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(71) Applicant *(for all designated States except US)*: **INERGY AUTOMOTIVE SYSTEMS RESEARCH (Société Anonyme)** [BE/BE]; Rue De Ransbeek, 310, B-1120 Brussels (BE).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **HILL, David** [US/US]; 8467 Arlis, Commerce Township, Michigan 48382 (US).

(74) Agents: **JACQUES, Philippe** et al.; SOLVAY (Société Anonyme), Intellectual Property Department Rue De, Ransbeek, 310, B-1120 Brussels (BE).

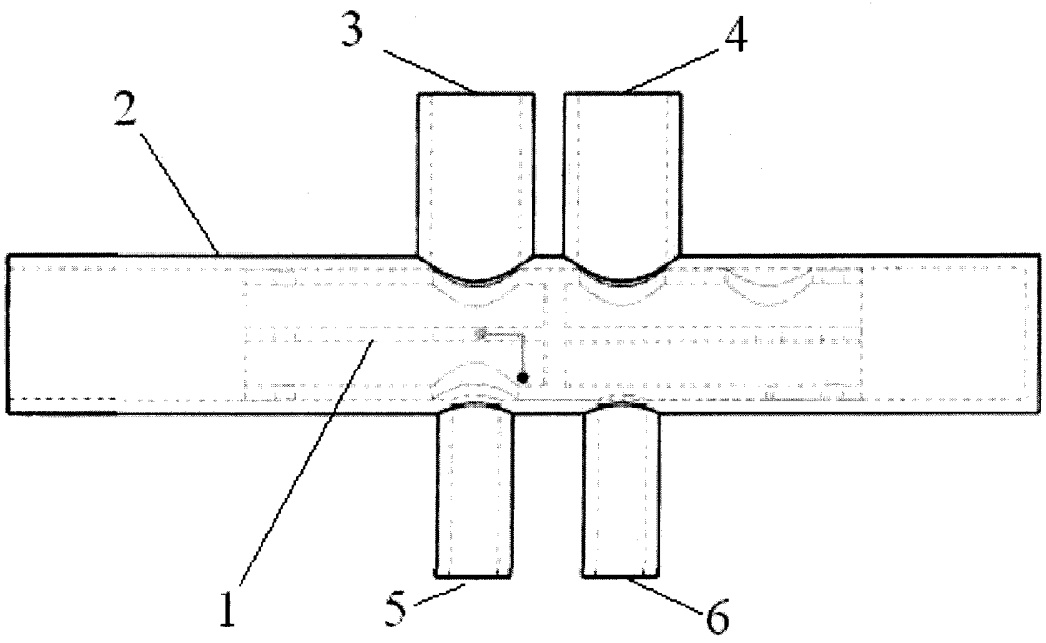
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(54) Title: ELECTRONICALLY CONTROLLED ELECTROMECHANICAL VALVE



(57) Abstract: Electronically controlled electromechanical valve having at least three ports through which a fluid can flow and at least three different stable positions in which at least 2 ports are in fluid communication, said valve comprising:- a stationary outer housing comprising at least three bores; - a translating inner section which translated about an axis and comprises adequate bores defining with the bores of the housing, the at least three ports of the valve; and - an electrical actuating system being controlled by an electronic controller and being able to switch the valve from one position to another by translating the inner section along its axis. Fuel system vapor management unit including such a valve.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Electronically controlled electromechanical valve

The present invention relates to an electronically controlled electromechanical valve and to a fuel system vapor management unit comprising such a valve.

Electronically controlled valves are well known and often used in several technical fields like automotive and aircraft engine and fuel system vapor management. Such valves usually have two or three ports. Three port valves are advantageously used instead of two separate two port valves when such valves have at least one port in common, in order to have a more compact and simple design. However, such valves usually have only 2 positions (each of them connecting 2 of the 3 ports).

