



(51) International Patent Classification:

F02D 41/22 (2006.01) F02D 41/14 (2006.01)
F02D 41/00 (2006.01)

(21) International Application Number:

PCT/EP2015/059899

(22) International Filing Date:

6 May 2015 (06.05.2015)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1409497.3 29 May 2014 (29.05.2014) GB

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: METHOD OF DIAGNOSING FAILURES IN INLET MANIFOLD PRESSURE SENSORS

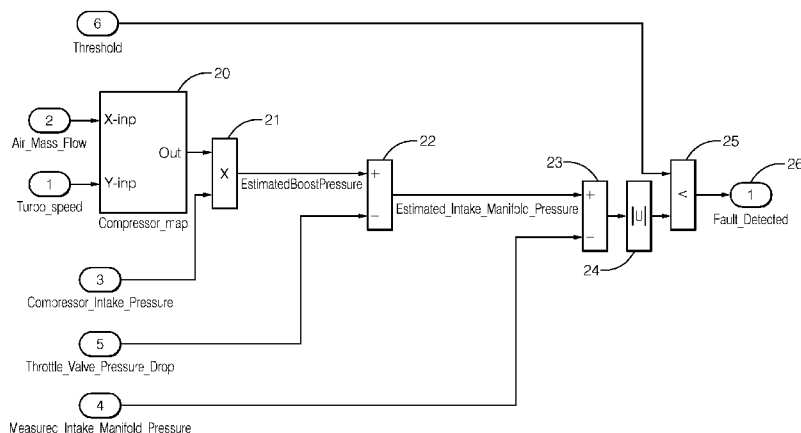


FIG. 4

(57) Abstract: A method of determining the pressure P_p at a point from the compressor outlet to the intake manifold of a turbocharged engine system comprising: providing a relationship between the turbo speed($\dot{\omega}$),compressor pressure ratio (P_1/P_0) and air mass flow (AMF); measuring the turbo speed($\dot{\omega}$); measuring or estimating the compressor inlet pressure, P_0 ; measuring the air mass flow (AMF); determining the pressure P_p from the parameters of steps b) c) and d) using said relationship.

Method Of Diagnosing Failures in Inlet Manifold Pressure Sensors

Field of the Invention

5 This application relates to a method for determining the pressure at a point from/between the compressor and the intake manifold of a turbocharged engine system and further to a method of detecting a failure in the operational functionality of a pressure sensor located between the outlet of the compressor of a turbocharged engine, and the intake manifold of an engine.

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Background of the Invention

Typically turbocharged engines have a turbocharged system fitted with a turbo-charger comprising a compressor and a turbine, a turbo speed sensor , and an air
15 mass flow (AMF) sensor to measure the air mass flow through the compressor, as well as an ambient pressure sensor.

A strategy is required by legislation to diagnose failures in pressure sensors such as the intake manifold pressure sensor.

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It is an object of the invention to provide a method to detect faults in intake manifold pressure sensors and hence to assess the plausibility of the intake manifold pressure sensor.

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Summary of the Invention

In one aspect is provided a method of determining the pressure P_p at a point from the compressor outlet to the intake manifold of a turbocharged engine system

- 5 comprising: providing a relationship between the turbo speed ($\dot{\omega}$), compressor pressure ratio (P_1/P_0) and air mass flow (AMF); measuring the turbo speed ($\dot{\omega}$); measuring or estimating the compressor inlet pressure, P_0 ; measuring the air mass flow (AMF); determining the pressure P_p from the parameters of steps b) c) and d) using said relationship.

- 10 The compressor inlet pressure may be determined or estimated from measured or assumed ambient pressure.

The compressor inlet pressure may be based on the measured or assumed ambient pressure minus any estimated or measured pressure losses across an air filter and/or flow sensors upstream of said compressor.

- 15 The compressor outlet pressure P_1 may be determined.

The pressure P_p at a point between said compressor and intake manifold may be determined to be said determined pressure P_1 minus any estimated or measured losses across components located between said point and said compressor outlet.

