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

(11) **EP 2 699 789 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
15.07.2015 Bulletin 2015/29

(21) Application number: **12712285.1**

(22) Date of filing: **01.03.2012**

(51) Int Cl.:
F02M 59/10 *(2006.01)* ***F02B 67/04*** *(2006.01)*
F02B 67/08 *(2006.01)* ***F02M 57/02*** *(2006.01)*
F01L 9/02 *(2006.01)*

(86) International application number:
PCT/FI2012/050205

(87) International publication number:
WO 2012/143601 (26.10.2012 Gazette 2012/43)

(54) FLUID SYSTEM AND INTERNAL COMBUSTION ENGINE

FLUIDSYSTEM UND BRENNKRAFTMASCHINE

SYSTÈME DE FLUIDE ET MOTEUR À COMBUSTION INTERNE

(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

(30) Priority: **21.04.2011 FI 20115391**

(43) Date of publication of application:
26.02.2014 Bulletin 2014/09

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Description

Technical field of the invention

[0001] The present invention relates to a fluid system for an internal combustion engine according to the preamble of claim 1. The invention also concerns an internal combustion engine in accordance with the preamble of the other independent claim.

[0002] Such system is disclosed in DE 10024268.

Background of the invention

[0003] Large reciprocating engines typically have several hydraulically operated systems for different purposes, such as lubrication, fuel injection and actuation of the gas exchange valves. Often there are one or more pumps for each of these systems. Alternatively, a high-pressure pump is used to supply hydraulic fluid to the different systems at high pressure and pressure reducing devices are used to reduce the pressure to the required lower pressure level in each system. In many applications, for instance in fuel injection systems, where the fuel pressure is increased or where the injection event is controlled with a separate hydraulic circuit, the hydraulic pressure and flow needs to be adjusted according to the operating conditions, such as the load and speed of the engine. The need for different pressure levels and/or flow rates leads to complicated systems with multiple pumps and/or to poor energy efficiency in the systems. A further disadvantage of prior art systems is that high-pressure pumps with adjustable flow capacity and/or pressure are expensive.

Summary of the invention

[0004] The object of the present invention is to provide an improved fluid system for an internal combustion engine. The fluid system comprises at least a first fluid circuit and a second fluid circuit, each of the fluid circuits forming part of a subsystem of an internal combustion engine. The characterizing features of the fluid system according to the invention are given in the characterizing part of claim 1. Another object of the invention is to provide an improved internal combustion engine. The internal combustion engine is characterized by a fluid system according to the present invention.

[0005] A fluid system according to the present invention comprises a pressure intensification arrangement comprising at least one pressure intensifier and having at least two alternative intensification ratios.

[0006] The invention has several advantages. Since a single pump can be used to supply fluid to several fluid circuits, the total number of pumps in the engine can be reduced. Alternatively, or in addition, some of the fluid circuits can be provided with a low-pressure pump instead of a high-pressure pump, which also helps to reduce costs of the system. Because of the simple construction of pressure intensifiers, the reliability of the system is improved. The invention also enables adjustment of the volume flow in the second circuit by controlling the operating frequency of the pressure intensifiers. A pressure intensification arrangement with at least two alternative intensification ratios enables the use of the invention for fluid circuits with varying pressure requirements.

[0007] The first fluid circuit can be, for instance, a hydraulic circuit operating gas exchange valves of the engine, or a lubricating oil circuit of the engine. The second fluid circuit can be, for instance, a hydraulic circuit operating fuel injectors of the engine, or a hydraulic circuit operating means for pressurizing fuel. There are different ways to implement the different intensification ratios. For instance, the fluid system can comprise two pressure intensifiers with different intensification ratios. Another option is to provide the pressure intensification arrangement with a pressure intensifier having at least two intensification ratios. The pump can be a variable displacement pump enabling variable output pressures and flows. The pressure intensifiers can be activated and deactivated for example by using electrically controllable means.

[0008] According to an embodiment of the invention, each pressure intensifier comprises a first chamber and a second chamber. At least one of the first chambers of the pressure intensifiers in the system is in fluid communication with the first fluid circuit and at least one of the second chambers is in fluid communication with the second fluid circuit. Each of the pressure intensifiers further comprises a reciprocating plunger having a first pressure surface in the first chamber and a second pressure surface in the second chamber, the area of the second pressure surface being smaller than the area of the first pressure surface.