For instance, US patent 6,382,191 discloses a fuel tank pressure control system which includes an electronically controlled valve assembly able to either connect the fuel tank and the canister only (for tank venting during normal operation and refueling), or the canister and the engine only (for purging and burning the fuel vapors adsorbed on the canister). This system, which closes the communication between the fuel tank and the canister when the latter is connected to the engine, prevents too rich air/fuel mixtures from entering the engine and hence, prevents unburned hydrocarbons. The valve assembly used therein can either be constituted of 2 separate 2 port valves, or of only one single 3 port valve. The choice of 2 separate 2 port valves offers the advantage of being able to selectively and progressively control the purge flow, while simply turning on and off the tank venting valve. The choice of a regular, single three port valve does not allow that feature, but offers the advantage of a compacter and simpler design.

Therefore, it is an object of the present invention to provide an electronically controlled electromechanical valve, able of controlling tank venting during normal operation and refueling, and canister purge (i.e. recovered fuel vapors entry into the engine from the canister), which valve offers a compact and simple design while allowing at least one intermediate position for having an intermediate purge flow.

Accordingly, the present invention concerns an electronically controlled electromechanical valve having at least three ports through which a fluid can flow and at least three different stable positions in which at least 2 ports are in fluid communication, said valve comprising:

- a stationary outer housing comprising at least four bores;

- a translating inner section which slides along an axis and comprises adequate bores defining with the bores of the housing, the at least three ports of the valve; and

- an electrical actuating system being controlled by an electronic controller and being able to switch the valve from one position to another by sliding the inner section along its axis.

This integrated valve is designed in an axial fashion, which allows for a simple and compact system. In addition, it allows not only the two traditional positions connecting each completely 2 of the 3 ports, but also at least an additional one, for instance allowing only partial communication between 2 of the 3 ports.

Other advantages of this integrated valve are:

- Lower Cost – This valve, which replaces 2 separate valves and associated piping system, reduces the total part count and hence, the cost of a system in which it is used.
- Quieter Product- Less noise comes from a valve that does not have to use pulse width modulation to control fluid flow, as it is the case with valves equipped with a linear solenoid actuator (the latter cycles the valve open and closed to vary the flow restriction according to the engine control unit (ECU) and this often results in undesirable noise).
- Digital Control Capability- A digitally controlled component is, in most occasions, easier to integrate into a microprocessor.

The valve according to the invention may be of any material (or combination of materials). It may be partially or totally made of metal and/or plastic(s). It preferably comprises polyacetal and may also comprise polyethylene at least in part of its surface in the case it is meant to be fixed by welding to a polyethylene fuel tank. Alternatively, it may be fixed mechanically (through a nail, screw…) to the fuel sending unit flange.

The valve according to the invention has a stationary outer housing and an inner translating section. The inner translating section is generally of a substantially cylindrical shape, the axis of the cylinder corresponding to the axis of translation of that part. The shape of the stationary outer housing is less critical but is generally substantially cylindrical as well. By "substantially cylindrical", it is meant that a substantial portion thereof is cylindrical, which does not exclude parts and/or appendices extending outside the generally

cylindrical form (in the case of the housing, like electrical and fluid connections for instance).

The stationary outer housing comprises at least four openings (or bores) through which a fluid can flow and which define with adequate bores in the inner translating section, at least three ports or passages through which a fluid can enter or exit the valve. According to some embodiments, the valve may comprise a fourth and even a fifth port allowing more fluid communication possibilities. In that case, in some position(s) of the valve, more than 2 ports may be into fluid communication.

The above mentioned bores and ports may have any shape and location inside the housing and the inner section. These shapes and locations are generally adapted to the shape and location of the fluid lines to which the ports will be connected.

The valve according to the invention has at least 3 stable positions, i.e. discrete positions in which at least 2 ports are in fluid communication and to which the valve switches from one to another in response to an electrical actuating system being controlled by an electronic controller. These 3 positions are advantageously such that 2 of them allow complete fluid communication between at least 2 ports and the third one allows only partial fluid communication between 2 ports. There could also be more than one intermediate position for having more than one partial flow between 2 given ports. Besides, the valve may also comprise an additional closed position, in which none of the above mentioned 3 ports are in fluid communication, and which is held by a suitable default mechanism (like a spring for instance) able to ensure that the system is sealed in the event of electrical power loss.