- 20 In a further aspect is provided a method of determining the operational functionality of a pressure sensor located downstream of the compressor outlet to the intake manifold of a turbocharged engine comprising determining the pressure P_p at a point between the compressor and intake manifold using any above referenced methods, and comparing this to the value of pressure provided by said

sensor, and indicating a fault if the difference between said pressure is greater than a threshold.

5 **Brief Description of Drawings**

The invention will now be described by way of example and with reference to the follow drawing of which:

10 Figure 1 shows a schematic representation of a turbocharged engine system to which examples of the invention can be applied;

Figure 2 shows the relationship between air mass flow and pressure ratio for different turbo speeds;

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Figure 3 shows a diagram similar to figure 1 and details parameters;

Figure 4 shows a block diagram representing a detailed implementation of one example of the invention.

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Brief Description of the Invention

25 In one aspect of the invention, a method is provided that estimates the intake manifold pressure and compares this with the value provided by the intake

manifold pressure sensor to determine if there is any significant difference which may indicate a fault.

Figure 1 shows a diagrammatic figure of a turbocharged engine system 1 with typical engine instrumentation. Figure 3 is identical to figure 1 but also shows parameters at various points. These figures will be described together. Air flowing into the engine 2 passes through an air filter 3 and an air mass flow sensor (AMF) 4, before it is compressed by compressor 5. The compressor inlet pressure is hereinafter referenced as P0 and the outlet pressure as P1. The compressor (or turbine to which it is connected) typically includes a turbo speed sensor 10. The compressed air may pass through an intercooler 6 and a throttle valve 7, before being supplied to the engine cylinders. The exhaust gases are passed through turbine 8 of the turbocharger system. An Engine Control Unit (ECU) 9 controls the operation of the engine and turbocharged systems and may be used to implement examples. An inlet manifold pressure sensor 11 is shown. It is this sensor which is require to operate reliably and accurately. An ambient pressure sensor may be used to give information to the ECU.

A compressor map is shown in figure 2 and shows a relationship between the pressure ratio across the compressor ($P1/P0$) and air mass flow for different turbo speeds. It would be clear to the skilled person as to how such a relationship may be determined and how the characteristics may be stored, for example, in an ECU as a stored map.

In a simple embodiment, the measured values of the air mass flow (AMF) and the turbo speed (ω) are used to determine the pressure ratio ($P1/P0$). The pressure ratio

is then used together with an estimate or measurement of the compressor inlet pressure P_0 , to provide an estimate of the compressor outlet (boost) pressure P_1 . The compressor outlet pressure P_1 may then be compared with the value from a pressure sensor located between the compressor outlet and the intake manifold to
5 determine the operational functionality of such a pressure sensor to see e.g. if it has a fault. In an example is the difference between the determined (estimated) pressure at a location downstream of the compressor (e.g. boost pressure or engine inlet manifold) is greater than a threshold, a fault is indicated in the pressure sensor.

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In a simple embodiment the compressor inlet pressure may be taken to be ambient pressure. This ambient pressure may be measured or assumed.

15

In a preferred embodiment the compressor inlet pressure may be estimated to be said assumed or measured ambient pressure, minus any measured or estimated pressure losses across the air filter and/or air mass flow sensor, ΔP_1 , see figure 3.

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In a further preferred embodiment, the pressure at the intake manifold (boost pressure) or any point between the compressor outlet and the intake manifold may be may be determined from the calculated compressor outlet pressure minus any pressure losses across components located therebetween, such as the intercooler and/or throttle valve ΔP_2 , see figure 3

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So in other words in a simple embodiment the compressor outlet (boost) pressure is taken to be the inlet manifold pressure. However in systems where there is an intercooler, the inlet manifold pressure may be determined based on the estimated compressor outlet pressure minus an estimated pressure drop over the intercooler

– thus pressure into the engine can be determined from the calculated compressor outlet pressure and any the pressure drop across the throttle valve and/or the intercooler to estimate the intake manifold (boost) pressure.