[0009] According to another embodiment of the invention, the pressure intensifiers are connected in parallel so that the first chamber of each pressure intensifier is in flow communication with the first fluid circuit and the second chamber of each pressure intensifier is in flow communication with the second fluid circuit. With two or more pressure intensifiers connected in parallel, the second fluid circuit can be operated with constant pressure. While one of the pressure intensifiers pressurizes fluid in the second fluid circuit, other pressure intensifiers can be reloaded. The redundancy of pressure intensifiers also improves the reliability and safety of the system, which is important especially in marine applications.

[0010] According to another embodiment of the invention, the system comprises means for selectively connecting a first pressure intensifier and a second pressure intensifier in parallel or in series. In a series connection, the first chamber of the first pressure intensifier is in flow communication with the first fluid circuit, the second chamber of the first pressure intensifier is in flow communication with the first chamber of the second pressure intensifier, and the second chamber of the second pressure intensifier is in flow communication with the second fluid circuit. With this arrangement, different intensifica-

tion ratios can be selected according to the need.

Brief description of the drawings

[0011]

Fig. 1 shows schematically the main parts of the fluid system.
Fig. 2 shows a fluid system according to an embodiment of the invention.
Fig. 3 shows a fluid system according to another embodiment of the invention.
Fig. 4 shows a simplified illustration of a piston-type pressure intensifier.

Detailed description of the invention

[0012] Embodiments of the invention are now described in more detail with reference to the accompanying drawings.

[0013] In figure 1 is shown schematically the main parts of the fluid system according to the invention. The fluid system comprises a first fluid circuit 1 and a second fluid circuit 2. The fluid circuits 1, 2 are part of subsystems of a large internal combustion engine and work within different pressure ranges. The engine can be for instance a main or an auxiliary engine of a ship. The first fluid circuit 1 can be for example part of the lubrication oil system of the engine, or a hydraulic circuit operating gas exchange valves of the engine. The second fluid circuit 2 can be for example a hydraulic circuit that is used for operating fuel injectors of the engine or for pressurizing the fuel to be injected. In general, the required pressure level in the second fluid circuit 2 is higher than in the first fluid circuit 1. If the first fluid circuit 1 operates gas exchange valves of the engine, the pressure in the first fluid circuit 1 can be for example in the range between 200 and 350 bar. If the second fluid circuit 2 is used for pressurizing fuel, the pressure in the second fluid circuit 2 can be for example in the range between 250 and 700 bar.

[0014] The fluid system comprises a pump 3 for supplying pressurized fluid into the system. In the embodiment of figure 1, the same pump 3 is used for supplying fluid into the first fluid circuit 1 through a first fluid supply line 20, and into the second fluid circuit 2 through a second fluid supply line 21. The second fluid supply line 21 is provided with a check valve 24 for protecting the pump 3 and the first fluid circuit 1 from the higher pressure of the second fluid circuit 2. The pump 3 is a variable displacement pump that is capable of supplying fluid at different pressures and flow rates. From the first fluid circuit 1, the fluid is returned to the tank 5 through a first return line 22, and from the second fluid circuit 2 through a second return line 23.

[0015] For increasing the pressure in the second fluid circuit 2, the fluid system is provided with a pressure intensification arrangement 4. To meet the variable pressure requirements in the second fluid circuit 2, the pressure intensification arrangement 4 is constructed so that at least two different pressure intensification ratios can be selected. Different intensification ratios can be achieved by different means. According to an embodiment of the invention, the pressure intensification arrangement is provided with at least two pressure intensifiers. If the pressure intensifiers have different intensification ratios, the desired intensification ratio can be selected by using the pressure intensifier that is most suitable for those operating conditions. It is also possible that different combinations of the pressure intensifiers are used. For instance, for smaller amplification, only one of the pressure intensifiers is used. When greater amplification is needed, the pressure intensifiers can be connected in series. The pressure intensification arrangement 4 can also comprise a single pressure intensifier with at least two different intensification ratios.

