(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 868 909 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.05.2015 Bulletin 2015/19

(51) Int Cl.:
F02M 35/10 *(2006.01)*

(21) Application number: **13464017.6**

(22) Date of filing: **01.11.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(71) Applicant: **Continental Automotive GmbH**
30165 Hannover (DE)

(72) Inventor: **Toma, Ciprian-Dan**
300715 Timisoara (RO)

(54) **Apparatus for cooling electronic components in a vehicle**

(57) With the invention an apparatus (1) is provided for actively cooling electronic components (2) in a vehicle. The apparatus (1) comprises a main air duct (4) for supplying an engine (3) of the vehicle with air, wherein the main air duct (4) receives a forced air flow via suction of the engine (3), a mass air flow sensor (6) disposed in the main air duct (4) for measuring an amount of forced air entering the engine (3) and a pipe (8) for cooling electronic components (2) with forced air, said pipe (8) being connected to the main air duct (4) and arranged upstream of the mass air flow sensor (6) .

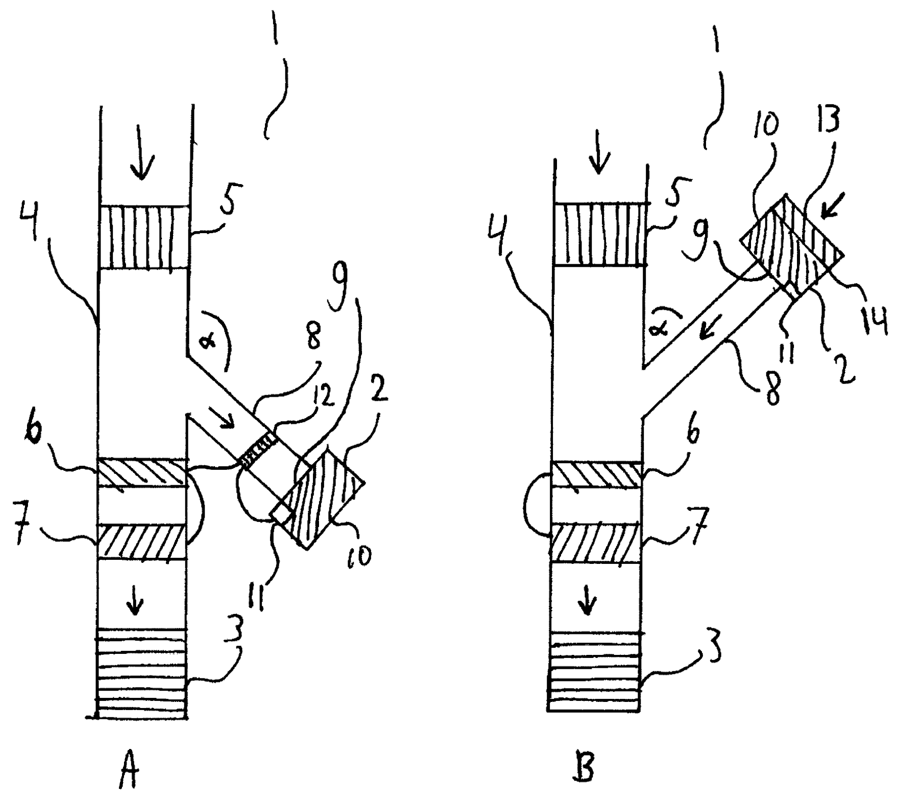

Fig. 1

EP 2 868 909 A1

Description

[0001] The invention discloses an apparatus for actively cooling an electronic component in a vehicle.

[0002] In automotive electronics an electronic control unit (ECU) is a generic term for any embedded system that controls one or more of the electronic systems or subsystems in a motor vehicle. ECUs are increasingly used in motor vehicles to perform a wide range of functions including engine control, powertrain control, brace control, suspension control, climate control, electronic stability control etc.

[0003] As the ECU deals with increasingly complex functions, it requires more processing power. In addition, an electronic control unit such as an engine control unit may comprise power electronics. As a result, the ECU consumes more electricity thereby producing unwanted heat. The maximum temperature of a regular central processing unit (CPU) usually lies at around 70°C. Above this temperature the performance and lifetime of the CPU decrease dramatically. For this reason, ECUs and CPUs may be protected by heat sinks which absorb the dissipated heat and deliver it to an ambient medium such as air or a liquid. Another way to prevent CPU overheating is to use multiple processing cores. However, data inconsistency and data incoherency between multiple cores and additional costs are problems that arise when using multiple processing cores. Another option is to provide fans for actively cooling the electronic components. However, fans comprise moving parts which limit their reliability and lifetime, especially with respect to the harsh environment in an engine compartment, i.e. high temperatures, vibrations and dust, and the lifetime of a motor vehicle which typically lies between 10-20 years. Fans also cause additional costs and a higher complexity of the system.

