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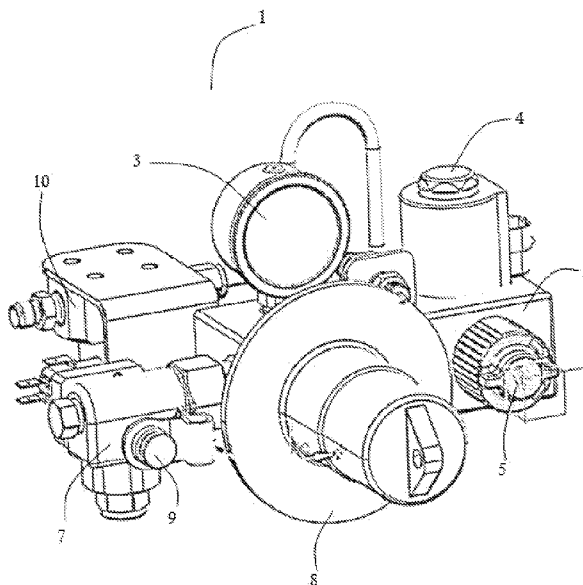


Fig. 1

(57) Abstract: The present invention relates generally to a fuel system module for a vehicle. The invention provides an integrated manifold that include channels or pass-through bores to form a fuel channel, injecting at least one port through which fuel communication with the fuel channel is established. Therefore, the integrated manifold provides faster injection and storage of gaseous fuel such as CNG for an internal combustion engine. Further, it also reduces overall cost, weight, joints, size, and potential failure and thereby improving the performance.

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“INTEGRATED MANIFOLD FOR A NATURAL GAS-FUELLED INTERNAL COMBUSTION ENGINE”

FIELD OF THE INVENTION

The present invention relates generally to a fuel system module for a vehicle. More particularly, the invention provides an integrated manifold for filling gaseous fuel (CNG) for an internal combustion engine while reducing overall cost, weight, joints, size, and thereby improve the performance.

BACKGROUND OF THE INVENTION

Over the period, liquid-fueled internal combustion engines have been used to produce power and drive machines and such internal combustion engines have undergone many improvements to become more efficient, more powerful, and/or less polluting. To assist with these improvements, fuel properties and quality have also improved, and alternative fuels such as methanol and other alcohol-based fuels have also been considered to help with reducing harmful emissions. However, compared to such liquid fuels, an equivalent amount of a combustible gaseous fuel, such as methane, propane, butane, hydrogen, natural gas, and blends of such fuels, with equivalence measured on an energy basis, can be combusted to produce the same power while producing less harmful emissions in the form of particulates and greenhouse gases.

As the search continues for cleaner burning fuels to reduce pollution in the nation's cities, many city transit authorities are converting their vehicles to run on compressed natural gas, commonly referred to as CNG. Compressed natural gas (CNG) is becoming more widely used for powering various different types of vehicles, due at least in part to the fact that CNG is a relatively economical, efficient, and environmentally favorable source of energy. Additionally, existing fuel systems for CNG vehicles are generally set up for specific fueling configurations and do not provide freedom for connecting different types and configurations of fuel tanks.

In patent application CN207455167, a CNG vehicle filling integrated control panel is disclosed. The control panel, comprising a panel body and a pneumatic interface body mounted on the back of the panel, drain valve, pressure gauge, pneumatic valves and air supply shut-off valves, the back panel is attached to the manifold valve block body, are provided with a plurality of interconnected internal mounting interfaces, pressure gauge, drain valve, the supply cut-off valve and a pneumatic shut-off valve are in communication through a tracheal interface mounted on the manifold valve block, pneumatic shut-off valve in communication with the inflator interfaces through the trachea, the front panel of the body is arranged with a pneumatic valve port interfaces emptying valve handle, the dial gauge, the pneumatic shut-off valve and the gas shut-off valve handle grip. In this arrangement, even though panel is pre-fabricated to assemble the set of equipment, it requires special attention while assembling set of interconnecting tubes. Further, since there is plurality of interconnecting tubes employed, chances of error and failure increases.

Based on the forgoing, there is a need for a fuel system module that can overcome the problems set above. In context, the present invention provides an integrated manifold with an elongated single fuel channel with provisions for attaching flow regulator and essential safety equipment's as per vehicle regulatory act, while reducing overall cost, weight, joints, size, potential failure and thereby improve the performance.

OBJECT OF THE INVENTION

The main object of present invention is to provide an integrated manifold for filling gaseous fuel (CNG) for an internal combustion engine while reducing overall cost, weight, joints, size, potential failure and thereby improve the performance.

Yet another object of present invention is to provide an integrated manifold which enhances filling performance for gaseous fuel (CNG) by reducing friction losses thus improving overall filling time of gaseous fuel tank.

Yet another object of present invention is to provide an integrated manifold for filling gaseous fuel (CNG) that reduces the overall packaging space.

SUMMARY OF THE INVENTION

The present invention relates generally to a fuel system module. More particularly, the invention provides an integrated manifold that include channels or pass-through bores to form a fuel channel, filling at least one port through which fuel communication with the fuel channel is established. Therefore, the integrated manifold provides faster filling of gaseous fuel such as CNG for an internal combustion engine. Further, it also reduces overall cost, weight, joints, size, and potential failure and thereby improving the performance.

In an embodiment of the present invention, a fuel system module with an integrated manifold for filling gaseous fuel (CNG) to the provided tank i.e. CNG tank for an internal combustion engine, comprises of a manifold having a continuous fuel channel of about 4.6 - 8 mm diameter. Further, the manifold is provided with suitable standard taper and/or straight threaded ports branched into the fuel channel to attach high pressure fittings for controlling the flow and essential mandatory equipment's as per vehicle regulatory act such as, but not limited to high pressure gauge, NGV and NZS filling valve assembly, high pressure filter, automatic shut off valve, ignition switch (micro switch), high pressure sensor, manual shut off valve, etc.

In an alternate embodiment of present invention, a fuel system module with integrated manifold is provided with two natural gas filling valves, one manual and one automatic shut off valve and one pressure gauge wherein one of the natural gas filling valves is amongst natural gas vehicle NGV2 or NGV1 for fast filling and the other natural gas filling valve is New Zealand Standard (NZS) for slow filling. The natural gas filling valves control and regulate the flow of high-pressure natural gas i.e. CNG, through micro switches that are configured to control the engine ignition during filling as per the safety standards. Further, both valves are provided with either dust cap and/or lock pins to safe guard fuel system from dirt and dust and further to operate the micro switch. The manual and automatic shutoff valves are configured to shut off the gaseous fuel (CNG) supply to engine when engine ignition is switched off.

In yet another alternate embodiment of present invention, a fuel system module with integrated manifold is equipped with one natural gas filling valve, one pressure gauge;

one manual and one automatic shut off valve wherein the manual and automatic shutoff valves are configured to shut off the gaseous fuel (CNG) supply to engine when engine ignition is switched off. Here, the natural gas filling valve is preferably natural gas vehicle NGV2.

In still another embodiment of present invention, a fuel system module with integrated manifold is equipped with two natural gas filling valves; one manual shut off valve; a pressure gauge and a pressure sensor. The pressure gauge and pressure sensor are provided to monitor pressure in the flow path of incoming gaseous fuel (CNG) and while the gaseous fuel is filling in the CNG tank of vehicle.

BRIEF DESCRIPTION OF DRAWINGS

The present invention will now be described with reference to the following drawings. The drawings and the associated descriptions are provided to illustrate embodiments of the invention and not to limit the scope of the invention:

Fig. 1 illustrates perspective view of a fuel system module having an integrated manifold for filling gaseous fuel (CNG) in accordance with an embodiment of the present invention.

Fig. 2 illustrates top view of a fuel system module having an integrated manifold for filling gaseous fuel (CNG) in accordance with an embodiment of the present invention.

Fig. 3 illustrates perspective view of a fuel system module having an integrated manifold for filling fuel (CNG) in accordance with another embodiment of the present invention.