[0016] In the embodiment of figure 2, the first fluid circuit 1 is arranged to operate gas exchange valves 14 of the engine and the second fluid circuit 2 is arranged to operate means 15 for pressurizing the fuel that is injected into the engine. The pressure intensification arrangement 4 comprises three pressure intensifiers 6, 7, 8. A first pressure intensifier 6 and a second pressure intensifier 7 are connected in parallel. A first control valve 9 is located between the first fluid circuit 1 and the first pressure intensifier 6, and a second control valve 10 is located between the first fluid circuit 1 and the second pressure intensifier 7. The first control valve 9 is arranged to open and close the fluid communication between the first fluid circuit 1 and the first pressure intensifier 6. The second control valve 10 is arranged to open and close the fluid communication between the first fluid circuit 1 and the second pressure intensifier 7. The first pressure intensifier 6 and the second pressure intensifier 7 have different intensification ratios. This enables different pressure amplification according to the required pressure level in the second fluid circuit 2. A third pressure intensifier 8 is arranged between the first and second pressure intensifiers 6, 7 and the second fluid circuit 2. A third control valve 11 is arranged to open and close flow communication between the first and second pressure intensifiers 6, 7 and the third pressure intensifier 8. In the embodiment of figure 2, the control valves 9, 10, 11 are solenoid valves. Since the control valves 9, 10, 11 can be used to prevent fluid flow from the first fluid circuit 1 to the second fluid circuit 2, they can be used as means for activating and deactivating the pressure intensifiers 6, 7, 8.

[0017] In figure 4 is shown an example of a suitable pressure intensifier 6, 7, 8. The pressure intensifier 6, 7, 8 comprises a reciprocating plunger 17 having a first pressure surface A1 and a second pressure surface A2. When fluid is introduced into a first chamber 18 of the pressure intensifier 6, 7, 8, the plunger 17 is moved. Consequently, fluid in a second chamber 19 of the pressure intensifier 6, 7, 8 is pressurized. The intensification ratio of the pressure intensifier 6, 7, 8 depends on the ratio

between the areas of the first pressure surface A1 and the second pressure surface A2.

[0018] The functioning of the pressure intensification arrangement 4 is now described with reference to figures 2 and 4. A drain valve 25, 26, 27 is arranged between each control valve 9, 10, 11 and pressure intensifier 6, 7, 8. Through the drain valve 25, 26, 27, the first chamber 18 of each pressure intensifier 6, 7, 8 can be emptied to the tank 5 for reloading the pressure intensifier 6, 7, 8. The duct connecting the second chamber 19 of each pressure intensifier 6, 7, 8 with the respective control valve 9, 10, 11 is provided with a first check valve 28 for allowing filling of the second chamber 18 when the pressure intensifier 6, 7, 8 is reloaded, but preventing the pressurized fluid from flowing to the wrong direction. The duct through which the pressurized fluid flows from each pressure intensifier 6, 7, 8 to the second fluid circuit 2 or to the third pressure intensifier 8 is provided with a second check valve 29 for preventing flow from the second fluid circuit 2 or from the third pressure intensifier 8 to the respective pressure intensifier 6, 7, 8.

[0019] A fourth control valve 12 is arranged to open and close the flow communication between the first and the second pressure intensifier 6, 7 and the second fluid circuit 2. By means of the fourth control valve 12, the third pressure intensifier 8 can be either by-passed or connected in series with either the first pressure intensifier 6 or the second pressure intensifier 7. If the third pressure intensifier 8 is by-passed, the total intensification ratio of the pressure intensification arrangement 4 is the same as that of the pressure intensifier 6, 7 that is used in the first pressure intensification stage. If the third pressure intensifier 8 is connected in series with the first or the second pressure intensifier 6, 7, the total intensification ratio is the product of the intensification ratios in the first and the second stages. Thus, with the pressure intensification arrangement according to the embodiment of figure 2, four different intensification ratios can be achieved. All the control valves 9, 10, 11, 12 and the drain valves 25, 26, 27 can be electrically controlled.

