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**Published**:

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

(54) Title: INTAKE PRESSURE SENSOR INSTALLATION METHOD

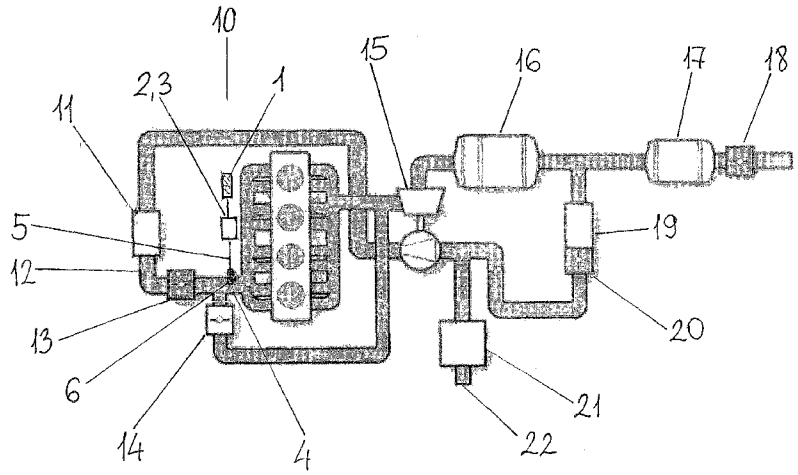


FIG. 1

(57) Abstract: The invention refers to diesel and gas internal combustion engines with turbo charger. The method of the intake pressure sensor (1) in the intake collector of internal combustion engines on the pipe (4) of the intake system, which delivers the compressed in the turbo charger and cooled in the intermediate cooler air into the engine. According to the invention, the intake pressure sensor (1) on intake collector is placed on pipe (4) of the intake system through the connection pipe (5), connected to the terminal (6) on the pipe (4), wherein in the connection pipe (5) the filter (2) is placed upstream the sensor (1). Filter (2) prevents dirt entering from pipe (4) of the intake system to the sensory element, which allows the sensor (1) to measure more accurately the air pressure at the inlet and optimizes the engine operation control.

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# Intake pressure sensor installation method

The subject of the invention is a method for self-cleaning facilitate of diesel and gas internal combustion engines with turbo charger, with the help of which the harmful effects of the exhaust gas recycled into the internal combustion engines and the inadequate operation caused by the deposits are eliminated, and the blockages of filters in the exhaust system are prevented. In this way the operation of the engines becomes more even, the combustion parameters of the fuel are improved, the life span of the engine is increased, and the need for maintenance is reduced.

he engines of the state of art motor vehicles (Euro 4,5,6, etc. standards) are provided with a number of supplementary parts, which are installed in order to comply with the environmental regulations. The so called EGR valve serves this purpose too, with the help of which a part of the recycled exhausts gas reduces the emission of polluting substances.

The operation of such engines are monitored by sensors providing measuring data continuously to the control unit of the engine, following the load and warming of the engine. The sensors installed in the factory are in oily and humid environment as a consequence of the engine operation, therefore, the data measured/transmitted by these sensors tend to vary depending on their contaminating. One of such sensors is the MAP (Manifold Absolute Pressure) sensor, which is connected to the so called Cooler pipe that carries the cooled and pressurised air in turbocharged diesel engines, which has a terminal at the MAP sensor, into which the MAP sensor is connected. After a while, the running of the engine, as well as the efficiency of the combustion becomes uneven. It is desirable to ensure that these sensors operate accurately.

A deposit is formed in the intake manifold, the oil and soot in the air of the manifold precipitates at a number of locations, e.g. at the intake manifold, at the flap valve, at the

intake length adjusting plates, and the sensors included in these parts provide false correction signal to the electronic controller, thus changing the operation of the engine in an inadequate way, on the basis of which the control takes places differently relative to the original intention. As a result, a premature deposit occurs in the filters of the exhaust system (catalytic converter, particulate filter), and even the full blockage of these components could occur. The engine initiates a regenerating process when this is detected, which increases the fuel consumption significantly.

