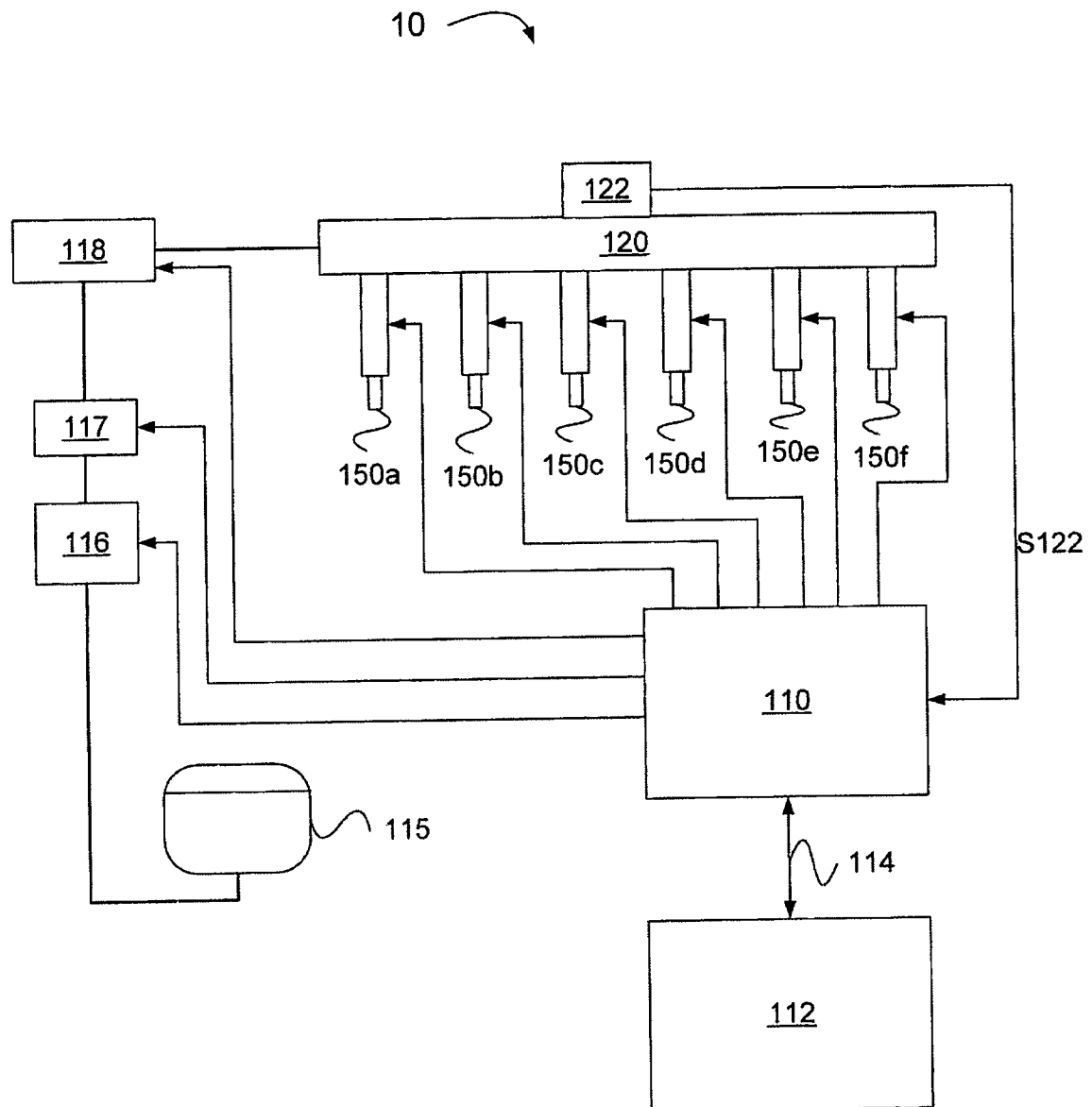


Fig. 1a

2/8

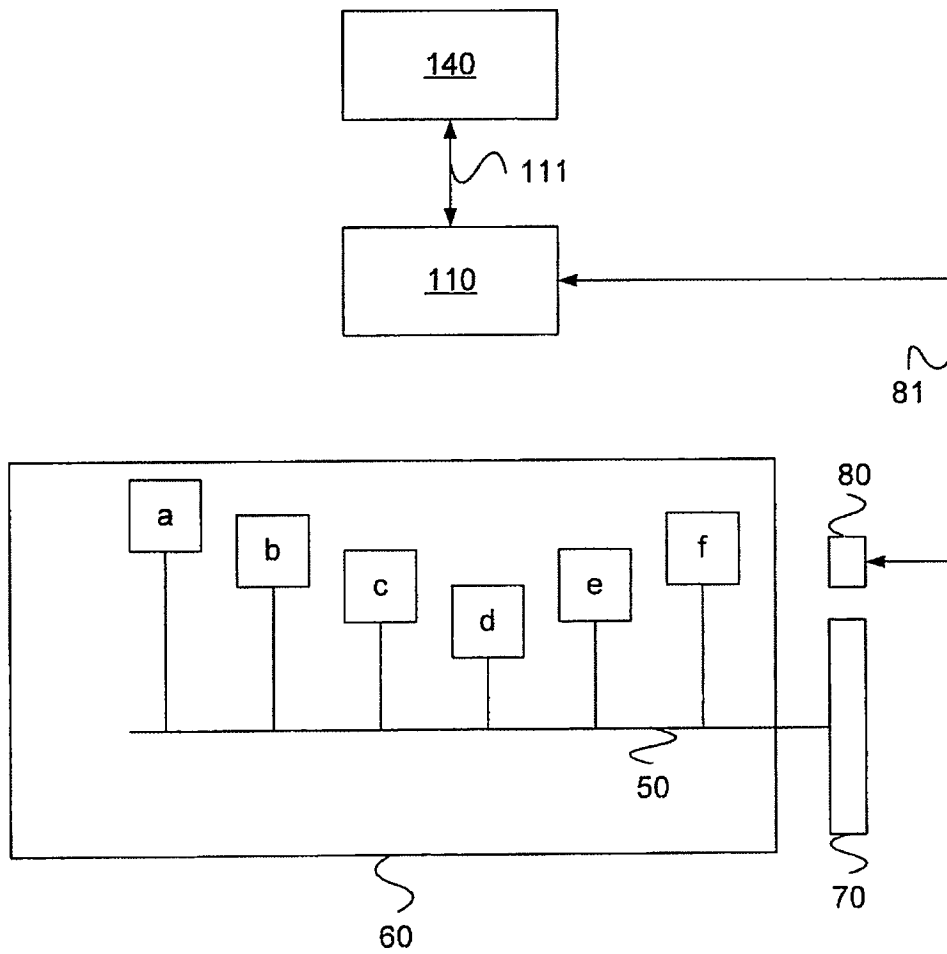


Fig. 1b

3/8

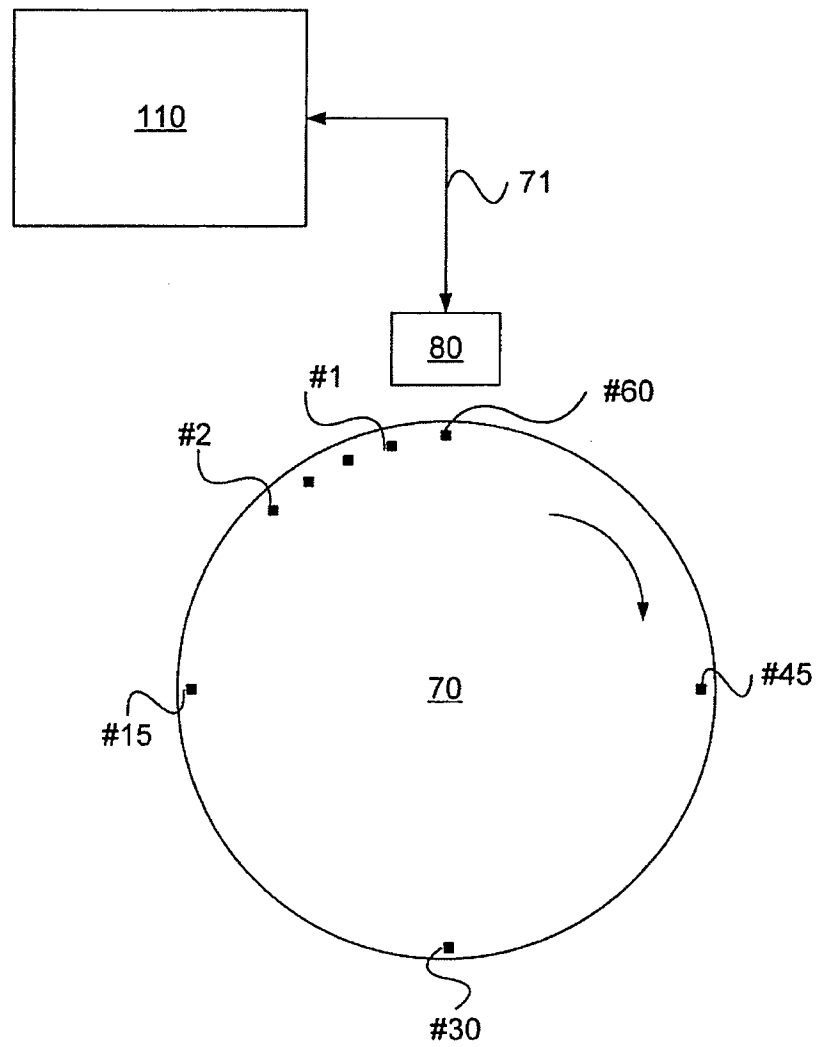


Fig. 2

4/8

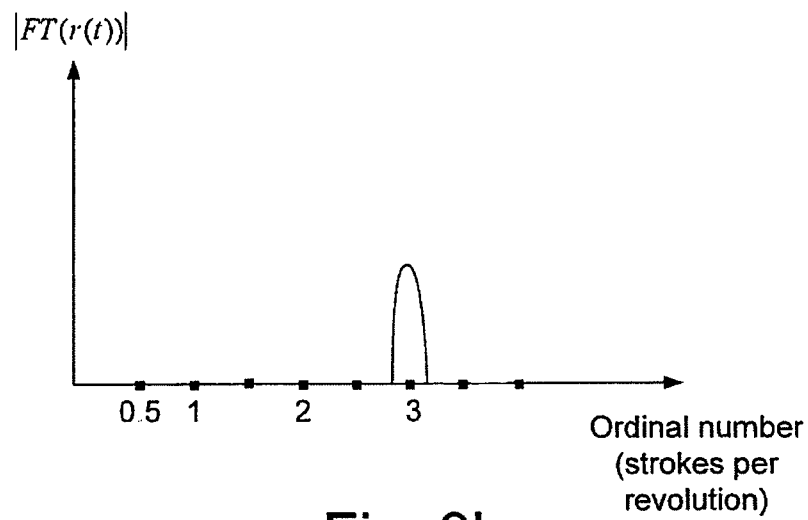


Fig. 3b

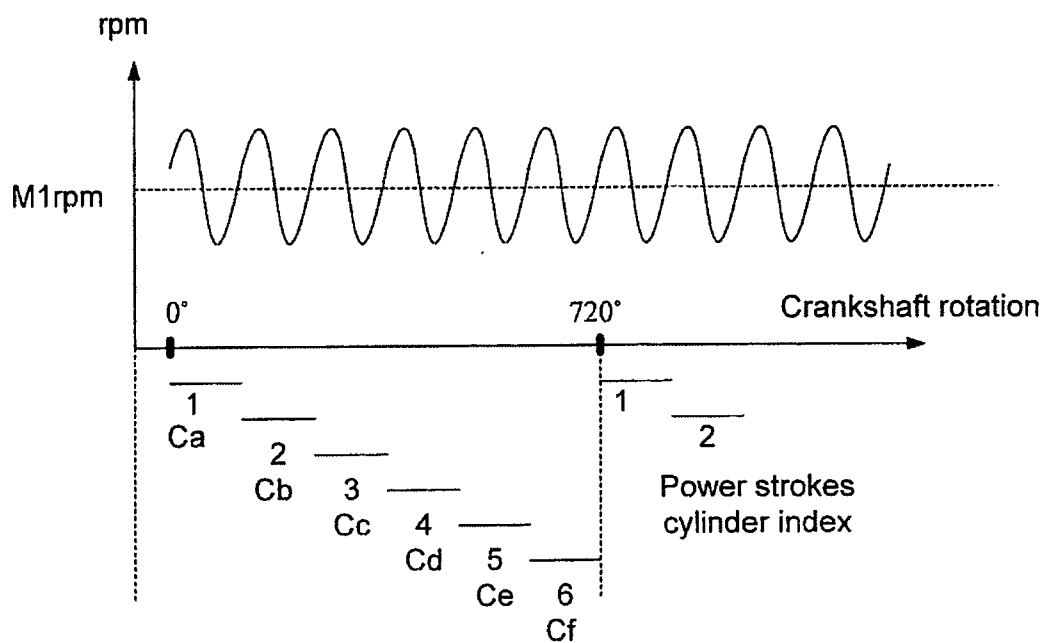


Fig. 3a

5/8

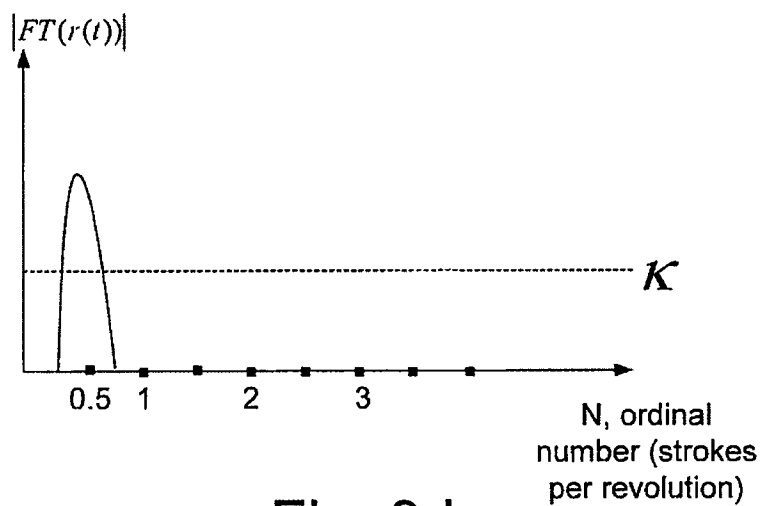


Fig. 3d

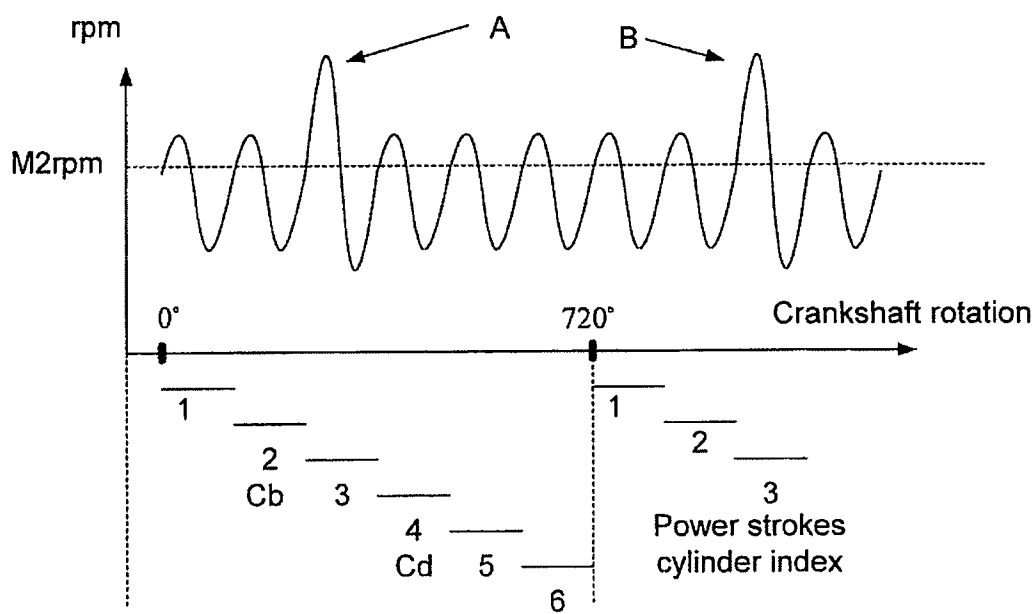