- 5 The inlet pressure to the compressor may be estimated as ambient. The ambient pressure may be provided by an ambient pressure sensor or a compressor inlet pressure sensor. Thus the calculated compressor inlet pressure and the modelled pressure ratio it is possible to estimate the boost pressure.
- 10 Thus the examples provide a method of estimating the pressure at a point between the compressor outlet and the intake manifold. Once this estimated pressure has been determined, it can be compared with values provided from a pressure sensor equivalently located between the compressor outlet and the intake manifold to see if such a pressure sensor is working properly. In further embodiments, the
- 15 difference between the pressure value from the sensor and that estimated may be compared with a threshold value, and a fault flagged or indicated if this difference is above a pre-set of variable threshold value.

Comparing the estimated intake manifold pressure against the measured intake

20 manifold pressure provides an intake manifold pressure plausibility test. One algorithm used to estimate the intake manifold pressure sensor can be seen in figure 4.

Inputs Air Mass Flow and Turbo Speed are measured and input into the

25 compressor map function 20 which relates the parameters of figure 2. The output is provides a value of the compressor ratio. The measured, estimated or assumed compressor intake pressure is used with the ratio at block 21 to determine/estimate

the compressor outlet (boost) pressure. The estimated or measured pressure drop across the throttle valve/intercooler is subtracted from the estimated compressor outlet (boost) pressure at block 22 to give the estimated value of intake manifold pressure. This value is then subtracted from the value measured by an inlet
5 manifold pressure sensor at block 23 and the modulus of this difference determined at 24, and then this difference is then compared with a threshold at block 25. If this difference is more than a pre-set threshold then a fault in the sensor is flagged at 26.

Claims

1. A method of determining the pressure P_p at a point from the compressor outlet to the intake manifold of a turbocharged engine system comprising:
 - 5 a) providing a relationship between the turbo speed ($\dot{\omega}$), compressor pressure ratio (P_1/P_0) and air mass flow (AMF) ;
 - b) measuring the turbo speed ($\dot{\omega}$) ;
 - c) measuring or estimating the compressor inlet pressure, P_0 ;
 - d) measuring the air mass flow (AMF);
 - 10 e) determining the pressure P_p from the parameters of steps b) c) and d) using said relationship.
2. A method as claimed in claim 1 wherein in step b) the compressor inlet pressure is determined or estimated from measured or assumed ambient pressure.
15
3. A method as claimed in claims 1 or 2 wherein the compressor inlet pressure is based on the measured or assumed ambient pressure minus any estimated or measured pressure losses across an air filter and/or flow sensors upstream of said compressor.
20
4. A method as claimed in claim 1 wherein step e) determines the compressor outlet pressure P_1 .
- 25 5. A method as claimed in claim 1 wherein the pressure P_p at a point between said compressor and intake manifold is determined to be said determined pressure

P1 minus any estimated or measured losses across components located between said point and said compressor outlet.

6. A method of determining the operational functionality of a pressure sensor
5 located downstream of the compressor outlet to the intake manifold of a turbocharged engine comprising determining the pressure P_p at a point between the compressor and intake manifold using any method of claims 1 to 5, and comparing this to the value of pressure provided by said sensor, and indicating a fault if the difference between said pressure is greater than a threshold.