The greatest problem is related to the location of the MAP system, although the differently shaped turbochargers provide continuous air flow with constant pressure for the operation of the engine, but the air congested and waiting in the intake manifold before entering the engine exhibits a significantly pulsating pressure (where the MAP sensor is located, which is always between the intercooler and the engine), and as a result, the values measured by the sensor pulsate also. If this pulsating value is measured with attenuation but without influencing its extent before transmitting it to the control unit, then it will ensure a much more accurately controlled operation, including a more accurate feeding of fuel, thus increasing the efficiency and power of the engine, ensuring a more economically efficient operation, a less noisy engine and a reduced emission of polluting substances.

The protection of the environment is always a desirable goal, but these supplementary accessories (soot filter, EGR /exhaust gas recirculation/ system, the many sensors, signal transmitters, etc.) work together with engine control (ECU, Engine Control Unit) in a complicated and delicate equilibrium state. It is not the mechanical condition of the engine, which is relevant here, but the measured and regulated values.

According to the state of art, the HU 704/90 patent description makes known a device for removing particles from the exhaust gas and fumes, which is suitable for reducing the particle content of exhaust gases and fumes produced when the crude oil derivatives are combusted. The essence of the solution described in this patent is that in the equipment a high-voltage generator serving the electrostatic separation of the particles and equipment for the components used for destroying the collected particles are

combined, and in which the latter equipment consists of at least one pair of conductors for the electrostatic separation of particles while the exhaust gases flow between the conductors, and the said conductors are connected to the appropriate poles of the mentioned generator, and the said separation system established in this manner is installed in the exhaust pipe or in the pipe carrying the fumes.

The HU 5460/89 patent description makes known a procedure and means for testing the intake and exhaust system of internal combustion engines.

The validated European patent E011355 makes knows a filter element that can be applied in the filters serving the separation of particles from the exhaust gases of internal combustion engines.

The patent application P9502382 makes knows a heat sink installed in the noise controlling exhaust drum, a continuously operating soot filter and catalytic converter for neutralizing the pollutant substances of internal combustion engines.

The KR100298748 patent description makes known engine of electronic control type.

The US2012/0116646 patent description makes knownmethod for compensating for valve lift deviation between engines equipped with cvvl mechanism.

The US2014/0130495 patent description makes known method for operating an internal combustion engine having high pressure and low pressure exhaust gas recirculation.

The purpose of the invention:

- Increasing the operating reliability of the engine.
- Preventing and eventually eliminating the blockage of the particulate filter.
- Reducing the extra consumption potentially caused by the blockage.
- Reducing the maintenance costs of the motor vehicle.

Fresh air flows into the combustion chamber through the intake valve during the operation of the internal combustion engine, and this air gets hot as compressed, the fuel is injected into this hot air, the ignition point of which is less then the temperature of the air, thus the fuel burns, moves the piston downwards, rotates the crankshaft, thus completing the work stroke, then the combustion products are discharged through the exhaust valve, and the process continues this manner.

One of the important features is the air to fuel mixing ratio, if the quantity of air is too small relative to the fuel, then black smoke tends to leave the engine, which is a combination of partially burned and unburned fuel. This forms the soot which should be reduced to a minimum quantity according to the EU standards, and this is what causes the soot filter to block, if too high quantity of soot is present. The other important factor is the extent of thermal value, because harmful other thypes of gases could emerge if the thermal value is too high. This is generally maintained at a certain level by mixing exhaust gas to the intake air, thus reducing the thermal value. This is the so called EGR system.