In one embodiment of the present invention, the electrical actuating system comprises at least two coils fixed on the outer stationary housing and at least one magnet fixed on the inner translating section, the coils being coupled to a power generator which is able to energize them, i.e. to generate an electrical current and make it circulate through them, in response to a signal from the electronic controller. In that case, each position of the valve is associated with a given coil being energized and attracting the magnet to it. In some cases, depending on the geometry and/or location of the fluid lines to be connected to the valve, it may be advantageous to use at least two magnets in order to allow for a quicker switch from one valve position to another as well as the desired number of positions to allow for partial communication between the engine and the canister. According

to another embodiment of the present invention, the electrical actuating system comprises a separate actuator (motor), placed on the end of the valve, which translates the inner section of the valve and puts it in given positions in response to a signal from the electronic controller. One embodiment of a motor drive includes a servo or stepper motor attached to a lead screw, inserted into the valve along the axis of translation. A matching nut is attached to the inner translating member, such that rotation of the servo or stepper motor translates the inner member within the component. In this case, it may be necessary to have multiple position feedback sensors on the valve body. These sensors are used to determine the position of the inner translating member in relation to the outer stationary member.

The use of such sensors is interesting in the event that the part is translated by an external source (as explained above) but also, with the coils system explained earlier, in the event of a power failure, in which the orientation of the part is not remembered.

The valve described above gives good results when used in a fuel system vapor management unit of an engine (and more particularly, of an internal combustion engine), especially if used in a unit similar to the one described in the above mentioned US patent. In that case, one position of the valve ensures complete flow communication between a fuel tank and a vapor recovery system and the 2 other ones ensure respectively complete and partial communication between this vapor recovery system and the engine. In addition the valve allows for isolation of the fuel system to limit vapor generation. The vapor recovery system is generally a charcoal canister, which adsorbs hydrocarbons from the tank though vapor vent lines allowing the tank to vent (during normal operation including filling) without sending hydrocarbons into the atmosphere. The hydrocarbons trapped in the canister are periodically routed to the engine for combustion, in an amount depending on the rotational speed of the engine and being metered with the valve according to the invention. This amount goes from zero when the engine is switched off (and when only the fuel tank and the canister are in total communication) to a maximum amount when the engine turns at a normal speed (and when only the canister and the engine are in total communication), and through an intermediate amount when the engine is turning at idle speed (and only the canister and the engine are in partial communication).

An additional feature that is often present in fuel system vapor management units is a vapor communication between the fuel tank and the filler

pipe. In many cases it serves three functions. First it allows vapor in the fuel tank to be recirculated into the filler pipe and re-liquefied, thus minimizing vapor generation during refueling. Second, it serves as the communication path between the tank and the filler pipe during leak detection diagnostics. Finally, in a crash situation, the filler cap is often relied on for relieving any pressure incurred upon impact via an over pressure valve. For this reason as well, there needs to be an open communication between the fuel tank and the filler pipe. The use of a valve according to the present invention can solve this problem as well, provided that said valve is equipped with at least an additional port to be connected to a vapor recirculation line extending to the filler pipe.

In recent times however, there has been a push to restrict the size of the vapor recirculation line to control the amount of vapor that enters the filler pipe during refueling, thus minimizing the amount that escapes into the atmosphere. This creates a contradiction between the refueling function and the pressure relief function. Therefore, it is nowadays generally preferable to have both a vapor recirculation line with a large diameter (for unrestricted vapor recirculation to the filler pipe) and one with a smaller diameter, to have a restricted vapor recirculation flow during refueling. Alternatively, there could be only one vapor recirculation line but the access to it could be either through a port of large diameter or through a port of smaller diameter. Accordingly, in a preferred embodiment, use is made of a valve as described above which comprises at least four ports for being connected respectively to the fuel tank, to the canister, to the engine, to a passage of large diameter to a vapor recirculation line and to a passage of small diameter to the (or another) vapor recirculation line, the management of which ports to be in fluid communication being performed by an electronic controller. It may be advantageous however to at have at least 2 ports for being connected to the fuel tank in order to separate venting and vapor recirculation function, i.e. one port is meant for establishing fluid communication with the canister and the other one, with the filler pipe. In such a valve, more than 2 ports may be in fluid communication in some position(s) of the valve.