[0004] The present invention aims to construct a reliable and cost-efficient cooling apparatus for electronic components in a vehicle.

[0005] This object is achieved by an apparatus according to the claim 1. Further embodiments of the invention may be derived from the dependent claims, the following description and the enclosed figures.

[0006] An apparatus for actively cooling an electronic component of a vehicle is specified. The apparatus comprises a main air duct for supplying an engine of the vehicle with air. The main air duct in particular receives a forced air flow via suction of the engine. Furthermore, a mass air flow sensor is disposed in the main air duct for measuring an amount of air, i.e. in particular forced air from the main duct - entering the engine. A pipe for cooling the electronic component with forced air is connected to the main air duct and arranged upstream of the mass air flow sensor.

[0007] With advantage, the electronic component in the vehicle is cooled with a forced air flow generated by suction of the engine. Said forced air flow flows faster than natural air convection. Hence, more heat may be dissipated by the forced air flow compared to a natural air flow, for example due to natural convection.

[0008] The apparatus is particularly reliable since it does not incorporate moving parts such as fans for moving the air. Furthermore, the solution is cost-efficient as it requires only a little number of additional - and comparatively simple - parts in an existing system.

[0009] The connection of the pipe to the main air duct upstream of the mass air flow sensor enables an accurate measurement of the amount of forced air flowing to the engine. An accurate measurement of the air flowing to the engine reduces environmental pollution and decreases the risk of overcharging the engine.

[0010] In a preferred embodiment, an air filter is disposed in the main air duct or before the inlet opening of the main air duct or at an outlet opening of the main air duct for filtering the forced air before entering the engine. In this way, the engine is supplied with filtered, clean air. Preferably, the air filter is arranged upstream of the pipe and the mass air flow sensor. Hence, filtered air flows through the mass air flow sensor, too. In this way the measurement of the mass air flow by the mass air flow sensor may be more precise.

[0011] In a further development, a valve is disposed in the pipe for regulating an amount of forced air flowing through the pipe. The valve may be operable to close, partially close or open the pipe in dependence on the valve position.

[0012] A temperature sensor may be disposed at the electronic components to be cooled. The valve may be controlled depending on a temperature measured by the temperature sensor. The temperature sensor may be connected to a control device, said control device may be operable control the valve. Preferably, the temperature sensor and the control device are a thermostat.

[0013] When the electronic components are sufficiently cold, it may be unnecessary to cool them with forced air, for instance in case of the vehicle being exposed to cold weather. In case the temperature of ambient air is below 0°C it may even be unfavourable to provide the electronic components with cold air. Some electronic components do not function well at low temperatures; in addition, some components may freeze over. Preferably, a signal sent by the thermostat may close the valve in case a temperature of the electronic components falls below a preset temperature. As a result, the entire forced air flow may flow towards the engine. Thus, with a closed valve in the pipe the engine may receive a maximum of forced air. This may be also advantageously used to alleviate the so-called turbo lag effect in turbocharged engines. A closed valve in the pipe may also be beneficial at ignition of a cold engine or when the vehicle accelerates. However, when the temperature of the electronic components reaches a predetermined value e.g. 50°C or more, a signal of the control device may open or partially open the valve to cool the electronic components down with forced air.

[0014] In a further development, the mass air flow sensor may also be operable to control the valve, thereby in particular ensuring a sufficient amount of forced air entering the engine. As described above it may be beneficial to provide the engine with a maximum of forced air. The air mass flow sensor directly measures the amount of forced air flowing towards the engine. In case the amount of air is not sufficient for optimal driving conditions and the temperature of the electronic components is not so high that overheating of the components may occur, the valve disposed in the pipe may be closed or partially closed. In a preferred embodiment, the control device and the mass air flow sensor interact in order to control the valve and to provide both the engine and the electronic components with a sufficient amount of forced air.