The false error indication and the inadequate regeneration is caused by a complicated phenomenon, where a significant deposit of soot is produced by the recycled exhaust gas mixed with the oil mist present continuously at the intake side (the crankcase gas is an intrinsic side-product of the engine, which is also returned to the intake side for environmental reason). Deposit occurs also on the sensor. The sensors send false values to the ECU, on the basis of which the ECU makes wrong decisions. This leads to the downwards spiralling, making the operation less appropriate, as a result of which the controller start a regeneration process. The continuously working regeneration of soot filter (causing extra fuel consumption, or in a worst case the failure of piece part) tends to limit the power, causes continuous error induction, or an engine failure in extreme cases.

Yet another phenomenon occurring is the gas fluctuation in the intake and exhaust system of the engine, where the gases do not flow steadily, but with pulses as a consequence of the operating principle of the engine. The values that can be measured

at the signal transmitter form a wavy line if plotted (see the attached drawings), the motor controller considers the upper value, although the actual value (average) is lower, therefore, the measured pressure in the intake pipe is over the real value, the controller feeds more fuel, the combustion becomes inadequate, soot is formed and blockage occurs. This phenomenon also contributes to the creation of the downward spiral, because the controlling takes place at a wrong value. The process of deposition is enhanced greatly if the vehicle is used in urban environment.

During the development of the invention the recognition was that contamination of the sensor of pressure in the intake pipe during operation at the present position can be eliminated and their accuracy of measurement can be guaranteed with the solution according to the invention, if the sensor of the pressure of intake pipe is removed from the place where installed in the factory, and a terminal is formed here, to which the sensor of pressure of intake pipe is connected via a pipe and in the given case a filter and a buffer tank.

In consideration of the above facts, the solution tried and tested by us essentially remedies these problems in a comprehensive way, if one of the most important signal transmitters, the sensor of pressure in the intake pipe is separated from the part of the intake pipe which is exposed to oil mist and fluctuation of pressure, and a combined oil filter, equalising (buffer) unit is installed between them. The structural and electronic unit of the engine is left in its original condition. By refining the measured values of the engine, while not changing its control values, the engine control unit performs a more balanced operation. In this way the efficiency of the engine is improved. The essential function of this unit is to keep the sensor of the intake manifold clean, to minimize the gas pressure fluctuation, thus ensuring a more efficient operation of the engine.

The invention is a method for self-cleaning facilitate of diesel and gas internal combustion engines with turbo charger, which is characterized by that, for placing the intake pressure sensor an outlet connecting pipe is attached to the pipe serving for the delivery of cooled and pressurized air in turbocharged diesel engines - to the terminal, which is otherwise made available by the factory at the intake pressure sensor, in which

the intake pressure sensor is screwed in by the factory - and a filter is put on this pipe, and after that the intake pressure sensor is connected with a similar outlet connecting pipe.

In a preferred application of the solution according to the invention an equalizer buffer tank is placed upstream to the intake pressure sensor for the purpose of smoothing the extensive pressure fluctuation in the connecting pipe that has been attached in this way, which averages the fluctuating pressure emerging as a result of the operation of the engine, and smoothes the pressure fluctuation, as a result of which the intake pressure sensor receives this equalized pressure, for which the turbine makes the regulation, and this will be an intermediate equivalent value, making the operation of the engine more balanced, allowing a better combustion and a reduced deposition of soot.

In another preferred application of the solution according to the invention the equalizer buffer tank placed upstream to the intake pressure sensor, functions also as a filter, is created as a unit.

In a further preferred application of the solution according to the invention the material of the outlet connecting pipe (5) attached to the pipe (4) that delivers the cooled and pressurised air, does not differ from the materials generally used in the automotive industry, in the given case it is heat resistant plastic or rubber generally used in engines.

In a further preferred application of the solution according to the invention the size and filtering capability of the used filter (2) and the equalizing buffer tank (3) are matched proportionally to the size of the installed turbine and to the volume of the pipe (4) delivering the cooled and pressurized air.

The solution according to the invention is furthermore set forth by the enclosed drawings:

Fig. 1 shows the schematic diagram of the cooled exhaust gas recycling (EGR) system used in diesel engines, together with the intake pressure sensor 1 and filter 2 relocated according to the invention.