Some preferred embodiments of the present invention will be explained in more detail through figures 1 to 5. Figures 1 to 4 relate to a three function 4 port valve which can be used in a fuel system vapor management unit both for venting of the fuel tank during refueling and normal operation, and for purging

the canister, also the vapor recirculation function. Figure 5 pictures an entire vapor management system using this valve.

Figure 1 shows one embodiment of the above described invention. An inner member (1) translates within an outer housing (2), via an actuator such as but not limited to a solenoid or a stepper motor (not pictured) attached to either end of the outer housing (2). The outer housing (2), has four ports. The first port (3) provides fluid communication to the fuel tank. The second port (4) is in fluid communication with the vapor storage canister. The third port (5) is in fluid communication of the fill head via a vapor recirculation line. The fourth port (6) is in fluid communication with the engine intake manifold.

Figure 2 shows the valve positioned such that there is fluid communication between the vapor recovery canister and the fuel storage tank. This position is held by energizing a coil and attracting a magnet adjacent to it (both not shown). In this position, the vapor recirculation line is in restricted communication between the tank and the filler pipe to control the amount of vapor that is reintroduced to the filler pipe during refueling.

Figure 3 shows the valve in a "closed position", which in this case means leaving no fluid communication between the fuel tank, the canister and the engine intake manifold. However, in this position, there is full communication between the fuel tank and the filler pipe through the large diameter vapor recirculation line in anticipation of leak diagnostics or a crash situation. This position is held via a spring (not pictured) to ensure that the system is sealed in the event of a power loss. In addition, this position will be used during driving to prevent fuel from contaminating the vapor recovery canister.

Figure 4 shows the valve positioned such that there is fluid communication between the vapor recovery canister and the engine intake manifold. In this position, there is no fluid communication between the fuel tank and the filler pipe. This position can be varied (just as shown in the first embodiment, by the use of at least an additional coil providing at least one intermediate position) to adjust for the amount of purged vapor the engine can handle at a given time.

Figure 5 shows a diagram of an entire vapor management system, including the valve pictured in figures 2-4 (1), a fuel storage tank (2), an engine intake manifold (3), a vapor recovery canister (4), fluid communication lines (5), the fluid communication between the valve (1) and the fuel storage tank (2) being made via a liquid/vapor discriminator (6). A vapor recirculation line (8) is shown to be in vapor communication with the fuel storage tank (2) and the filler

pipe (9) selectively based on the valve position. In addition, an electronic communication line is shown (7). This line may be used to receive signals from the engine control module specifying a valve position, which are then processed by an integral signal conditioner on the valve. The communication line shown (7) could also consist of a number of power sources and a ground to energize the appropriate coils to make the valve function properly. A third scenario for the communication line (7) is where it would connect to a separate fuel system processor. Note that a one-way check valve may be necessary between the engine intake manifold and the valve to eliminate the possibility of back flow on engine deceleration.

CLAIMS

1 – Electronically controlled electromechanical valve having at least three ports through which a fluid can flow and at least three different stable positions in which at least 2 ports are in fluid communication, said valve comprising:

- a stationary outer housing comprising at least three bores;

- a translating inner section which translates along the primary axis of the outer housing and comprises adequate bores defining with the bores of the housing, the at least three ports of the valve; and

- an electrical actuating system being controlled by an electronic controller and being able to switch the valve from one position to another by translating the inner section along its axis.