[0020] In the embodiment of figure 3, the pressure intensification arrangement 4 is provided with a first pressure intensifier 6 and a second pressure intensifier 7. The pressure intensifiers 6, 7 can be selectively connected in parallel or in series. The functioning of this embodiment is described with reference to figures 3 and 4. A first control valve 9 and a second control valve 10 can be used to choose which one of the first and the second pressure intensifiers 6, 7 is used for increasing pressure in the second fluid circuit 2. When the first control valve 9 is open and the second control valve 10 is closed, the first pressure intensifier 6 is in use. A third control valve 11 and a fourth control valve 12 are used for controlling whether the first pressure intensifier 6 is used alone or together with the second pressure intensifier 7. The control valves 9, 10, 11, 12 work thus as means for selectively connecting the pressure intensifiers 6, 7, 8 in parallel or in series. If the third control valve 11 is closed and the fourth control valve 12 is open, the first pressure intensifier 6 and the second pressure intensifier 7 are connected in series. The fluid from the second chamber 19 of the first pressure intensifier 6 flows into the first chamber 18 of the second pressure intensifier 7. The total intensification ratio of the pressure intensification arrangement 4 is thus the product of the intensification ratios of the two pressure intensifiers 6, 7. If the intensification ratios of the first and the second pressure intensifiers 6, 7 are different, three different intensification ratios can be achieved with the pressure intensification arrangement 4. Also in this embodiment, the pressure intensifiers 6, 7 are provided with drain valves 25, 26 enabling reloading of the pressure intensifiers 6, 7, and with check valves 28, 29 for guiding the pressurized fluid to the right direction. The pressure intensification arrangement 4 could also comprise more than two intensification stages. For instance, three pressure intensifiers could be arranged so that the pressure intensifiers can be selectively connected in parallel, all three pressure intensifiers in series, or any combination of two pressure intensifiers in series.

[0021] It will be appreciated by a person skilled in the art that the invention is not limited to the embodiments described above, but may vary within the scope of the appended claims. For instance, the fluid system can be provided with more than two fluid circuits. The additional fluid circuits can have the same or different pressure level than the first and second fluid circuits.

Claims

1. A fluid system for an internal combustion engine, the fluid system comprising at least a first fluid circuit (1) and a second fluid circuit (2), each of the fluid circuits (1, 2) forming part of a subsystem of an internal combustion engine, the fluid system further comprising a pump (3) for supplying fluid into the system and a pressure intensification arrangement (4) having at least two alternative intensification ratios and comprising at least a first pressure intensifier (6) for increasing pressure in the second fluid circuit (2) and a second pressure intensifier (7) for increasing pressure in the second fluid circuit (2), **characterized in that** each of the pressure intensifiers (6, 7) comprises a first chamber (18) and a second chamber (19), at least one of the first chambers (18) being in fluid communication with the first fluid circuit (1) and at least one of the second chambers (19) being in fluid communication with the second fluid circuit (2), each of the pressure intensifiers (6, 7) further comprising a reciprocating plunger (17) having a first pressure surface (A1) in the first chamber (18) and a second pressure surface (A2) in the second chamber (19), the area of the second pressure surface (A2) being smaller than the area of the first pressure surface (A1).

2. A fluid system according to claim 1, **characterized in that** the first fluid circuit (1) is a hydraulic circuit operating gas exchange valves (14) of the engine.

3. A fluid system according to claim 1, **characterized in that** the first fluid circuit (1) is a lubricating oil circuit of the engine.

4. A fluid system according to any of claims 1-3, **characterized in that** the second fluid circuit (2) is a hydraulic circuit operating fuel injectors (15) of the engine.

5. A fluid system according to any of claims 1-3, **characterized in that** the second fluid circuit (2) is a hydraulic circuit operating means (16) for pressurizing fuel.

6. A fluid system according to any of the preceding claims, **characterized in that** the pressure intensifiers (6, 7, 8) have different intensification ratios.

7. A fluid system according to any of the preceding claims, **characterized in that** the pressure intensifiers (6, 7, 8) are connected in parallel so that the first chamber (18) of each pressure intensifier (6, 7, 8) is in flow communication with the first fluid circuit (1) and the second chamber (19) of each pressure intensifier (6, 7, 8) is in flow communication with the second fluid circuit (2).

8. A fluid system according to any of claims 1-6, **characterized in that** the system comprises means (9, 10, 11, 12) for selectively connecting the first pressure intensifier (6) and the second pressure intensifier (7) in parallel or in series so that the first chamber (18) of the first pressure intensifier (6) is in flow communication with the first fluid circuit (1), the second chamber (19) of the first pressure intensifier (6) is in flow communication with the first chamber (18) of the second pressure intensifier (7), and the second chamber (19) of the second pressure intensifier (7) is in flow communication with the second fluid circuit (2).