[0015] A throttle may be disposed in the main air duct for regulating the amount of forced air entering the engine. Preferably, the throttle is disposed downstream of the mass air flow sensor. In this way, the amount of air detected by the mass air flow sensor is an accurate representation of the air flowing to the throttle. The mass air sensor may be connected to the throttle to control the degree of opening of the throttle. The throttle may be a butterfly valve.

[0016] An angle between the pipe and a part of the main air duct upstream of the pipe may be obtuse or acute. In case the angle is obtuse, the forced air flows from the main air duct through the pipe before it reaches the electronic component. In addition, when the air filter is mounted upstream of the pipe, the air flow is filtered before entering the pipe. Accordingly, the electronic component may be cooled with clean air resulting in a better performance and longer lifetime of the electronic components. A cooling nozzle may be mounted between the pipe and the electronic component. In this way, the direction and speed of the forced air flow can be controlled more precisely.

[0017] In an alternative embodiment, an angle between the pipe and a part of the main air duct upstream of the pipe is acute. Consequently, the air flow in the pipe has an opposite direction. Within this configuration forced air is transported via the electronic component into the pipe and from there into the main air duct. In this embodiment, it may be advantageous to provide an additional filter upstream of the electronic component in order to cool the electronic component with clean air. Optionally, the valve in the pipe may be omitted as the entire forced air flow enters the engine. However, in a preferred embodiment a valve controlled by a control unit is used here as well to prevent the electronic components from low temperatures as outlined above.

[0018] The electronic component may be represented by an electronic control unit (ECU) of the vehicle, in particular by an engine control unit. Furthermore, the ECU may be positioned in a housing. That the ECU is positioned in the housing in particular means that the ECU, in particular a casing of the ECU is partially or completely surrounded by the housing.

[0019] Said housing may comprise a first opening and at least one second opening for receiving and expelling or expelling and receiving forced air, depending on the angle between the pipe and the main air duct. The pipe may connect the main air duct to the first opening of the housing.

[0020] In a configuration with an obtuse angle, the first opening may be an inlet opening for receiving forced air. A cooling nozzle may be arranged at the outlet opening of the pipe and at the inlet opening of the housing to improve a direction and velocity of the air flow within the housing. Eventually, the forced air may be expelled via the at least one second opening of the housing. The at least one second opening may comprise a plurality of outlet openings.

[0021] In case the angle is acute the direction of the forced air flow is opposite. An additional air filter may then be located at the at least one second opening of the housing. The at least one second opening may comprise a plurality of inlet openings.

[0022] The ECU may feature a heat sink for passively cooling the electronic components in the ECU. The heat sink in turn may be actively cooled by the forced air flow, and may exhibit a plurality of fins.

[0023] For example, the electronic control unit has a casing with an interior in which a circuit board is arranged. Preferably, the casing comprises the heat sink. The heat sink comprises a plurality of elongated cooling fins. The cooling fins are arranged at an outer surface of the casing. For example, the cooling fins are in one piece with the casing. The cooling fins may be arranged parallel to one another with respect to the elongated direction. The housing is preferably positioned so that it covers the cooling fins. The first opening of the housing is positioned adjacent to one lateral end of the cooling fins and the at least one second opening is positioned adjacent to an opposite lateral end of the cooling fins. Said lateral ends are delimiting the cooling fins in the elongated direction. In this way, the forced air flow may be directed along the cooling fins in the elongated direction between the first and second openings, so that particularly good heat dissipation from the cooling fins is achievable by means of convection.

[0024] Further advantages and advantageous embodiments and development of the apparatus will become apparent from the exemplary embodiments which are described below in connection with the figures.

[0025] In the figures:

Figures 1A and 1B show schematic views of two embodiments of an apparatus for cooling electronic components of a vehicle, and

Figure 2 is a detailed schematic view of a cooling of an electronic control unit.

[0026] In the exemplary embodiments and figures, identical, similar or similarly acting constituent parts are provided with the same reference symbols. The elements illustrated in the figures and their size relationships among one another should not be regarded as true to scale. Rather, individual elements may be represented with an exaggerated size for the sake of better representability and/or for the sake of better understanding.