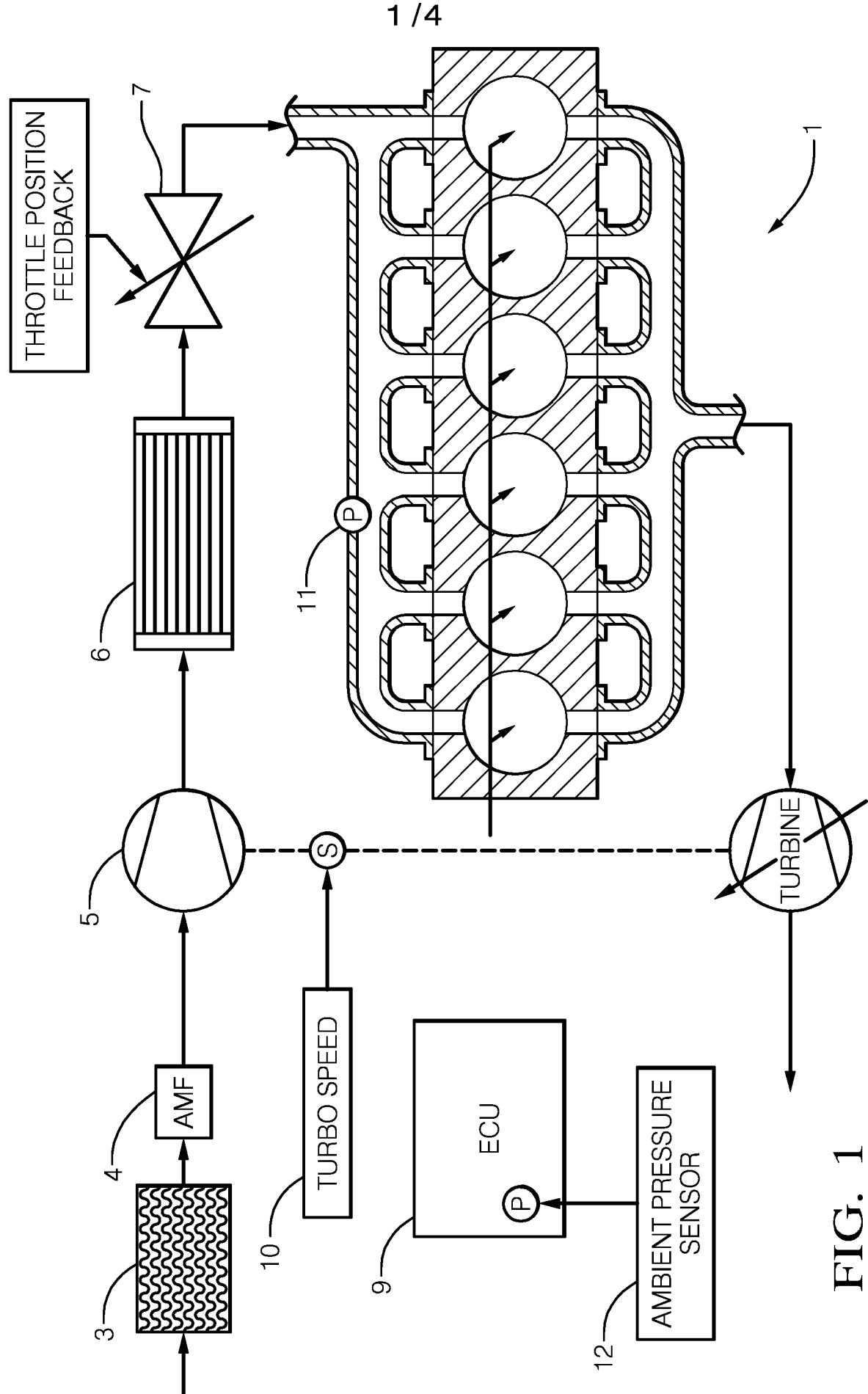


FIG. 1