Fig. 4 illustrates perspective view of a fuel system module having an integrated manifold for filling fuel (CNG) in accordance with an alternate embodiment of the present invention.

Fig. 5 illustrates perspective view of a fuel system module having an integrated manifold for filling fuel (CNG) in accordance with an alternate embodiment of the present invention;

Fig. 6 illustrates perspective view of a fuel system module having an integrated manifold for filling fuel (CNG) in accordance with an alternate embodiment of the present invention.

Fig. 7 illustrates perspective view of a fuel system module having an integrated manifold for filling fuel (CNG) in accordance with an alternate embodiment of the present invention.

Fig. 8 illustrates front and side view of the integrated manifold in accordance with an alternate embodiment of the present invention.

Figs. 9a and 9b illustrate a gaseous flow in the integrated manifold in accordance with an alternate embodiment of the present invention.

Figs. 10a and 10b illustrate a gaseous flow in the integrated manifold in accordance with an alternate embodiment of the present invention.

Figs. 11a and 11b illustrates a gaseous flow in the integrated manifold in accordance with an alternate embodiment of the present invention.

Fig. 12 shows a graphical representation of flow rate v/s pressure for the fuel system module in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings. While the following description details the preferred embodiments of the present invention is not limited in its application to the details of construction and arrangement of the parts illustrated in the accompanying drawings.

With reference to the figures, numerical designation has been given for each element to facilitate the reader's understanding of the present invention, and particularly with reference to the embodiments of the present invention illustrated in the figures. The enclosed description and drawings are merely illustrative of preferred embodiments. Although specific components, materials, configurations and uses of the present invention are illustrated and set forth in this disclosure, it should be understood that a

number of variations to the components and to the configuration of those components described herein and in the accompanying figures can be made without changing the scope and function of the invention set forth herein.

In an embodiment of the present invention, a fuel system module with an integrated manifold for filling gaseous fuel (CNG) to the provided tank i.e. CNG tank for an internal combustion engine, comprises of a manifold having a continuous fuel channel of about 4.6 - 8 mm diameter, preferably manufactured from corrosion resistant material such as, but not limited to aluminum, stainless steel, brass, plastic, etc. Further, the manifold is provided with suitable standard taper and/or straight threaded ports branched into the fuel channel to attach high pressure fittings for controlling the flow and essential mandatory equipment's as per vehicle regulatory act such as, but not limited to high pressure gauge, NGV and NZS filling valve assembly, high pressure filter, automatic shut off valve, ignition switch (micro switch), high pressure sensor, manual shut off valve, etc. Optionally, the integrated manifold is provided with a filter assembly comprising of high pressure fittings, a filter bracket and a high pressure filter which receives the gaseous fuel (CNG) passing through the fuel channel and high pressure tubes at its inlet, and through its outlet feed the gaseous fuel (CNG) into a high pressure storage tank i.e. CNG tank. As per the vehicle requirement, more than one CNG tank is connected to the integrated manifold.

The ignition switch provided with integrated manifold is electrically connected with vehicle ignition key. When ignition switch is in off condition or dust cap is in open condition (dust cap is used over the NGV1/NGV2/NZS receptacle to operate the ignition switch), it does not allow vehicle to start. During CNG gas filling, dust cap remains in open condition and ignition switch is ON condition, so driver cannot crank the vehicle. It avoids any accident during filling that may occur in case filling nozzle is connected to filling valve and driver start running vehicle without knowing nozzle disconnection.

In an alternate embodiment of present invention, a fuel system module the manifold is provided with two natural gas filling valves, one manual and one automatic shut off valve and one pressure gauge wherein the natural gas filling valves include a combination amongst natural gas vehicle NGV2, natural gas vehicle NGV1 and a

natural gas filling valve of New Zealand Standard (NZS). The natural gas vehicle NGV1 and NGV2 are provided for fast filling and natural gas filling valve of New Zealand Standard NZS is provided for slow filling. The natural gas filling valves control and regulate the flow of high-pressure natural gas i.e. CNG, through micro switches that are configured to control the engine ignition during filling as per the safety standards. Further, both valves are provided with either dust cap and/or lock pins to safe guard fuel system from dirt and dust and further to operate the micro switch. Further the integrated manifold is equipped with one manual and one automatic shut off valve wherein the manual and automatic shutoff valves are configured to shut off the gaseous fuel (CNG) supply to engine when engine ignition is switched off.

The manual shut off valve is used to manually shut off the CNG supply towards the engine. While, the automatic shut off valve is electronically operated and used to automatically shut off the supply towards the engine. The automatic shut off valve is preferably positioned at the top of the integrated manifold and it is connected to vehicle ignition key and when engine is cranked, it gets on and allows CNG supply to engine. It is to prevent damage in case if fire in engine room. When driver switches off ignition, the automatic shut off valve stops CNG supply towards engine.

In another alternate embodiment of present invention, a fuel system module with integrated manifold is equipped with one natural gas filling valve, one pressure gauge; one manual and one automatic shut off valve wherein the manual and automatic shutoff valves are configured to shut off the gaseous fuel (CNG) supply to engine when engine ignition is switched off. Here, the natural gas filling valve is preferably natural gas vehicle NGV2.

In another alternate embodiment of present invention, a fuel system module with integrated manifold is equipped with two natural gas filling valves; one manual shut off valve; a pressure gauge and a pressure sensor. The pressure gauge and pressure sensor are provided to monitor pressure in the flow path of incoming gaseous fuel (CNG) and while the gaseous fuel is filling in the CNG tank of vehicle.

Fig. 1 and **Fig. 2** illustrates perspective and top view of a fuel system module **(1)** having an integrated manifold **(2)**, a pressure gauge **(3)** monitors pressure of main fuel channel/flow path of incoming gaseous fuel (CNG) and plurality of shut off valves i.e.

an automatic shut off valve (4) and manual shut off valve (5) is configured to shut off the gaseous fuel (CNG) supply to engine when engine ignition is off. Further, integrated manifold (2) have plurality of gas filling valves i.e. natural gas vehicle (NGV1 and NGV2) (6) for fast filling and New Zealand Standard (NZS) (7) for slow filling. Further, provided gas filling valves are provided with either dust cap (8) and/or lock pins (9) to safe guard fuel system module from dirt/dust and further to operate the micro switch. In addition, a manual rotary shut off valve (5) to communicate with the fuel channel and a filter assembly (10) is provided which receives the gaseous fuel (CNG) passing through the fuel channel (15) and high pressure tubes (14) at its inlet, and through its outlet feed the gaseous fuel (CNG) into a high pressure gaseous fuel line. Said integrated manifold (2) has a fuel-channel (15) of diameter in the range of 4.6 to 8 mm has a flow rate in the range of 2.2 - 2.3 kg/m; said fuel system module (1) has a 4-5% increase in flow rate; and said fuel system module (1) has a 50-55% reduction in packaging space, a 50-55% reduction in overall weight, and a 40-45% reduction in number of joints.

Fig. 3 illustrates perspective view of the fuel system module (1) having an integrated manifold (2), a pressure gauge (3), a natural gas filling valve (NGV2) (6), a New Zealand standard (NZS) (7) filling valve, fittings (11) used to connect the other components i.e. fuel supply line, an automatic shut off valve (4), a manual shut off valve (5), an ignition switch (12) which is used as a safety device which is electrically connected with vehicle ignition key, when ignition switch is in off condition or dust cap is in open condition, it does not allow vehicle to start.

Fig. 4 illustrates perspective view of the fuel system module (1) in accordance with an alternate embodiment of the present invention having an integrated manifold (2) with one natural gas filling valve i.e. natural gas vehicle (NGV2) (6), a pressure gauge (3), an automatic shut off valve (4), a manual shut off valve (5), fittings (11), an ignition switch (12).

Fig. 5 illustrates perspective view of the fuel system module (1) in accordance with an alternate embodiment of the present invention having an integrated manifold (2), a natural gas filling valve (NGV2) (6), a natural gas filling valve (NGV1) (16), a pressure gauge (3), an automatic shut off valve (4), a manual shut off valve (5), plurality of ignition switch (12).