[0027] Figure 1 shows an apparatus 1 for an cooling electronic component 2 of a vehicle. An air intake manifold of an engine 3 forces air into a main air duct 4. A flow direction of the forced air is indicated by arrows. Before entering the main duct 4, the forced air is filtered through an air filter 5. A mass air flow sensor 6 is mounted in the main air duct 4 downstream of the air filter 5. Said mass air flow sensor 6 measures the amount of air flowing towards the engine 3. The air mass sensor 6 may for instance be a vane meter, a cold wire, a hot wire, a membrane sensor, laminar flow elements or a Kármán vortex sensor. A throttle 7 is disposed downstream of the air mass sensor 6 in the main air duct 4 for regulating the amount of forced air entering the engine 3. The throttle 7 is connected to the mass air flow sensor 6 and controlled thereby, and features a butterfly valve. However, other devices may be used as a throttle.

[0028] A pipe 8 for leading an amount of forced air from the main air duct 4 onto the electronic component 2 of the vehicle is located between the air filter 5 and the mass air flow sensor 6. In other word, the pipe 8 branches off from the main duct 4 between the air filter 5 and the mass air flow sensor 6. One end of the pipe 8 is connected to a portion of the main air duct 4 extending from the air filter 5 to the mass air flow sensor 6.

[0029] In the embodiment of Figure 1A, the pipe 8 receives clean air due to the arrangement of the air filter 5 upstream of the pipe 8. Therefore, the electronic components 2 are cooled with clean, filtered air. An outlet opening of the pipe 8 is connected to a first opening 9 of a housing 10 in which an electronic control unit (ECU) 2 is located. In Figure 1A the first opening 9 of the housing is an inlet opening through which the housing receives forced air. Said housing 10 will be described in more detail in Figure 2. The ECU 2 incorporates several microcontrollers bearing single or multi core central processing units (CPUs). The microcontrollers perform and control a wide range of functions within the vehicle that are not specified in detail here. The CPUs show higher clock rates compared to CPUs of ECUs not being actively cooled.

[0030] The ECU 2 further comprises a thermostat 11 which measures the temperature of the CPUs and other electronic components. The thermostat 11 and the mass air flow sensor 6 are both connected to a valve 12 which is arranged in the pipe 8. The thermostat 11 and/or the mass air flow sensor 6 control the valve 12 in order to regulate the amount of forced air entering the housing 10 as well as the engine 3. The main air duct 4 may exhibit a somewhat larger diameter than a main air duct without a pipe 8 in order to provide the cylinders of the engine 3 with a satisfactory amount of forced air.

[0031] In Figure 1A an angle α between the pipe 8 and a part of the main air duct 4 upstream of the pipe 8 is obtuse. By way of example, the value of the angle α is 130°. In other embodiments, the obtuse angle α may have any value greater than 90°. Due to the obtuse angle α pipe 8 expels the forced, clean air via the first opening 9 into the housing 10.

[0032] In the embodiment shown in Figure 1B the angle α between the pipe 8 and a part of the main air duct 4 upstream of the pipe 8 is acute. By way of example the angle α has a value of 45°. However, this acute angle α may have any value smaller than 90°.

[0033] The flow direction of the forced air within the pipe 8 of Figure 1B is opposite to the flow direction of the forced air in the pipe 8 shown in Figure 1A. The pipe 8 now receives forced air from the first opening 9 of housing 10. That is, in this case the first opening 9 is the outlet opening of the housing 10. In Figure 1B an additional filter 13 is located at a plurality of second openings 14 of the housing 10 to ensure the ECU 2 to be cooled with clean, filtered air. In this case the second openings 14 are inlet openings through which the forced air enters the housing 10. The entire forced air flow reaches the engine 3 in the embodiment shown.

[0034] Contrary to the embodiment of Figure 1A, a valve is not disposed in the pipe 8. However, in a variant of the embodiment of Fig. 1B, a valve connected to thermostat 11 may be mounted in the pipe 8, for example to protect the electronic components from freezing over during cold weather.

[0035] In Figure 2 the ECU 2 and the housing 10 are shown in more detail. The angle α between the pipe 8 and a part of the main air duct 4 upstream of the pipe 8 is obtuse in the configuration shown. The ECU 2 exhibits a plurality of elongated fins 15 that passively cool the ECU 2 and function as a heat sink. The fins 15 are comprises at an outer surface of a casing of the ECU 2. The casing encloses an interior in which a circuit board (not visible in the figures) is arranged which circuit board carries the CPUs.