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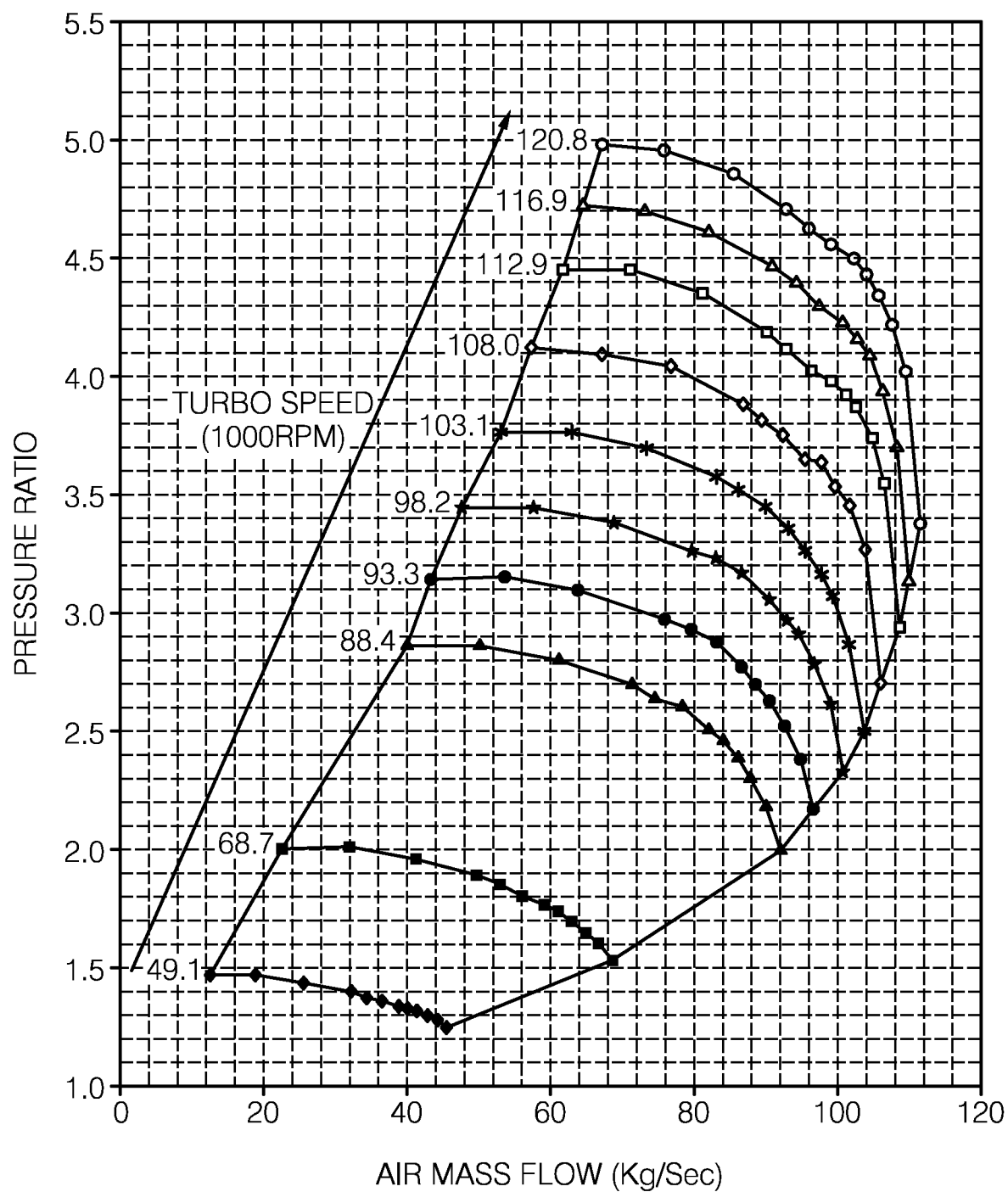