Fig. 3c

6/8

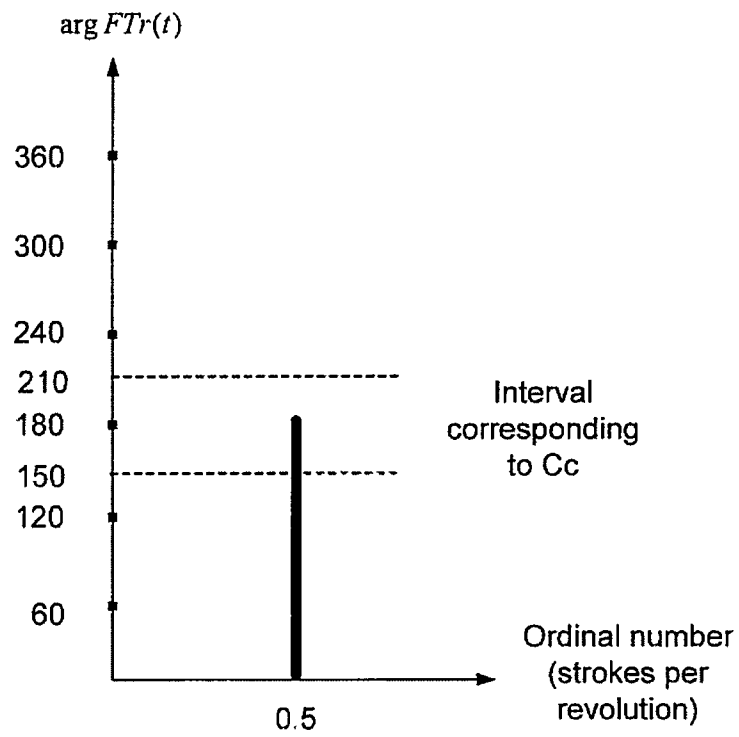


Fig. 3e

7/8

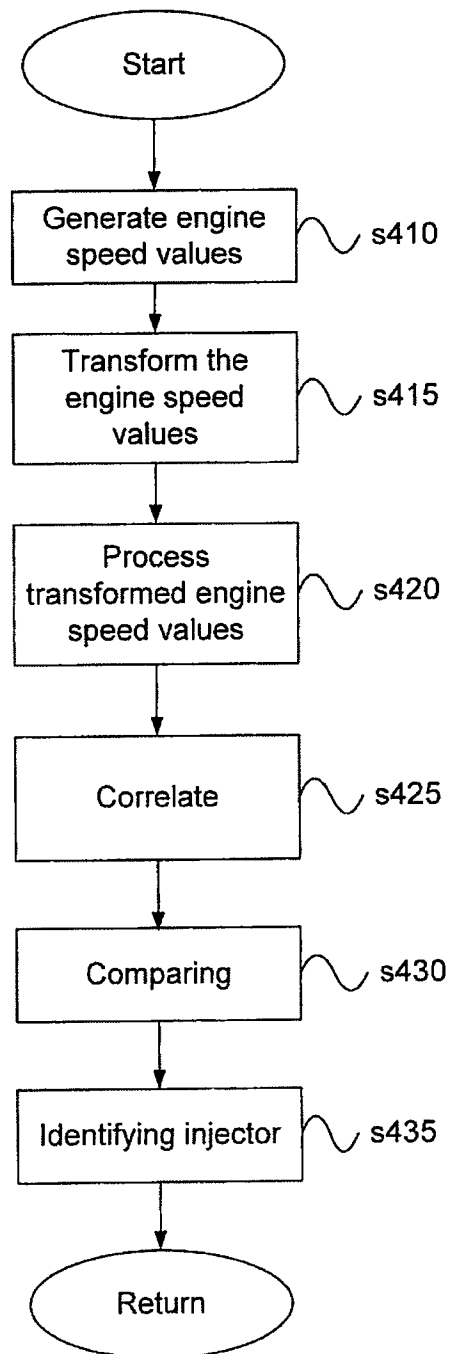


Fig. 4

8/8

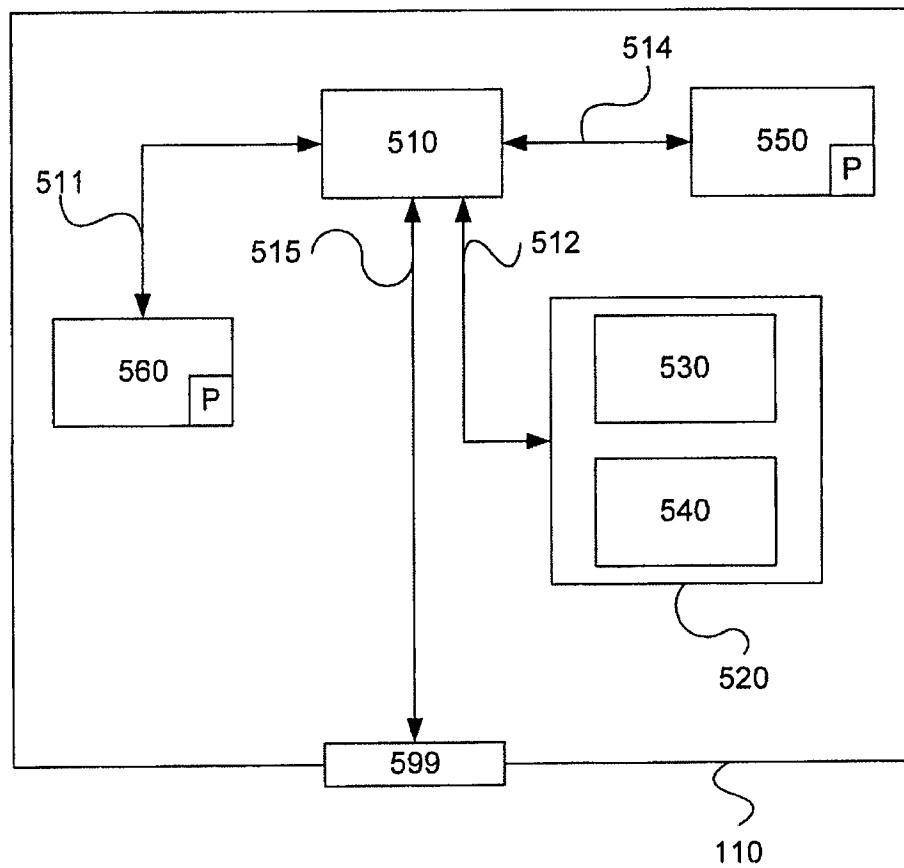


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2008/050521

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: F02M, F02D, 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, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 6651490 B1 (CECCARANI ET AL), 25 November 2003 (25.11.2003), column 1, line 12 - line 33; column 2, line 4 - line 12; column 2, line 53 - line 65, column 3, line 63 - column 4, line 5; column 5, line 60 - column 6, line 10; column 7, line 3 - line 4 --	1-16

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

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Date of the actual completion of the international search

19 August 2008

Date of mailing of the international search report

20-08-2008

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2008/050521

C (Continuation). 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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A	US 5771482 A (RIZZONI, G), 23 June 1998 (23.06.1998), column 8, line 27 - line 44; column 9, line 36 - line 48 --	1-16
A	US 4873870 A (CITRON, S ET AL), 4 July 1989 (04.07.1989), column 1, line 19 - line 21; column 6, line 47 - line 58; column 12, line 34 - line 38 -- -----	1-16

International patent classification (IPC)**F02M 65/00** (2006.01)**F02D 41/14** (2006.01)**G01M 15/11** (2006.01)**Download your patent documents at www.prv.se**

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Cited literature, if any, will be enclosed in paper form.

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28/06/2008

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