9. A fluid system according to any of the preceding claims, **characterized in that** the system comprises electrically controllable means (9, 10, 11) for activating and deactivating the pressure intensifiers (6, 7, 8).

10. A fluid system according to any of the preceding claims, **characterized in that** each of the pressure intensifiers (6, 7, 8) has at least two different intensification ratios.

11. An internal combustion engine, **characterized by** a fluid system in accordance with any of claims 1-10.

Patentansprüche

1. Fluidsystem für eine Verbrennungskraftmaschine, wobei das Fluidsystem wenigstens einen ersten Fluidkreis (1) und einen zweiten Fluidkreis (2) umfasst, wobei jeder der Fluidkreise (1, 2) einen Teil eines Untersystems einer Verbrennungskraftmaschine bildet, wobei das Fluidsystem ferner eine Pumpe (3) zum Einspeisen von Fluid in das System und eine Druckverstärkungsanordnung (4), die wenigstens zwei alternative Verstärkungsverhältnisse hat und wenigstens einen ersten Druckverstärker (6) zum Steigern des Drucks in dem zweiten Fluidkreis (2) und einen zweiten Druckverstärker (7) zum Steigern des Drucks in dem zweiten Fluidkreis (2) umfasst, **dadurch gekennzeichnet, dass** jeder der Druckverstärker (6, 7) eine erste Kammer (18) und eine zweite Kammer (19) umfasst, wobei wenigstens eine der ersten Kammern (18) in Fluidverbindung mit dem ersten Fluidkreis (1) steht und wenigstens eine der zweiten Kammern (19) in Fluidverbindung mit dem zweiten Fluidkreis (2) steht, wobei jeder der Druckverstärker (6, 7) ferner einen hin- und hergehenden Tauchkolben (17) umfasst, der eine erste Druckfläche (A1) in der ersten Kammer (18) und eine zweite Druckfläche (A2) in der zweiten Kammer (19) hat, wobei die Fläche der zweiten Druckfläche (A2) kleiner ist als die Fläche der ersten Druckfläche (A1).

2. Fluidsystem nach Anspruch 1, **dadurch gekennzeichnet, dass** der erste Fluidkreis (1) ein Hydraulikkreis, der Gaswechselventile (14) des Motors betreibt, ist.

3. Fluidsystem nach Anspruch 1, **dadurch gekennzeichnet, dass** der erste Fluidkreis (1) ein Schmierölkreis des Motors ist.

4. Fluidsystem nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** der zweite Fluidkreis (2) ein Hydraulikkreis, der Kraftstoff-Einspritzvorrichtungen (15) des Motors betreibt, ist.

5. Fluidsystem nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** der zweite Fluidkreis (2) ein Hydraulikkreis, der Mittel (16) zum Unterdrucksetzen von Kraftstoff betreibt, ist.

6. Fluidsystem nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Druckverstärker (6, 7, 8) unterschiedliche Verstärkungsverhältnisse haben.

7. Fluidsystem nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Druckverstärker (6, 7, 8) parallel verbunden sind, so dass die erste Kammer (18) jedes Druckverstärkers (6, 7, 8) in Strömungsverbindung mit dem ersten Flu-

idkreis (1) steht und die zweite Kammer (19) jedes Druckverstärkers (6, 7, 8) in Strömungsverbindung mit dem zweiten Fluidkreis (2) steht.

8. Fluidsystem nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** das System Mittel (9, 10, 11, 12) umfasst, um selektiv den ersten Druckverstärker (6) und den zweiten Druckverstärker (7) so parallel oder in Reihe zu verbinden, dass die erste Kammer (18) des ersten Druckverstärkers (6) in Strömungsverbindung mit dem ersten Fluidkreis (1) steht, die zweite Kammer (19) des ersten Druckverstärkers (6) in Strömungsverbindung mit der ersten Kammer (18) des zweiten Druckverstärkers (7) steht und die zweite Kammer (19) des zweiten Druckverstärkers (7) in Strömungsverbindung mit dem zweiten Fluidkreis (2) steht.

9. Fluidsystem nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das System elektronisch steuerbare Mittel (9, 10, 11) zum Aktivieren und Deaktivieren der Druckverstärker (6, 7, 8) umfasst.