Fig. 2 shows the charging pressure P in the function of the engine speed f at its original value, as well as after it has been corrected with the solution according to the invention. Fig. 3 shows the fluctuation of pressure P of the gas being within the intake pipe in the function of the engine speed f at its original value, as well as after it has been corrected with the solution according to the invention.

Fig. 1 shows the schematic diagram of the cooled exhaust gas recycling (EGR) system used in diesel engines, together with the intake pressure sensor 1 and filter 2 relocated according to the invention. In Fig. 1 it is possible to see the intake pressure sensor 1, the filter 2, the equalizer buffer tank 3, the pipe 4 delivering the cooled and pressurized air, as well as the outlet/connecting pipe 5 and the terminal 6. The figure also shows the further components of the cooled exhaust gas recycling system 10, the charging air filter 11, intake pipe 12, choke valve 13, flap valve 14, turbocharger 15, oxidation catalytic converter and particulate filter 16, the NOx catalytic converter 17, the exhaust choke valve 18, as well as the EGR cooler 19, the valve 20, the air mass meter 21 and the air inlet 22.

As can be seen in the figure, the intake pressure sensor user for detecting the condition of the exhaust gas of turbocharged diesel engines is relocated from the environment affected by soot and oil mist to an environment which is free from oil and soot, using the method according to the invention. In line with the solution according to the invention an outlet connecting pipe 5 is mounted on a pipe 4 carrying the cooled and pressurised air used in the turbocharged diesel engines for installing the intake pressure sensor 1 - on the said pipe carrying the cooled and pressurized air a terminal 6 is mounted at the intake pressure sensor 1, in which otherwise the intake pressure sensor 1 is screwed in by the factory - and a filter 2 is placed on that outlet connecting pipe, and after that a similar outlet connecting pipe 5 is used to connect the intake pressure sensor 1. As a result of this arrangement, the filter 2 catches the contamination, but then the pressure will be measured accurately by the intake pressure sensor 1, consequently, the regulation of the operation of the diesel engine will be more accurate, and the value measured by the intake pressure sensor 1 will be precise, while the soot will deposit in

the engine with a much less rate, and the system will not deliver air quantities exceeding the demanded quantity.

An equalizing buffer tank 3 is installed upstream to the intake pressure sensor 1 for the purpose of smoothing the extensive pressure fluctuation in the outlet connecting pipe 5 mounted in this manner, which averages the fluctuating pressure emerging as a result of the engine operation, and smoothes the pressure fluctuation, as a result of which the intake pressure sensor 1 receives this equalized pressure, upon which the regulation of the turbine is based, and this will be an intermediate equivalent value, therefore, the running of the engine becomes more responsive, making the combustion more efficient and allowing even less deposits.

In case of a preferred application shown in the figure, the equalizing buffer tank 3 installed upstream to the intake pressure sensor 1 works also as a filter 2, both being built together as a unit, in the given case it could be a simple fuel filter, which performs both functions simultaneously.

Fig. 2 shows the charging pressure P in the function of the engine speed f at its original value, as well as after it has been corrected with the solution according to the invention. The original value of the charging pressure PT1 is marked in the figure together with its corrected value PT2, which is evidently higher than the original value. This leads to a better operation of the engine.

Fig. 3 shows the fluctuation of pressure P of the gas being within the intake pipe in the function of the engine speed f at its original value, as well as after it has been corrected with the solution according to the invention. The original value of the intake pipe pressure PSZ1 is marked in the figure together with its corrected value PSZ2, which is evidently more even than the original value. This also contributes to the better, more balanced operation of the engine.