Fig. 6 illustrates perspective view of the fuel system module (1) in accordance with an alternate embodiment of the present invention having an integrated manifold (2), a natural gas filling valve (NGV2) (6), a new Zealand standard valve (NZS) (7), a pressure gauge (3), a high pressure connecting tube (14), a filter bracket (18) which is attached to the back of the integrated manifold (2), a high pressure filter (19) which is attached to the said filter bracket (18) and a high pressure fitting (17), an automatic shut off valve (4), a manual shut off valve (5), an ignition switch (12), a high pressure sensor (13).

Fig. 7 illustrates perspective view of the fuel system module (1) in accordance with an alternate embodiment of the present invention having an integrated manifold (2), a natural gas filling valve (NGV2) (6), a natural gas filling valve (NGV1) (16), a pressure gauge (3), a high pressure connecting tube (14), a filter bracket (18) which is attached to the back of the integrated manifold (2), a high pressure filter (19) which is attached to the said filter bracket (18) and a high pressure fitting (17), an automatic shut off valve (4), a manual shut off valve (5), an ignition switch (12), a high pressure sensor (13).

Fig. 8 illustrates front and side view of the integrated manifold (2) in accordance with an alternate embodiment of the present invention having a through fuel channel (15) made into it of 4.6 - 8 mm diameter, and it is made up of corrosion resistance material such as, but not limited to aluminum, stainless steel, brass, plastic, etc. Further, the integrated manifold (2) comprises at least one port (20) for connecting the NZS filling valve, at least one port (21) for connecting the NGV filling valve, plurality of port (22) for connecting the filter bracket (18) of the filter assembly (10), at least one outlet (23) for connecting a gas tank filling port (28), an outlet (24) for connecting an engine supply port (29), an outlet (25) for connecting a manual shut off valve (5), an outlet (26) for optionally connecting an automatic shut off valve (4), a port (27) for connecting high pressure gauge (3). The high pressure fittings (17) of filter assembly (10) are optionally connected on outlet (23).

Figs. 9a and **9b** illustrate a gaseous flow in the integrated manifold (2) in accordance with an alternate embodiment of the present invention wherein integrated manifold (2) has one port (20) for slow filling through natural gas filling valve with New Zealand standard (NZS), one port (21) for fast filling through natural gas vehicle (NGV). The natural gas at a time flows from either port (20) or (21) for fast filling and slow filling

respectively through fuel channel (15) to either outlet (23) for CNG tank filling or to outlet (24) for engine supply. Similarly, the gas flows towards outlet (27) connected to a high pressure gauge (3) and towards pressure sensor (13) for monitoring pressure in fuel channel (15) while filling the CNG tank or while being connected to engine supply.

Figs. 10a and 10b illustrate a gaseous flow in the integrated manifold (2) in accordance with an alternate embodiment of the present invention wherein integrated manifold (2) has one port (21) for fast filling through natural gas vehicle (NGV). The natural gas travels from natural gas filling port (21) to either of two ports (23) for filling two separate CNG tanks and one port (24) for engine supply. The engine supply of gas flow is controlled using a manual shut off valve (5) or automatic shut off valve (4). Similarly, the gas flows towards outlet (27) connected to pressure gauge (3) and towards outlet (26) connecting the automatic shut off valve (5).

Figs. 11a and 11b illustrates a gaseous flow in the integrated manifold (2) in accordance with an alternate embodiment of the present invention wherein integrated manifold (2) has one port (20) for slow filling through natural gas filling valve with New Zealand standard (NZS), one port (21) for fast filling through natural gas vehicle (NGV). The natural gas travels from natural gas filling port (21) to either of two ports (23) for filling two separate CNG tanks and one port (29) for engine supply. The engine supply of gas flow is controlled using a manual shut off valve (5) or automatic shut off valve (4). Similarly, the gas flows towards outlet (27) connected to pressure gauge (3) and towards outlet (26) connecting the automatic shut off valve (5).

Fig. 12 shows a graphical representation of flow rate v/s pressure for the fuel system module. The graphical representation shows that the flow rate of fuel system module with integrated manifold (2) has a flow rate in the range of 2.2-2.3 kg/m. The flow rate obtained shows that there is a 4-5% increase in flow rate. A comparative analysis between a convention fuel filing system and fuel system module with integrated manifold is given below in **Table 1**.

Table 1

Comparison between convention fuel filing system and fuel system module with integrated manifold

Description	Fuel system module with Integrated manifold	Conventional System
Packaging	170X160X180	300X200X150
Weight	2.4 Kg	4.5 Kg
Failure Mode	Less number of joints reduced failure modes.	Large number of joints increased the failure modes.
Number of Joints	11	17
Cost reduction	40 % approx.	

From the comparative analysis it is clear that the integrated manifold **(2)** in the fuel system module **(1)** for filling gaseous fuel (CNG) reduces the overall packaging space by 50-55%, weight by 50-55% and number of joints by 40-45%. In a convention fuel filing system there are at least 17 joints and thus the large of joints make the conventional fuel filling system susceptible to failure. As the numbers of joints are significantly reduced and the overall packaging space and weight has reduced therefore consequently there is at least a 40% reduction in cost. Therefore the fuel system module **(1)** with integrated manifold **(2)** is cost effective. The integrated manifold **(2)** for filling gaseous fuel (CNG) enhances performance by reducing friction losses which improves overall filling time of gaseous fuel tank.

CLAIMS**I claim:**

1. A fuel system module **(1)** comprising of:

an integrated manifold **(2)**, a manual shut off valve **(5)**, at least one natural gas filling valve, at least one dust cap **(8)** and/or lock pin **(9)**, at least one ignition switch **(12)**, and a pressure gauge **(3)**;

wherein,

said integrated manifold **(2)** further comprises:

- a) at least one port **(20)** for connecting said at least one natural gas filling valve for slow filling;
- b) at least one port **(21)** for connecting said at least one natural gas filling valve for fast filling;
- c) at least one port **(22)** for optionally connecting a filter assembly **(10)**;
- d) at least one outlet **(23)** for connecting a gas tank filling port **(28)**;
- e) an outlet **(24)** for connecting an engine supply port **(29)**;
- f) an outlet **(25)** for connecting said manual shut off valve **(5)**;
- g) an outlet **(26)** for optionally connecting an automatic shut off valve **(4)**;
and
- h) an outlet **(27)** for connecting a high pressure gauge **(3)**.

said integrated manifold **(2)** has a fuel-channel **(15)** of diameter in the range of 4.6 to 8 mm and a flow rate in the range of 2.2 -2.3 kg/m;

said fuel system module **(1)** has a 4-5% increase in flow rate; and

said fuel system module **(1)** has a 50-55% reduction in packaging space, a 50-55% reduction in overall weight, and a 40-45% reduction in number of joints.

2. The fuel system module **(1)** as claimed in claim **1**, wherein the said filter assembly **(10)** has at least one high pressure fitting **(17)**, at least one high pressure filter **(19)** and at least one filter bracket **(18)**.
3. The fuel system module **(1)** as claimed in claim **1**, wherein optionally a high pressure sensor **(13)** is connected to the integrated manifold **(2)** to monitor pressure while filling natural gas through at least one natural gas filling valve.
4. The fuel system module **(1)** as claimed in claim **1**, wherein the high-pressure sensor **(13)** measures the pressure and provides a digital signal to give an indication on a vehicle dashboard.
5. The fuel system module **(1)** as claimed in claim **1**, wherein said at least one natural gas filling valve includes but not limited to a NGV1 filling valve **(16)**; a NGV2 filling valve **(6)**; and a NZS filling valve **(7)**.
6. The fuel system module **(1)** as claimed in claim **5**, wherein said NGV1 filling valve **(16)** and NGV2 filling valve **(6)** is for fast filling and NZS filling valve is for slow filling.
7. The fuel system module **(1)** as claimed in claim **1**, wherein a high pressure connective tube **(14)** is used to externally connect and transfer natural gas between two components of the fuel system module **(1)**.
8. The fuel system module **(1)** as claimed in claim **1**, wherein said manual shut off valve and automatic shut off valve is configured to shut off the gaseous fuel supply to engine of vehicle when vehicle ignition switch is off.
9. The fuel system module **(1)** as claimed in claim **1**, wherein when said ignition switch **(12)** is electrically connected to an ignition key of a vehicle.
10. The fuel system module **(1)** as claimed in claim **1**, wherein said automatic shut off valve **(4)** is attached at the top of the integrated manifold **(2)**.