[0036] The housing 15 is put over the fins 15 to cover a portion of the casing. In this way, the fins 15 are actively cooled by the forced air flow generated by suction of the engine. A cooling nozzle 16 is mounted between the pipe 8 and the first opening 9 of the housing 10. By using this cooling nozzle 16 the ECU 2 may be efficiently cooled.

[0037] In another embodiment, the cooling nozzle 16 is located above the ECU 2 in a distance of the casing and no housing is provided. The nozzle may be expediently arranged such that the forced air flows along the fins 15.

[0038] In Figure 2, the cooling nozzle 16 is located at an upper part of the housing 10, because most of the heat is produced in an upper part of the ECU 2 in the example shown. However, in other embodiments the nozzle 16 may also be arranged in the middle or a lower part of the housing 10 depending on where the majority of the heat is generated. The housing 10 shields the ECU

2 from external heat of the engine 3 as well as it assists in removing internal heat generated by the ECU 2.

[0039] The housing 10 further comprises a plurality of second openings 14. In the present embodiment, the second openings are outlet openings through which the forced air flow is expelled. One second opening may be arranged in each case between two adjacent fins 15, for example. In case the angle α between the pipe 8 and a part of the main air duct 4 upstream of the pipe 8 is acute an additional air filter 13 may be disposed at the plurality of second openings 14.

[0040] The invention is not limited to specific embodiments by the description on the basis of said exemplary embodiments but comprises any combination of elements of different embodiments. Moreover, the invention comprises any combination of claims and any combination of features disclosed by the claims.

Claims

1. Apparatus (1) for actively cooling an electronic component (2) of a vehicle, comprising

- a main air duct (4) for supplying an engine (3) of the vehicle with air, wherein the main air duct (4) receives a forced air flow via suction of the engine (3),
- a mass air flow sensor (6) disposed in the main air duct (4) for measuring an amount of forced air entering the engine (3) and
- a pipe (8) for cooling the electronic component (2) with forced air, said pipe (8) being connected to the main air duct (4) and arranged upstream of the mass air flow sensor (6).

2. Apparatus (1) according to claim 1, wherein an air filter (5) is disposed in the main air duct (4) or at an inlet opening of the main air duct or at an outlet opening of the main air duct for filtering the forced air flow before entering the engine (3).

3. Apparatus (1) according to claim 2, **characterized in that** the air filter (5) is arranged upstream of the pipe (8) and the mass air flow sensor (6).

4. Apparatus (1) according to one of the preceding claims, wherein a valve (12) is disposed in the pipe (8) for regulating an amount of forced air flowing through the pipe (8).

5. Apparatus (1) according to claim 4, **characterized by** a temperature sensor (11) disposed at the electronic component (2) to be cooled, wherein the valve is controlled depending on a temperature measured by the temperature sensor.

6. Apparatus (1) according to claim 4 or 5, wherein the mass air flow sensor (6) is operable to control the valve (12), in particular for ensuring a sufficient amount of forced air entering the engine (3).

7. Apparatus (1) according to one of the preceding claims, **characterized in that** an angle (α) between the pipe (8) and a part of the main air duct (4) upstream of the pipe (8) is an obtuse angle and the apparatus is configured for operation with an air flow from the main duct (4) into the pipe (8) to the electronic component (2)

8. Apparatus (1) according to one of claims 1 to 6, **characterized in that** an angle (α) between the pipe (8) and a part of the main air duct (4) upstream of the pipe (8) is an acute angle and the apparatus is configured for operation with an air flow from the electronic component (2) though the pipe (8) into the main duct (4).

9. Apparatus (1) according to one of the preceding claims further comprising a housing (2), wherein the electronic component (2) is positioned in the housing (10), said housing (10) having a first opening (9) and at least one second opening (14) for receiving and expelling forced air, wherein the pipe (8) connects the main air duct (4) to the first opening (9) of the housing (10).

10. Apparatus (1) according to one of the preceding claims, comprising an electronic control unit (ECU) of the vehicle which represents the actively cooled electronic component (2).

11. Apparatus (1) according claim 10, **characterized in that** the ECU comprises a heat sink (15) for cooling electronic components of the ECU (2), the heat sink (15) being actively cooled by the forced air flow.