In case of a preferred application of the solution according to the invention, the inlet pressure sensor is routed out of the contaminated environment, and is installed after a

combined suitable sized tank and filter, which are installed subsequently for this purpose at the "metered" side. In this way, the engine is provided with air even at the "lower" speed ranges, where the air quantity was earlier just sufficient or less than sufficient in disadvantageous cases. In this way the utilization efficiency of the extensively recycled exhaust gas at idle speed is improved primarily. In the flushing phase the available excess air flows to the backburner (catalytic converter, particulate filter) located in the exhaust pipe, as a result of which the air facilitates their operation also at low speed. The sensor is routed to a terminal, and the charging air delivered to it is filtered and buffered, as a result of which the intake air pressure sensor always sends accurate values. In this way, the engine controller unit always receives appropriate value. In this air flow the pressure of the charging air is an excessively pulsating value (there are surge pressure caused by the operation of the engine), - which are smoothed by a buffer tank.

The part corresponding to the invention is in the same branch as the filter. As a result, the sensor and the tank are always clean, it can provide consistent signals, and the regulating unit ensures a much more sophisticated operation based on the signals provided by the sensor. The varying geometry of the turbocharger is forced to react earlier, so a better air-fuel ratio is established in the combustion chamber at lower speed range. All parts are kept in the original condition provided by the factory when the sensor is relocated.

There is a special turbine (VTG) in the turbocharged internal combustion engines, in which the efficiency of the turbine can be controlled by varying the angle of the blades (VTG - Variable Turbine Geometry), which has this beneficial influence in all the internal combustion engines working with turbocharger and afterburner. With the help of the solution according to the invention it is possible to intervene in the control of this geometry.

In case of an actual application of the solution according to the invention the charging pressure is detected by a sensor, i.e. the intake air pressure sensor, which is installed by the factory in the charging air pipe. This is a pressure sensor, the so called MAP sensor.

In most of the motor vehicles manufactured and distributed so far, the intake air pressure sensor is located in an environment affected by soot and oil mist. As the intake air pressure sensor becomes dirty, the regulating value transmitted to the engine control gets distorted, which is otherwise a heavily pulsating pressure value. The solution according to the invention eliminates this deficiency.

There is a connecting point, in the given case a terminal at the intake air pressure sensor 1 on the pipe 4 carrying the cooled and pressurized air - which is the pipe of cooled and pressurized air - in which the intake air pressure sensor 1 is installed by the factory. A pipe is connected to this terminal according to the invention, which could be a regularly used pipe, and a filter 2, as well as an equalizer buffer tank 3 is mounted on this pipe. The intake air pressure sensor 1 is connected to this. As a result, the filter 2 catches the contamination, the equalizer buffer tank 3 attenuates, smoothes the pressure fluctuations, but the intake air pressure sensor measures the pressure accurately. This makes the regulations accurate and the measured value precise. Soot deposits in the engine with a much lower rate, and the engine does not carry extra air quantity.

In case of a further preferred application and embodiment the connecting pipe 5 itself is designed in a manner that it can absorb the fluctuations, the pressure variation. In this case the material of the pipe can be resilient plastic, or the pipe is designed in a way, e.g. with helix or spiral shape, that absorbs the fluctuations by the varying volume of the pipe. In the present case this embodiment realize the buffer tank 3, or it causes the effect, which is realized by the buffer tank 3.

The advantages of the solution according to the invention are as follows:
As a result of the solution according to the invention the filter catches the contamination, but after that the pressure is measured accurately by the intake air pressure sensor, as a result of which the regulation of the engine operation becomes accurate, the value measured by the intake air pressure sensor will be precise, soot deposits in the engine with a much lower rate, and the engine does not carry more air than necessary.

No contamination occurs during operation at the intake air pressure sensors used for checking the pressure of the charging air circle of internal combustion engines, the measured pressure value does not pulsate, as a result of which the intake air pressure sensor transmits much more uniform signals to the controlling electrical unit, and this makes the running of the engine more balanced, while the combustion parameters are improved, the consumption decreases, the life span of the engine increases, and the demand for maintenance is reduced.