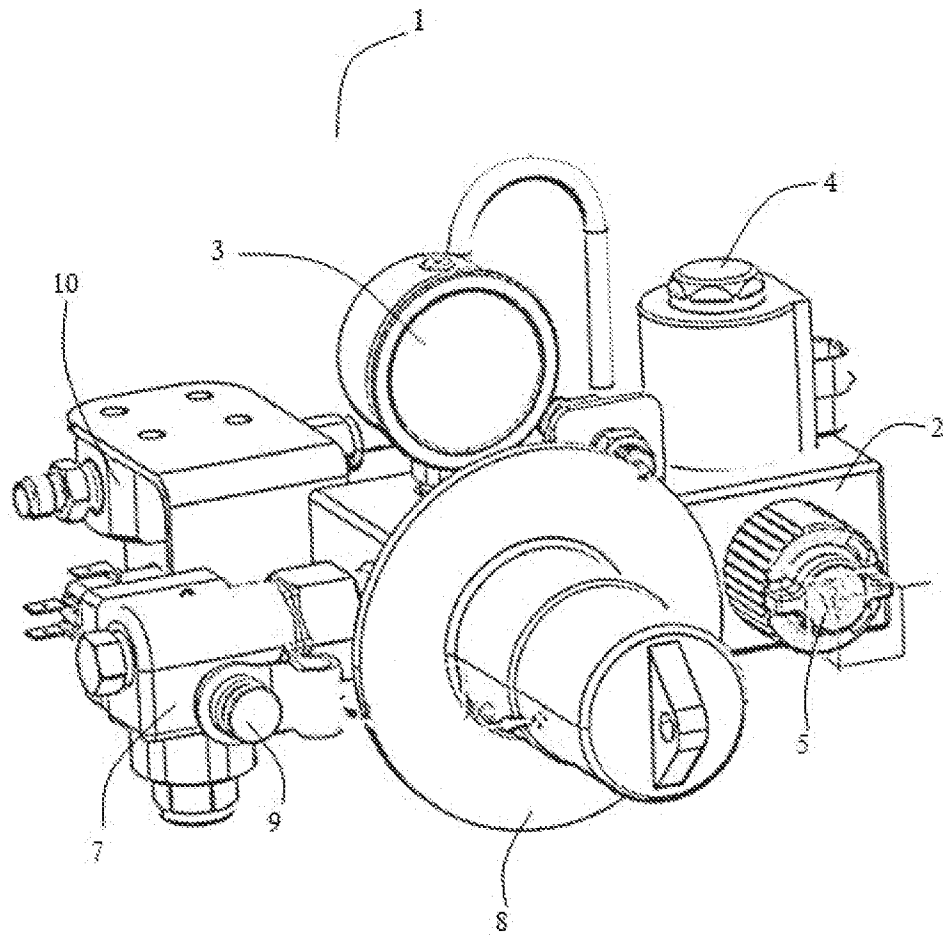


Fig. 1

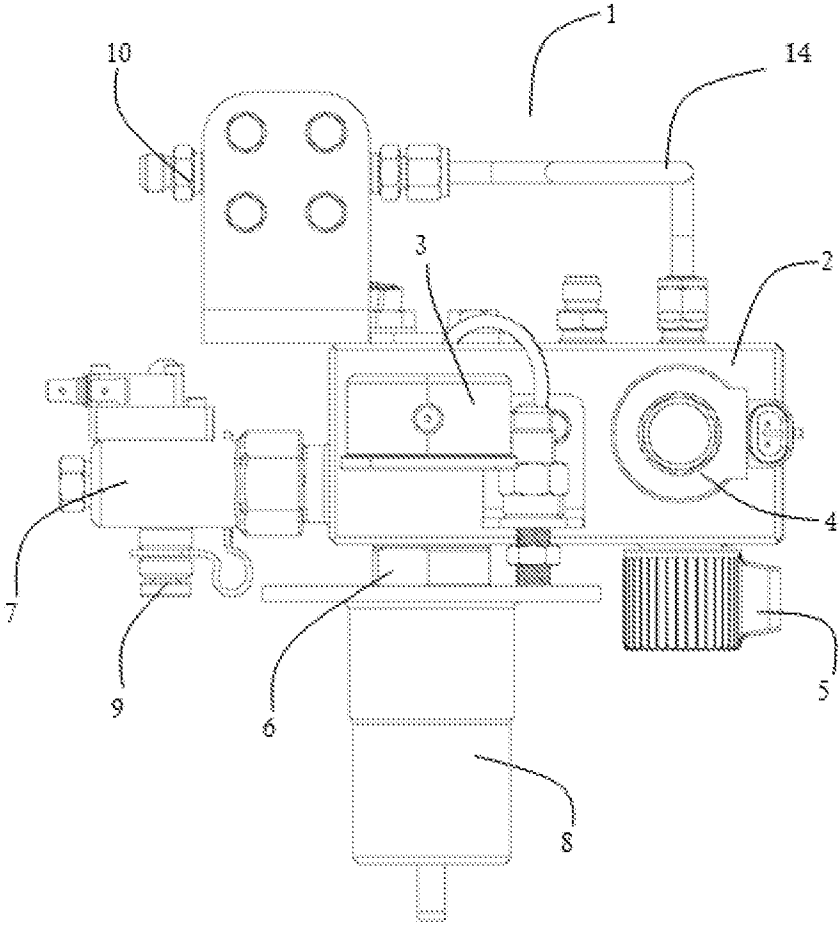


Fig. 2

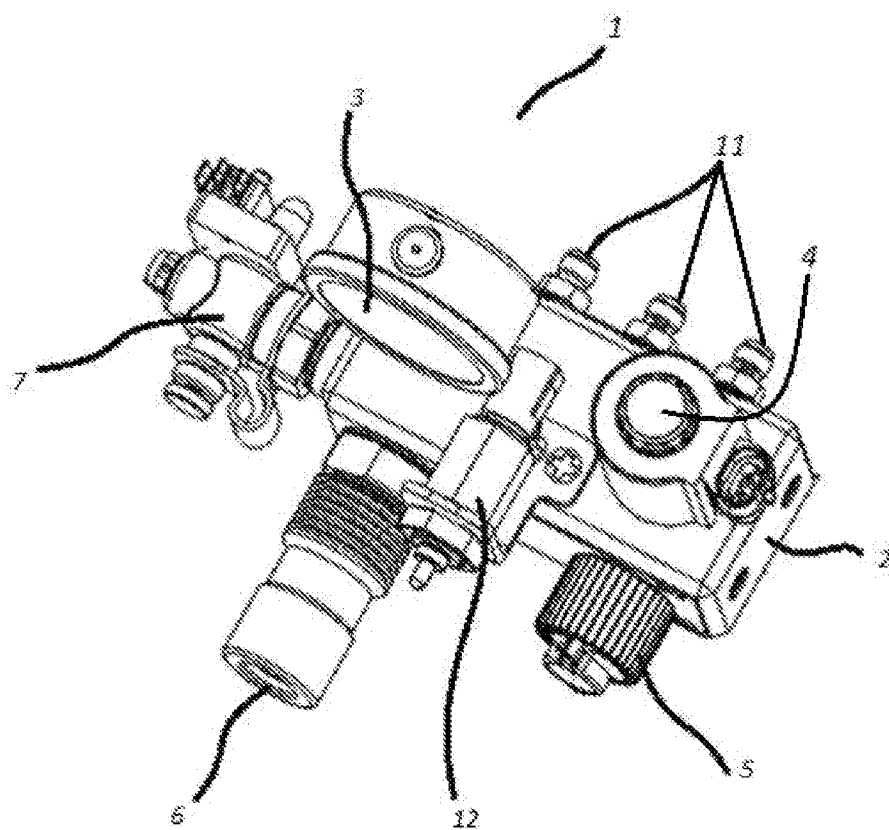


Fig. 3

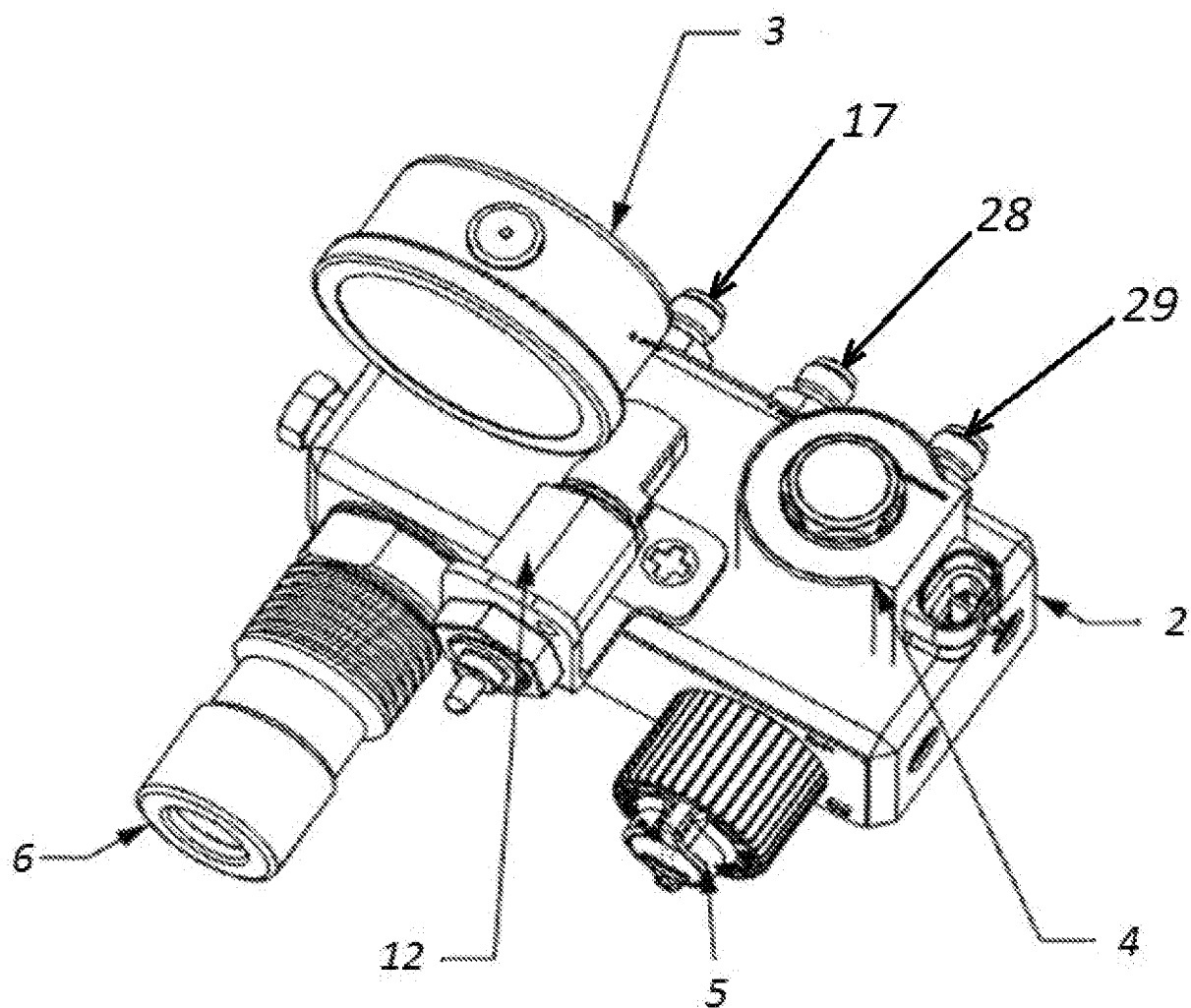


Fig. 4

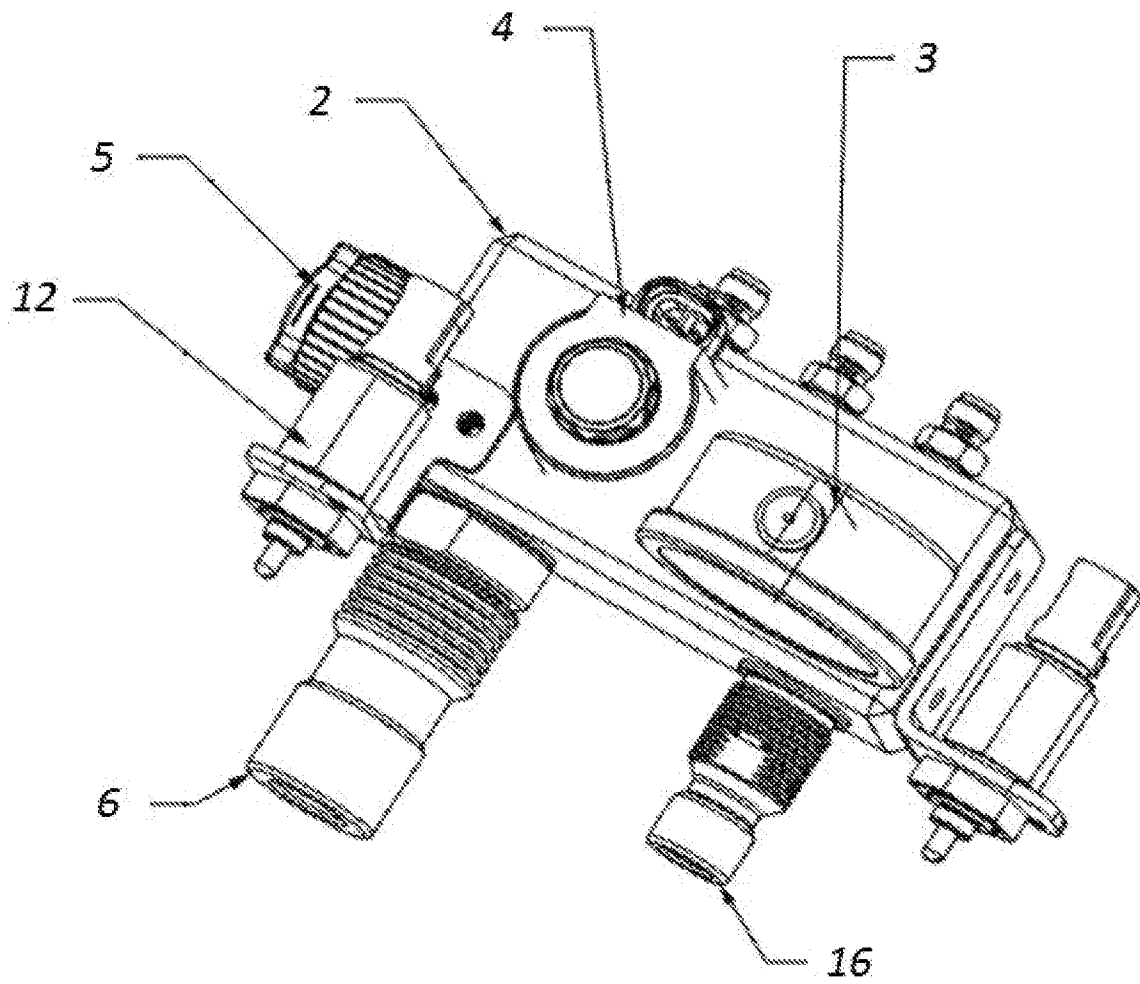


Fig. 5

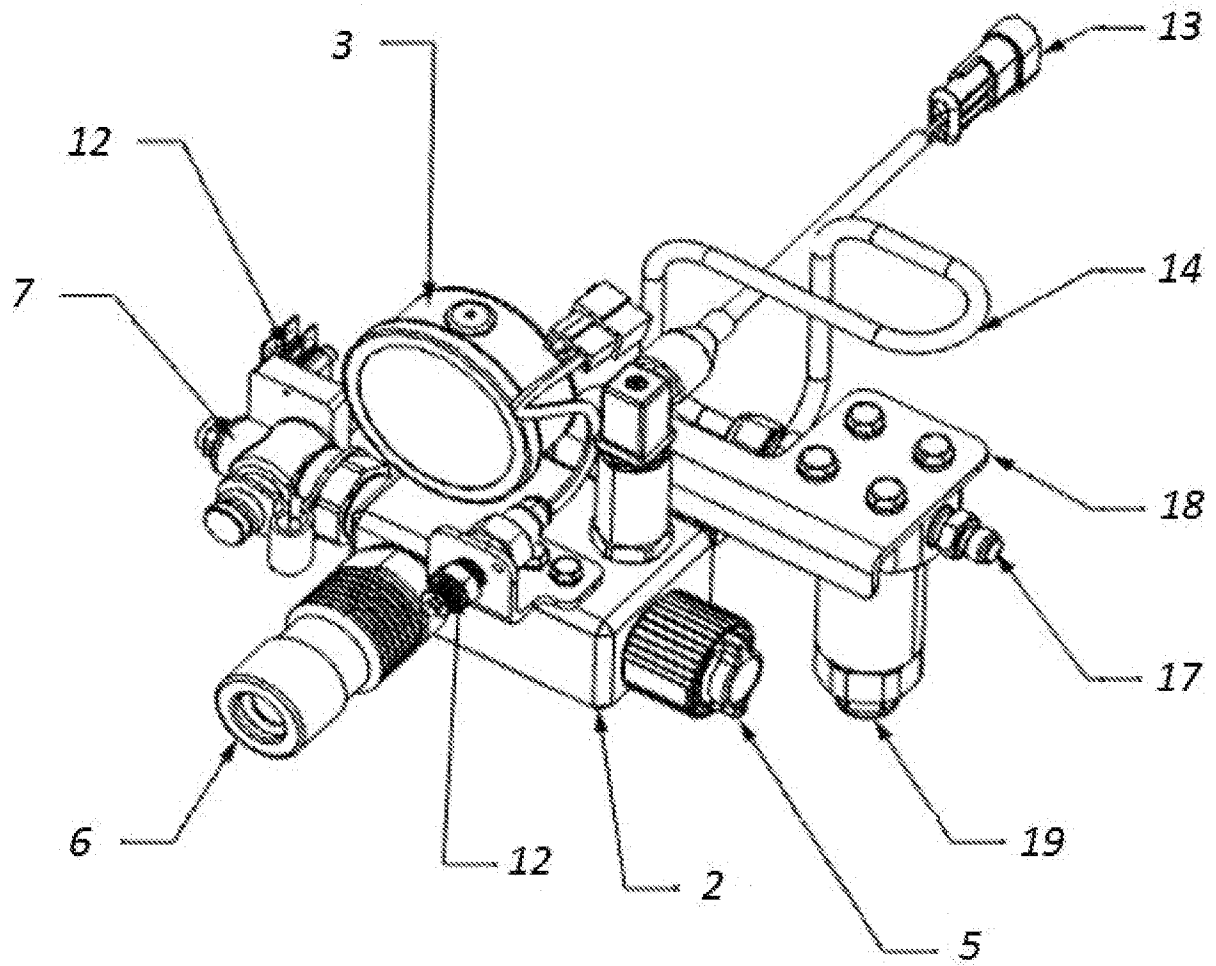


Fig. 6

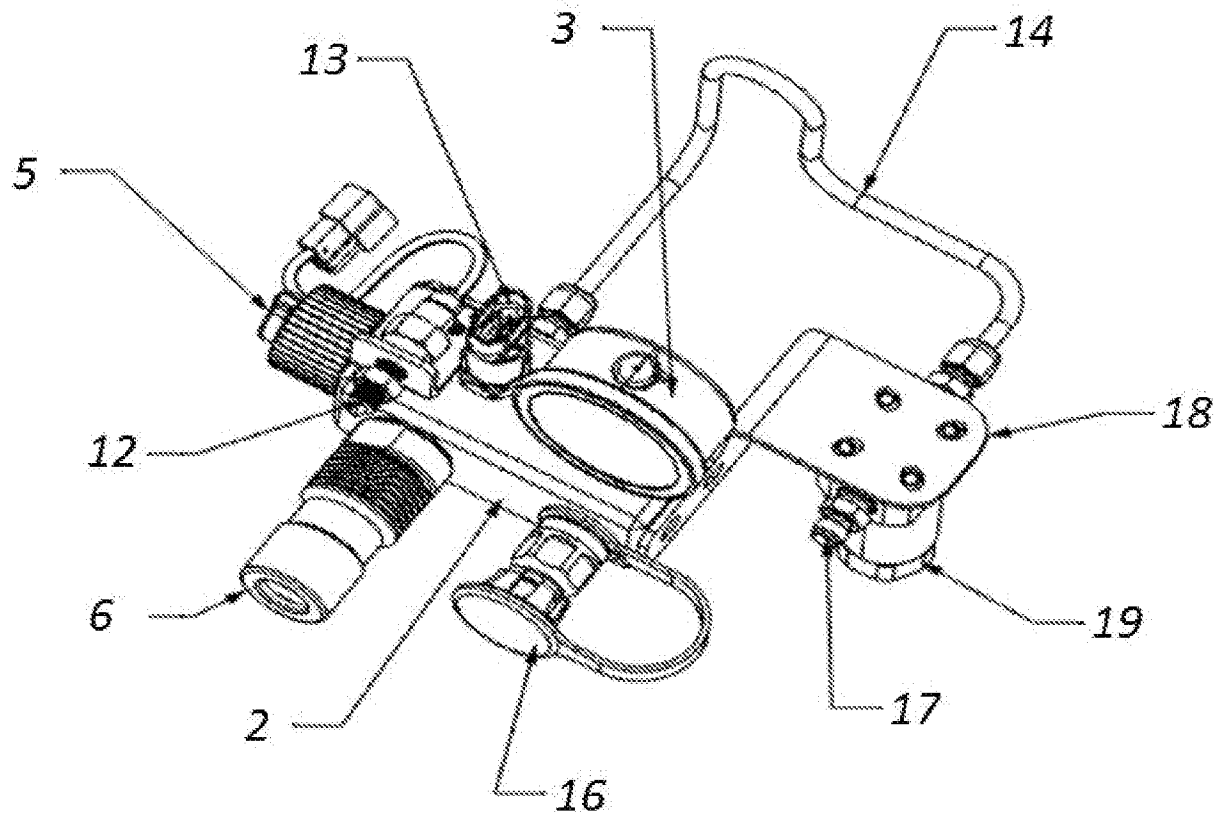


Fig. 7

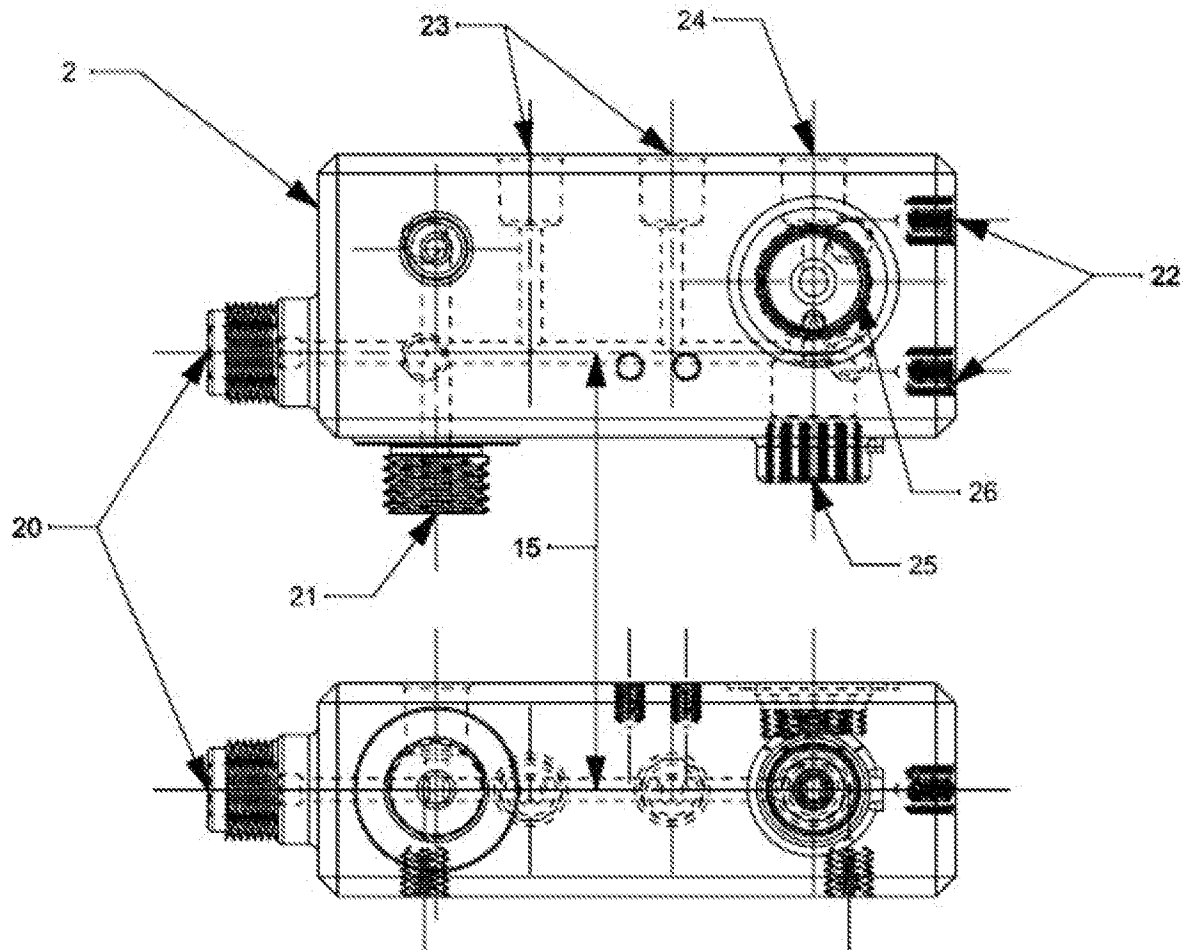


Fig. 8

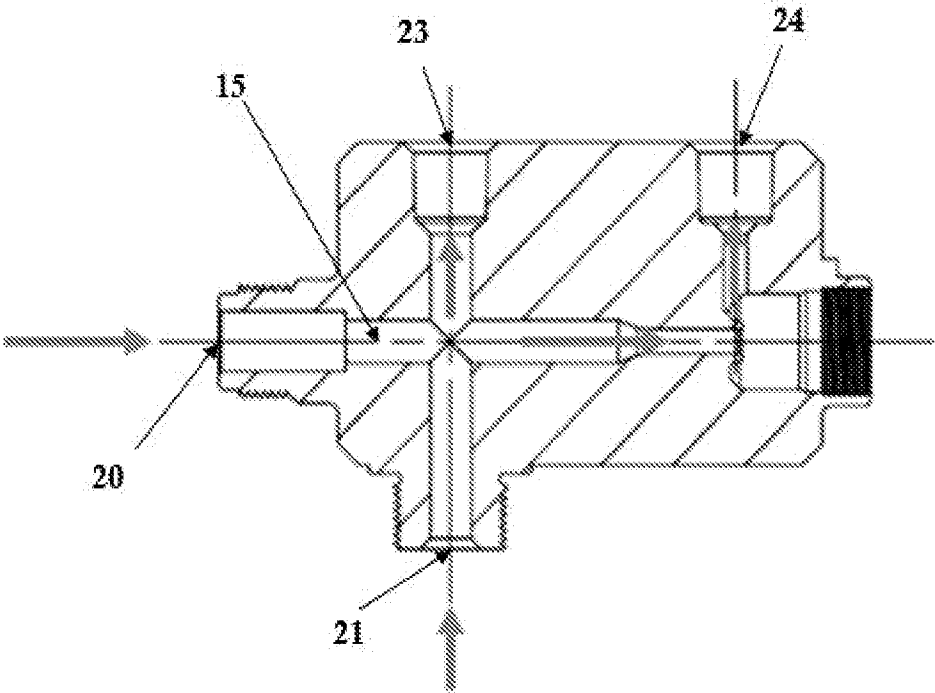