2 – Valve according to the preceding claim, characterized in that it comprises an additional closed position, in which none of the above mentioned 3 ports are in fluid communication, and which is held by a suitable default mechanism able to ensure that the system is sealed in the event of electrical power loss.

3 - Valve according to any of the preceding claims, characterized in that the electrical actuating system comprises at least two coils fixed on the outer stationary housing and at least one magnet fixed on the inner translating section, the coils being coupled to a power generator which is able to energize them, i.e. to generate an electrical current and make it circulate through them, in response to a signal from the electronic controller, so that each position of the valve is associated with a given coil being energized and attracting the magnet to it.

4 - Valve according to any of the preceding claims, characterized in that the electrical actuating system comprises at least two magnets.

5 – Valve according to claim 1 or 2, characterized in that the electrical actuating system comprises a motor placed at either end of the valve, which translates inner section of the valve and puts it in given positions in response to a signal from the electronic controller.

6 – Fuel system vapor management unit for an internal combustion engine, characterized in that it comprises a valve according to any of the preceding claims.

7 – Unit according to the preceding claim, characterized in that one position of the valve ensures complete flow communication between a fuel tank and a vapor recovery system and the 2 other positions ensure respectively complete and partial communication between this vapor recovery system and the engine.

8 – Unit according to claim 6 or 7, characterized in that the valve comprises at least an additional port to be connected to a vapor recirculation line extending to the filler pipe.

9 – Unit according to the preceding claim, characterized in that the valve comprises at least four ports for being connected respectively to the fuel tank, to the canister, to the engine, to a passage of large diameter to the vapor recirculation line and to a passage of small diameter to the (or another) vapor recirculation line.

10 - Unit according to the preceding claim, characterized in that it comprises a second port for being connected to the fuel tank.