FIG. 2

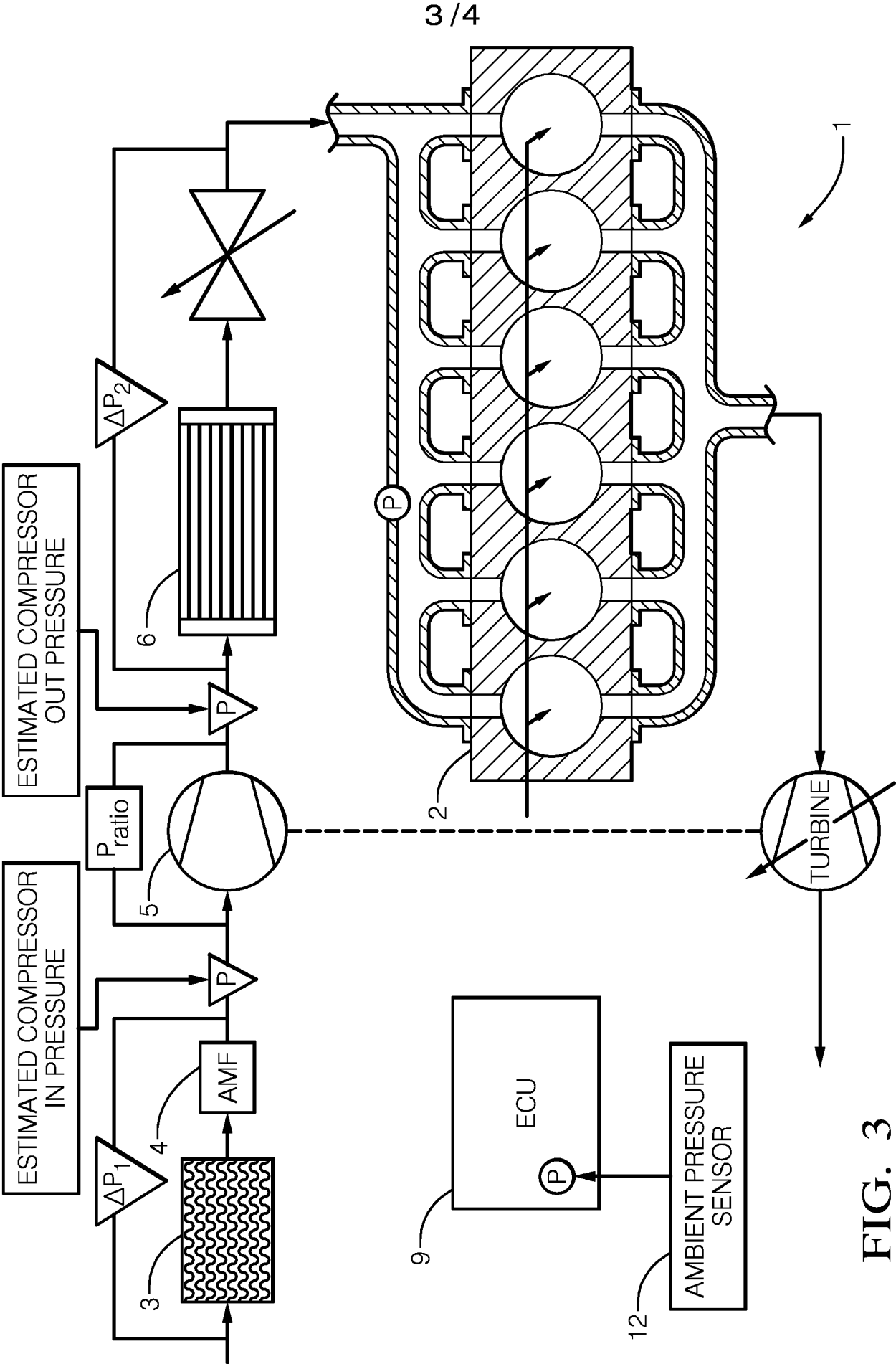


FIG. 3

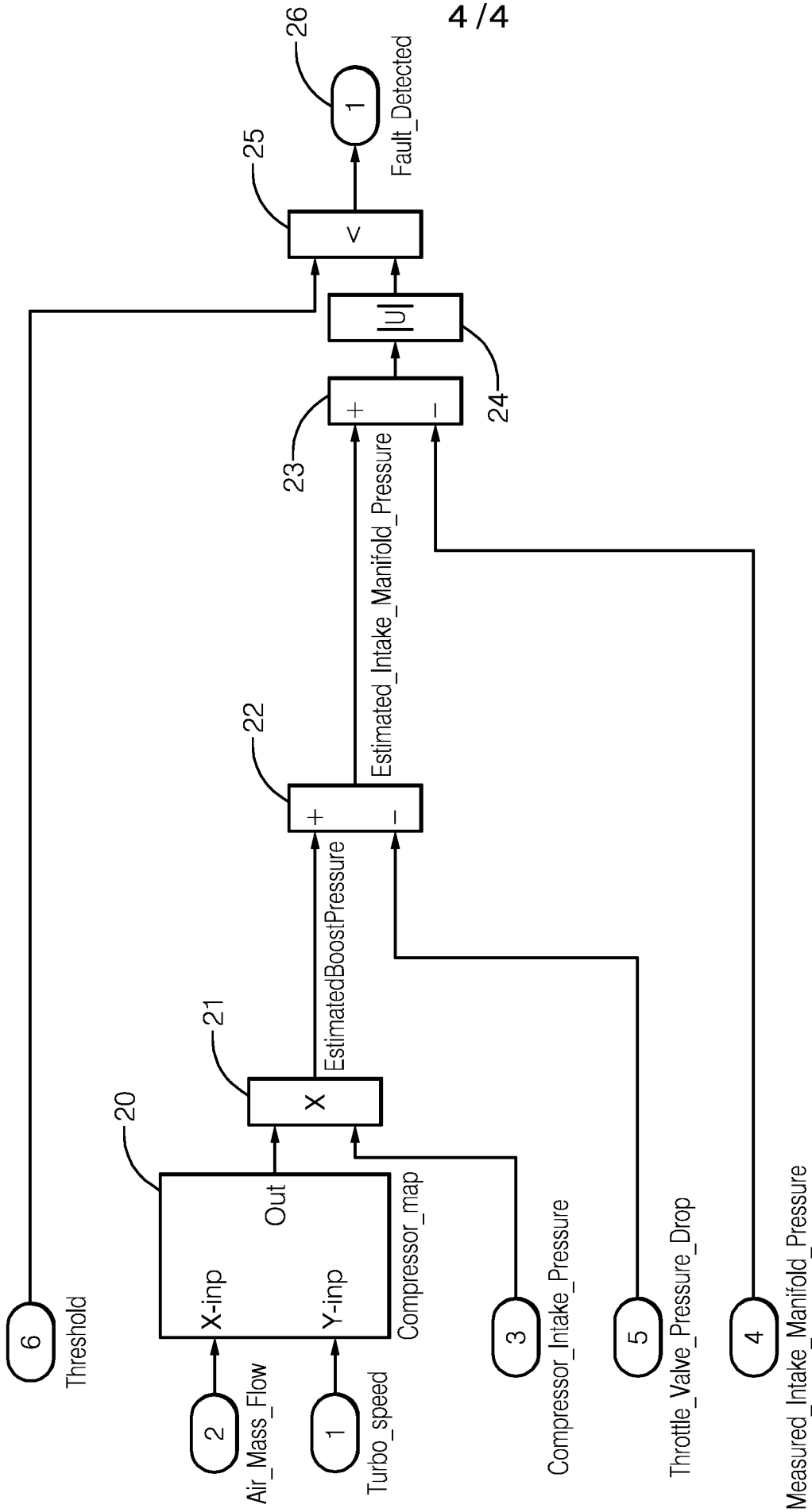


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/059899

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02D41/22 F02D41/00
ADD. F02D41/14

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)
F02D

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 936 161 A2 (BOSCH GMBH ROBERT [DE]) 25 June 2008 (2008-06-25) paragraphs [0021] - [0030] -----	1-6
X	WO 93/12332 A1 (CATERPILLAR INC [US]) 24 June 1993 (1993-06-24) page 19, line 8 - page 20, line 11 figure 7 -----	1,4,5
X	WO 01/29386 A1 (BOSCH GMBH ROBERT [DE]; BAEUEERLE MICHAEL [DE]; RIES MUELLER KLAUS [DE]) 26 April 2001 (2001-04-26) claims 1, 8 page 2, line 1 - page 3, line 6 figure 2 -----	1-6



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

7 July 2015

Date of mailing of the international search report

14/07/2015

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/059899

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