Fig. 9a

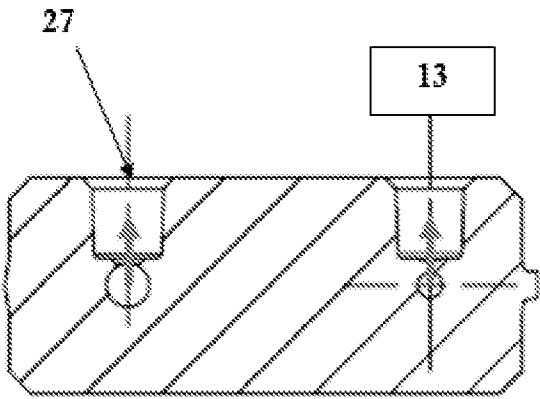


Fig. 9b

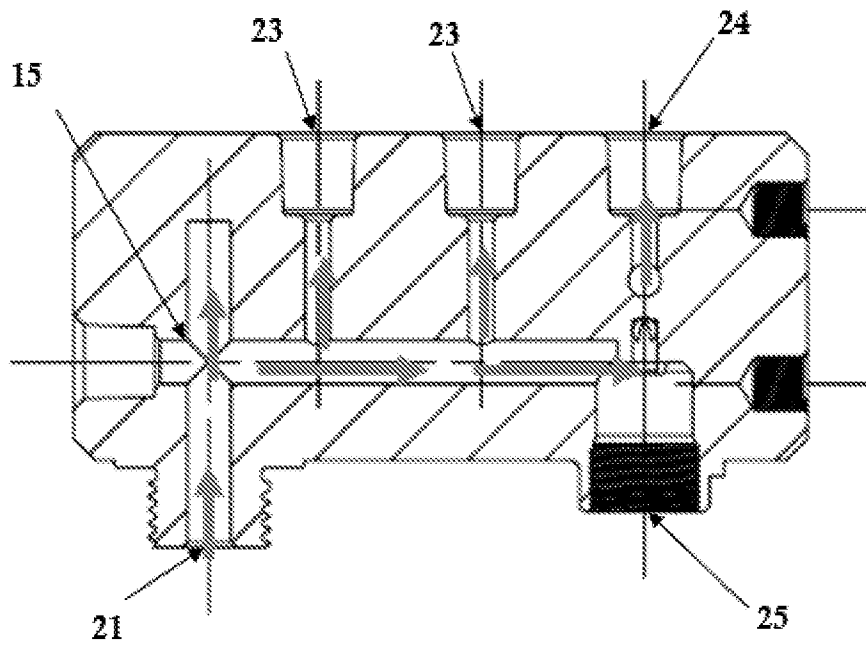


Fig. 10a

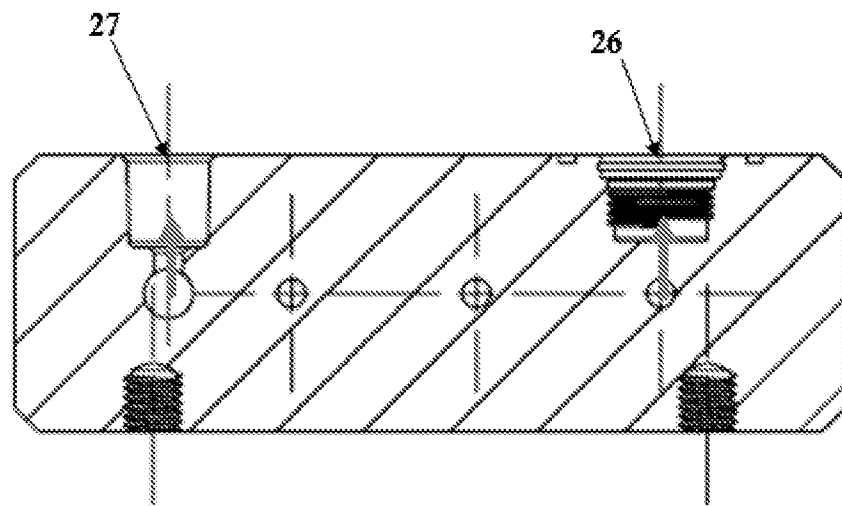


Fig. 10b

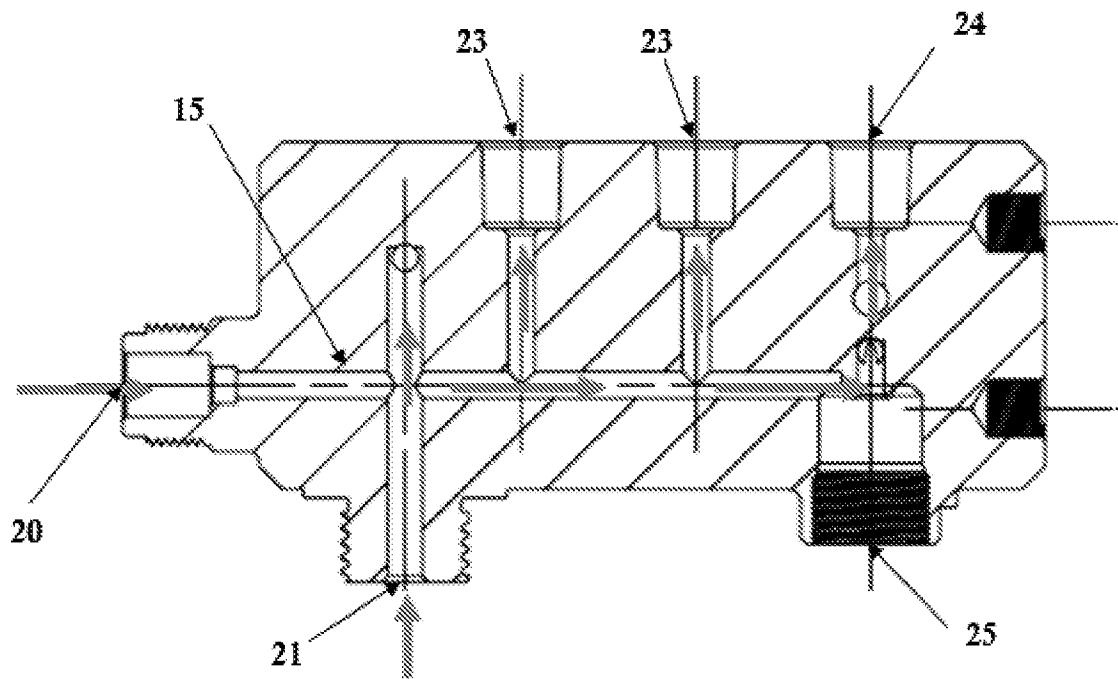


Fig. 11a

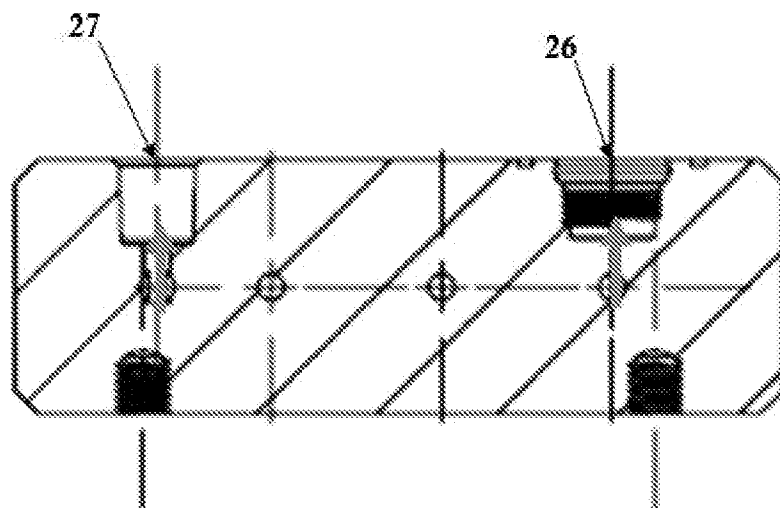


Fig. 11b

12/12

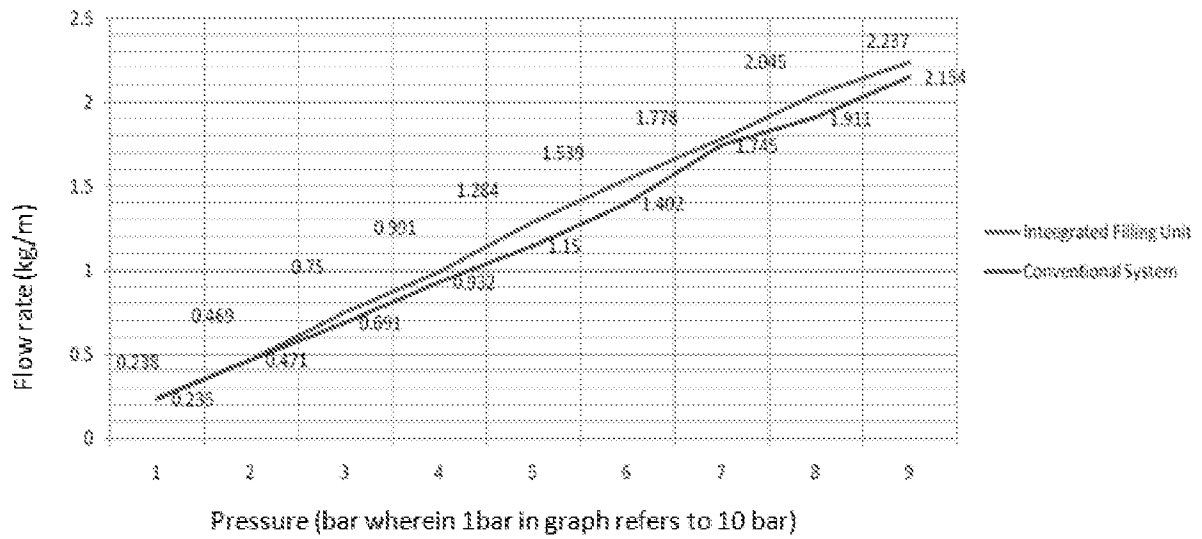


Fig. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2019/056538

A. CLASSIFICATION OF SUBJECT MATTER
F17C13/02, F17C13/04, F02B43/00, F02D19/06 Version=2019.01

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)

F17C, F02B, 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)

TotalPatent One, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US6321775 (B1) (THE JOHNS HOPKINS UNIVERSITY) 27 NOVEMBER 2001 (27.11.2001) abstract, Fig.1, column 2: lines 50-51, column1: lines 60-61 -----	1-10
A	US6041762 (A) (IMPCO TECHNOLOGIES, INC) 28 MARCH 2000 (28.03.2000) abstract, column 1: lines 33-34, column 2: lines 50-51	1-10

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"D" document cited by the applicant in the international application	"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
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"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	

Date of the actual completion of the international search 26-11-2019	Date of mailing of the international search report 26-11-2019
Name and mailing address of the ISA/ Indian Patent Office Plot No.32, Sector 14, Dwarka, New Delhi-110075 Facsimile No.	Authorized officer Sidharth Kumar Telephone No. +91-1125300200

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2019/056538

Citation	Pub.Date	Family	Pub.Date
US 6321775 B1	27-11-2001	AU 1237500 A	15-05-2000
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