12. Apparatus (1) according to claim 9 and one of claims 10 and 11, wherein

- the electronic control unit has a casing with an interior in which a circuit board is arranged, the casing comprising the heat sink (15),
- the heat sink comprises a plurality of elongated cooling fins at an outer surface of the casing,
- the housing (10) is positioned so that it covers the cooling fins, and
- the first opening (9) of the housing (10) is positioned adjacent to one lateral end of the cooling fins and the at least one second opening (14) is positioned adjacent to an opposite lateral end of the cooling fins.

13. Apparatus (1) according to one of the preceding claims, **characterized in that** a throttle (7) is disposed in the main air duct (4) for regulating the amount of forced air entering the engine (3).

14. Apparatus (1) according to one of the preceding claims, **characterized by** a cooling nozzle (16) mounted between the pipe (8) and the electronic component (2).

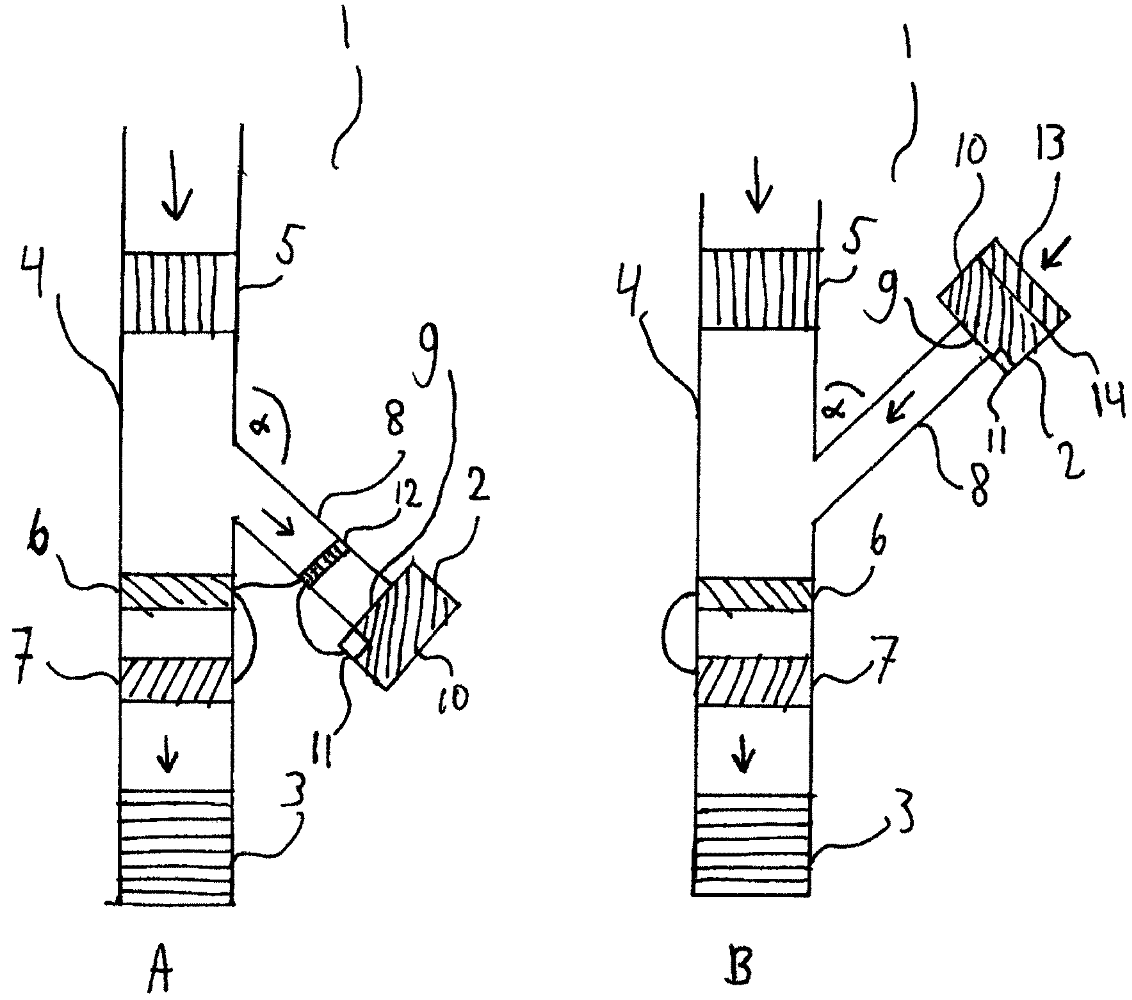

Fig. 1

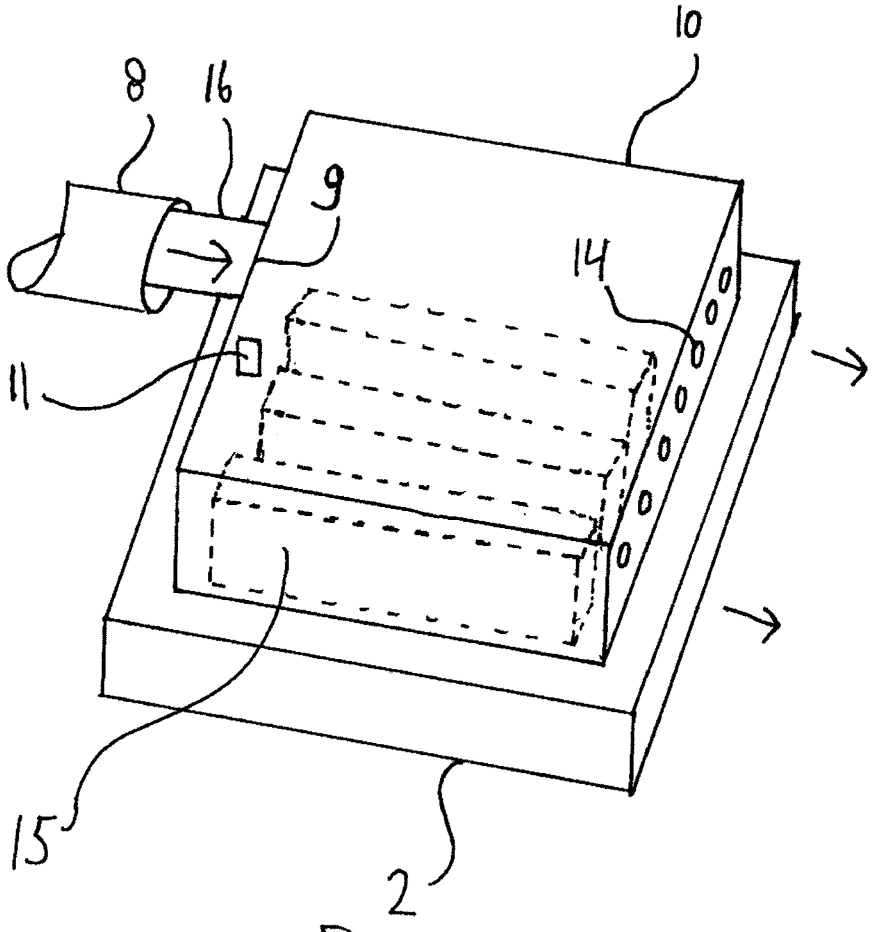

Fig. 2

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 13 46 4017

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2002/104490 A1 (ITAKURA KEISUKE [JP] ET AL) 8 August 2002 (2002-08-08) * abstract * * page 2, paragraph 28; figure 5 *	1-4,6, 8-13	INV. F02M35/10