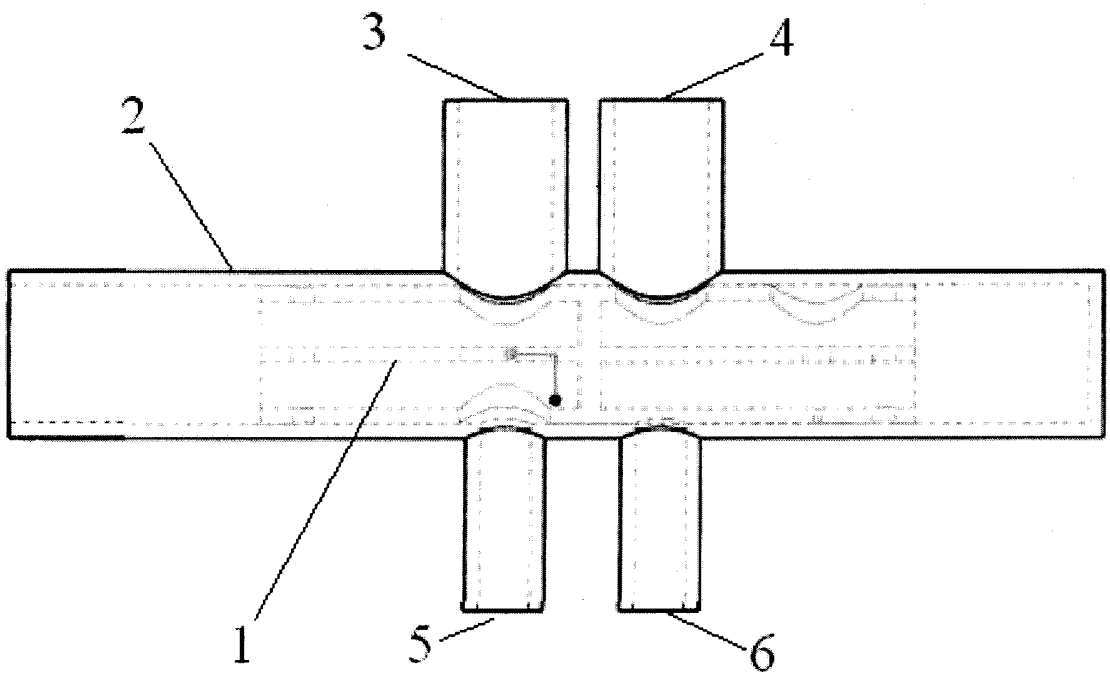


Fig. 1

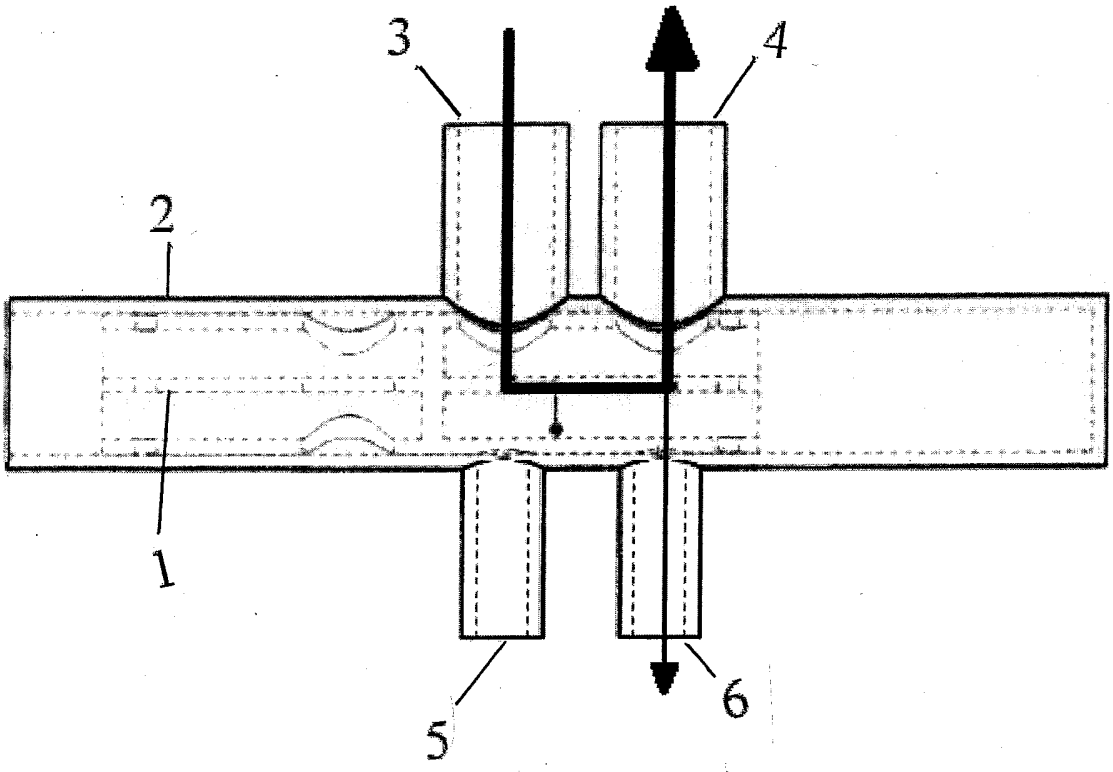


Fig. 2

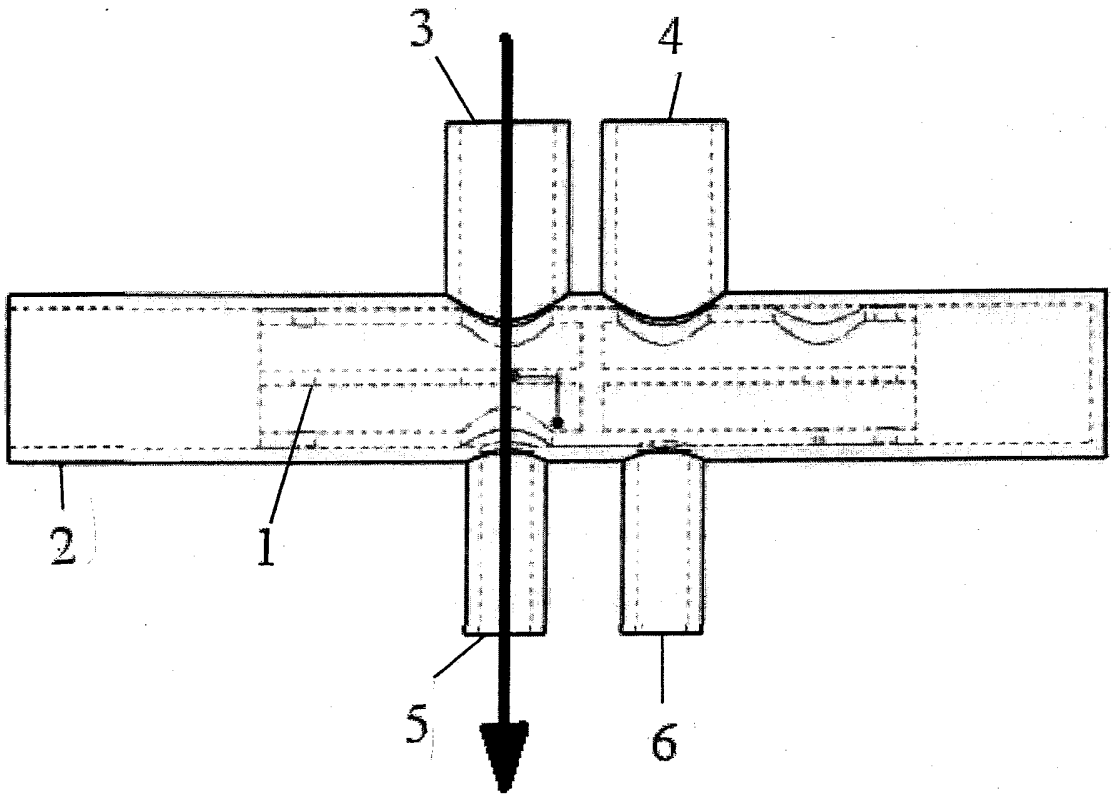


Fig. 3

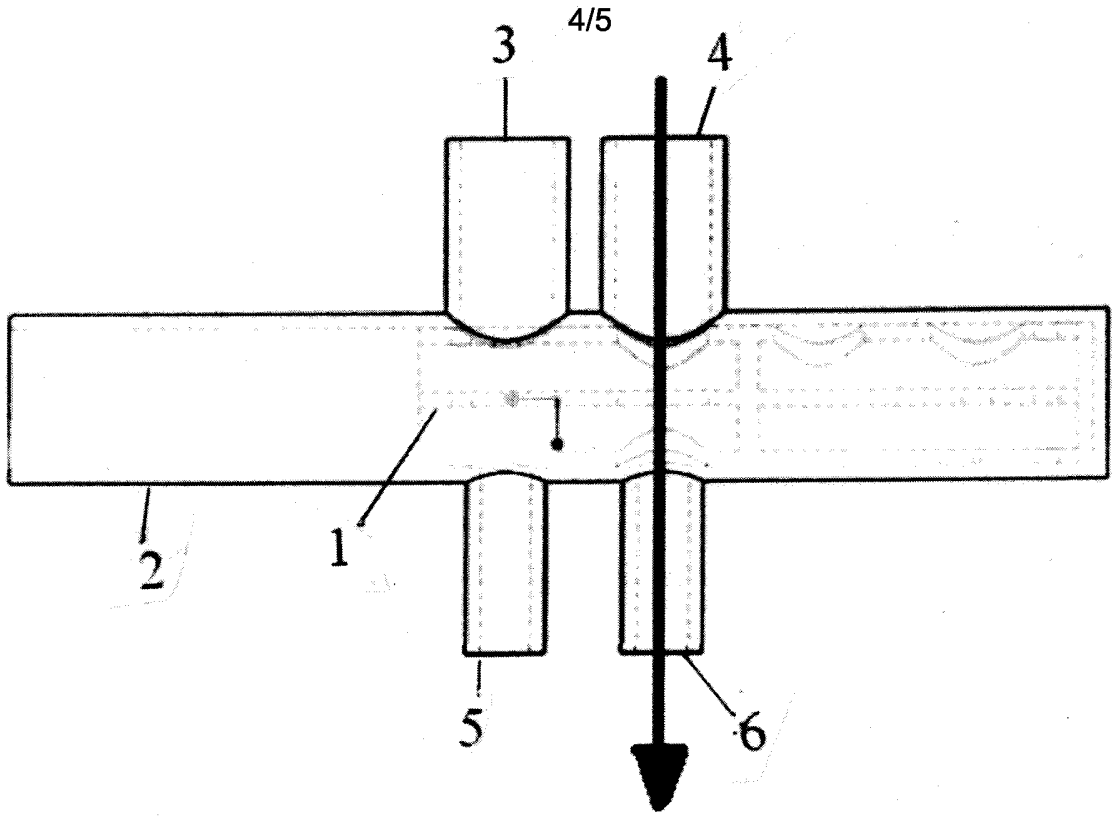


Fig. 4

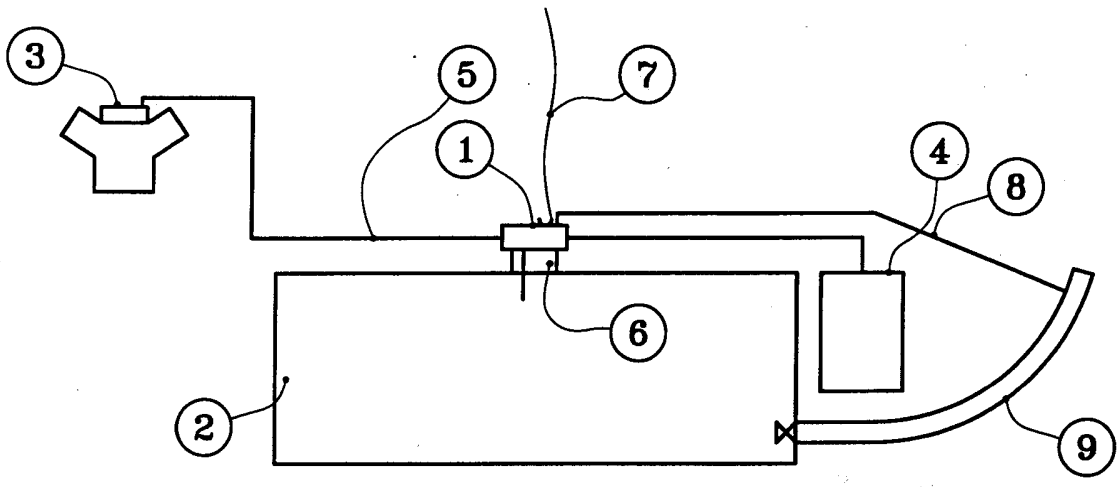


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/050085

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16K11/07 F16K31/06

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)
F16K

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 practical, 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.
X	DE 43 19 162 A1 (MANNESMANN REXROTH GMBH, 97816 LOHR, DE) 15 December 1994 (1994-12-15) column 4, line 51 - column 8, line 53; figures	1-5
Y		6-10
P,Y	WO 2005/059349 A (INERGY AUTOMOTIVE SYSTEMS RESEARCH ; HILL, DAVID) 30 June 2005 (2005-06-30) claims 6-10; figure 9	6-10
X	DE 12 64 192 B (FLUID POWER LIMITED) 21 March 1968 (1968-03-21) the whole document	1,2

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 May 2006	19/05/2006

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/050085

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		3-5
A	PATENT ABSTRACTS OF JAPAN vol. 2002, no. 11, 6 November 2002 (2002-11-06) & JP 2002 195122 A (MIKUNI CORP), 10 July 2002 (2002-07-10) abstract; figure 1	6-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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