An additional benefit of the system is that the motor vehicle accelerates more effectively at lower speed range because of the sufficient quantity of air. This is the result of the signal of the transmitter that follows the intake air pressure because of the buffer tank, thus a sufficient quantity of air (boost pressure) is delivered to the combustion chamber at the actual critical accelerating phase, where the smoke generation causes problem. These pressure conditions are shown in the attached drawings.

Further advantage is that no structural modification is necessary, the convenient relocation of existing parts and sensors ensures an improved operation of the turbine. The regulating value of the sensor - engine controller is not changed. The efficiency of combustion is also improved significantly.

Further advantage is that the life span of all secondary parts is increased, which are sensitive to the varying angular velocity, such as the double-mass flywheel, crankshaft, belt pulley, mechanical parts of the timing, engine supporting stands, transmission gear. A further advantage is that the solution according to the invention reduces the creation of nitrogen oxides and the emission of soot during the operation.

**List of references:**

1 – manifold absolute pressure sensor *(MAP sensor)*

2 – filter

3 – equalizer buffer tank

4 – pipe for carrying the cooled and pressurised air *(Cooler pipe)*

5 – outlet/connecting pipe

6 – pipe stub

10 – cooled (LP) exhaust gas recycling (EGR) system

11 – charged air intercooler

12 – intake pipe

13 – throttle valve J338

14 – EGR Solenoid N18 (Hot)

15 – turbo

16 – oxidation catalytic converter and particulate filter

17 – NOx catalytic converter

18 – Exhaust throttle valve J883

19 – EGR cooler

20 – EGR valve 2 N213 (cooled)

21 – MAF G70 mass airflow meter

22 – Air intake

PT1 - original boost pressure

PT2 - corrected boost pressure

PSZ1 - original manifold pressure

PSZ2 - corrected manifold pressure

**CLAIMS:**

1. Method for self-cleaning facilitate of diesel and gas internal combustion engines with turbo charger,

characterized by that

for placing the intake pressure sensor (1) an outlet connecting pipe (5) is attached to the pipe (4) serving for the delivery of cooled and pressurized air in turbocharged diesel engines - to the terminal (6), which is otherwise made available by the factory at the intake pressure sensor (1), in which the intake pressure sensor (1) is screwed in by the factory - and a filter (2) is put on this pipe, and after that the intake pressure sensor (1) is connected with a similar outlet connecting pipe (5).

2. Method according to claim 1, characterised by that an equalizer buffer tank (3) is placed upstream to the intake pressure sensor (1) for the purpose of smoothing the extensive pressure fluctuation in the connecting pipe (5) that has been attached in this way, which averages the fluctuating pressure emerging as a result of the operation of the engine, and smoothes the pressure fluctuation, as a result of which the intake pressure sensor (1) receives this equalized pressure, for which the turbine makes the regulation, and this will be an intermediate equivalent value, making the operation of the engine more balanced, allowing a better combustion and a reduced deposition of soot.

3. Method according to claim 1, characterised by that the equalizer buffer tank (3) placed upstream to the intake pressure sensor (1), functions also as a filter (2), is created as a unit.

4. Method according to claims 1 - 3, characterised by that the material of the outlet connecting pipe (5) attached to the pipe (4) that delivers the cooled and pressurised air, does not differ from the materials generally used in the automotive industry, in the given case it is heat resistant plastic or rubber generally used in engines.

5. Method according to claims 1 - 4, characterised by that the size and filtering capability of the used filter (2) and the equalizing buffer tank (3) are matched proportionally to the size of the installed turbine and to the volume of the pipe (4) delivering the cooled and pressurized air.