A	DE 10 2005 057308 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 14 June 2007 (2007-06-14) * the whole document *	1	
A	DE 103 32 946 A1 (DAIMLER CHRYSLER AG [DE]) 3 February 2005 (2005-02-03) * the whole document *	1	
A	DE 44 03 219 A1 (DAIMLER BENZ AG [DE]) 10 August 1995 (1995-08-10) * the whole document *	1	
A	EP 0 997 632 A1 (ROVER GROUP [GB]) 3 May 2000 (2000-05-03) * the whole document *	1	
A	FR 2 715 972 A1 (RENAULT [FR]) 11 August 1995 (1995-08-11) * the whole document *	1	TECHNICAL FIELDS SEARCHED (IPC) F02M

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	22 April 2014	Van Zoest, Peter

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 46 4017

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

22-04-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2002104490 A1	08-08-2002	DE 10204848 A1	08-08-2002
		JP 3562474 B2	08-09-2004
		JP 2002235618 A	23-08-2002
		US 2002104490 A1	08-08-2002
DE 102005057308 A1	14-06-2007	NONE	
DE 10332946 A1	03-02-2005	NONE	
DE 4403219 A1	10-08-1995	NONE	
EP 0997632 A1	03-05-2000	EP 0997632 A1	03-05-2000
		GB 2343163 A	03-05-2000
FR 2715972 A1	11-08-1995	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82