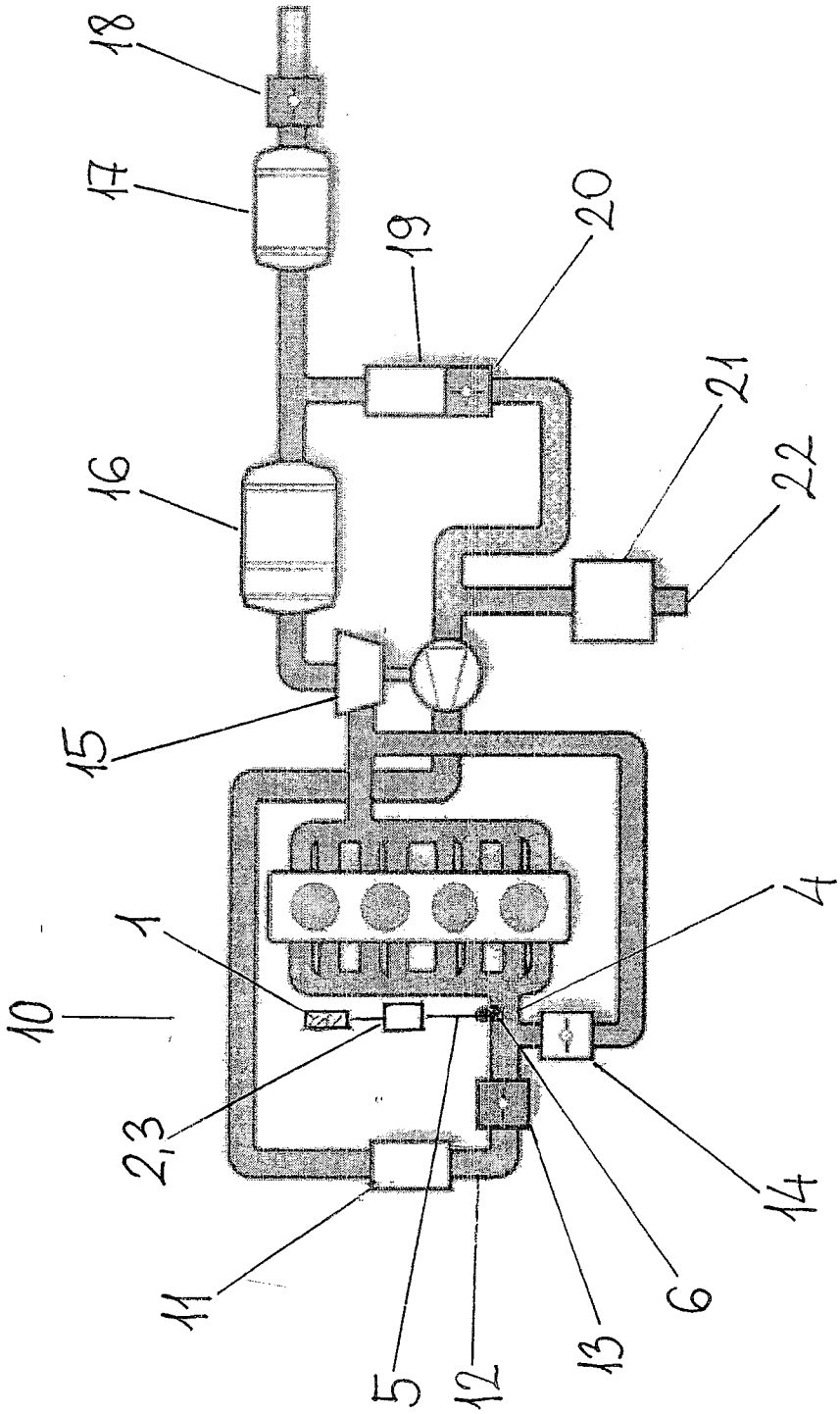


FIG. 1

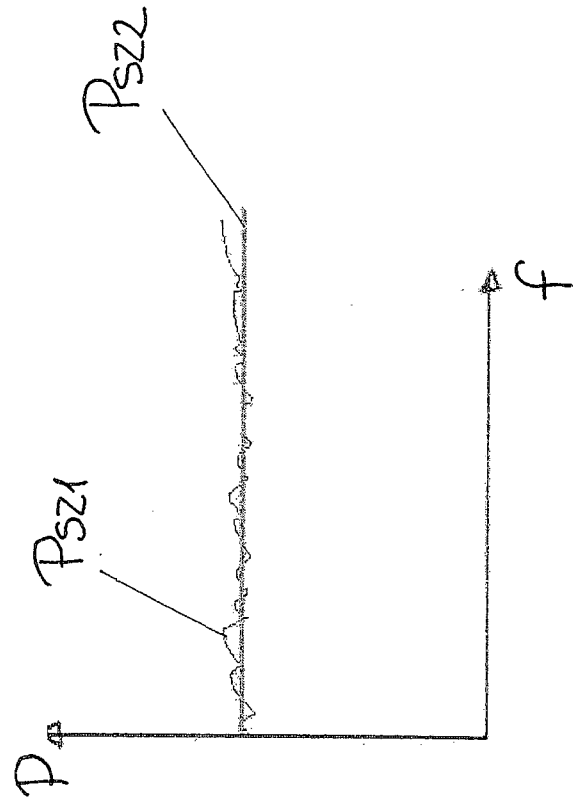


FIG. 3

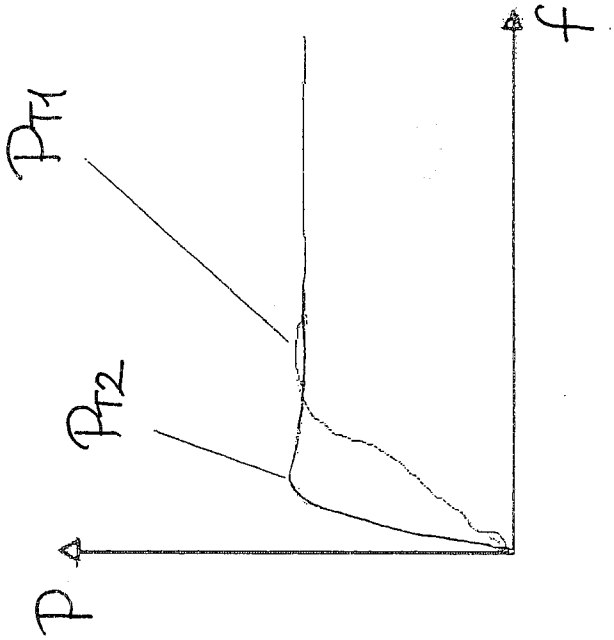


FIG. 2.

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/HU 2015/000071

A. CLASSIFICATION OF SUBJECT MATTER

***F02B 33/00*** *(2006.01)*
***F02M 67/02*** *(2006.01)*

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)

F02B 33/00, G01L 23/00, 23/24, 19/00, 19/08, F02M 67/02, 69/00, 69/48

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)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US 2009/0193904 A1 (MITSUBISHI FUSO TRUCK AND BUS CORPORATION) 06.08.2009, fig. 1, par. [0036] | 1-4 |
| Y | JPH 1037781 A (SUZUKI MOTOR CORP) 10.02.1998, fig. 24-26, abstract, par. [0004]-[0007] | 1-4 |
| Y | US 5069063 A (MARTIN CHROBACZEK et al.) 03.12.1991, fig. 2, 3, abstract | 2-4 |
| A | DE 4021915 A1 (BOSCH GMBH ROBERT) 16.01.1992 | 1-4 |
| A | JPS 5866034 A (NIPPON DENSO CO) 20.04.1983 | 1-4 |

☐ 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

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

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

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

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

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

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

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

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 02 March 2016 (02.03.2016) | 17 March 2016 (17.03.2016) |
| Name and mailing address of the ISA/RU:<br>Federal Institute of Industrial Property,<br>Berezhkovskaya nab., 30-1, Moscow, G-59,<br>GSP-3, Russia, 125993<br>Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37 | Authorized officer<br>S. Bushin<br>Telephone No. 499-240-25-91 |

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/HU 2015/000071

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 5
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.