10. Fluidsystem nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** jeder der Druckverstärker (6, 7, 8) wenigstens zweiunterschiedliche Verstärkungsverhältnisse hat.

11. Verbrennungskraftmaschine, **gekennzeichnet durch** ein Fluidsystem nach einem der Ansprüche 1 bis 10.

Revendications

1. Système de fluide pour un moteur à combustion interne, le système de fluide comprenant au moins un premier circuit de fluide (1) et un deuxième circuit de fluide (2), chacun des circuits de fluide (1, 2) formant une partie d'un sous-système d'un moteur à combustion interne, le système de fluide comprenant en plus une pompe (3) pour alimenter en fluide le système et un agencement d'intensification de pression (4) ayant au moins deux rapports d'intensification alternatifs et comprenant au moins un premier intensificateur de pression (6) pour augmenter la pression dans le deuxième circuit de fluide (2) et un deuxième intensificateur de pression (7) pour augmenter la pression dans le deuxième circuit de fluide (2) **caractérisé en ce que** chacun des intensificateurs de pression (6, 7) comprend une première chambre (18) et une deuxième chambre (19), au moins une des premières chambres (18) étant en communication de fluide avec le premier circuit de fluide (1) et au moins une des deuxièmes chambres (19) étant en communication de fluide avec le deuxième circuit de fluide (2), chacun des intensificateurs de pression (6, 7) comprenant en plus un plongeur alternatif (17) ayant une première surface de pression (A1) dans la première chambre (18) et une deuxième surface de pression (A2) dans la deuxième chambre (19), l'aire de la deuxième surface de pression (A2) étant plus petite que l'aire de la première surface de pression (A1).

2. Système de fluide selon la revendication 1 **caractérisé en ce que** le premier circuit de fluide (1) est un circuit hydraulique faisant fonctionner des soupapes d'échange de gaz (14) du moteur.

3. Système de fluide selon la revendication 1 **caractérisé en ce que** le premier circuit de fluide (1) est un circuit d'huile lubrifiante du moteur.

4. Système de fluide selon l'une quelconque des revendications 1-3 **caractérisé en ce que** le deuxième circuit de fluide (2) est un circuit hydraulique faisant fonctionner des injecteurs de carburant (15) du moteur.

5. Système de fluide selon l'une quelconque des revendications 1-3 **caractérisé en ce que** le deuxième circuit de fluide (2) est un circuit hydraulique faisant fonctionner un moyen (16) pour pressuriser le carburant.

6. Système de fluide selon l'une quelconque des revendications précédentes **caractérisé en ce que** les intensificateurs de pression (6, 7, 8) ont des rapports d'intensification différents.

7. Système de fluide selon l'une quelconque des revendications précédentes **caractérisé en ce que** les intensificateurs de pression (6, 7, 8) sont raccordés en parallèle de sorte que la première chambre (18) de chaque intensificateur de pression (6, 7, 8) est en communication d'écoulement avec le premier circuit de fluide (1) et la deuxième chambre (19) de chaque intensificateur de pression (6, 7, 8) est en communication d'écoulement avec le deuxième circuit de fluide (2).

8. Système de fluide selon l'une quelconque des revendications 1-6 **caractérisé en ce que** le système comprend des moyens (9, 10, 11, 12) pour raccorder sélectivement le premier intensificateur de pression (6) et le deuxième intensificateur de pression (7) en parallèle ou en série de sorte que la première chambre (18) du premier intensificateur de pression (6) est en communication d'écoulement avec le premier circuit de fluide (1), la deuxième chambre (19) du premier intensificateur de pression (6) est en communication d'écoulement avec la première chambre (18) du deuxième intensificateur de pression (7) et la deuxième chambre (19) du deuxième intensifica-

teur de pression (7) est en communication d'écoulement avec le deuxième circuit de fluide (2).

9. Système de fluide selon l'une quelconque des revendications précédentes **caractérisé en ce que** le système comprend des moyens pouvant être commandés électriquement (9, 10, 11) pour activer et désactiver les intensificateurs de pression (6, 7, 8).

10. Système de fluide selon l'une quelconque des revendications précédentes **caractérisé en ce que** chacun des intensificateurs de pression (6, 7, 8) a au moins deux rapports d'intensification différents.

11. Moteur à combustion interne **caractérisé par** un système de fluide selon l'une quelconque des revendications 1-10.

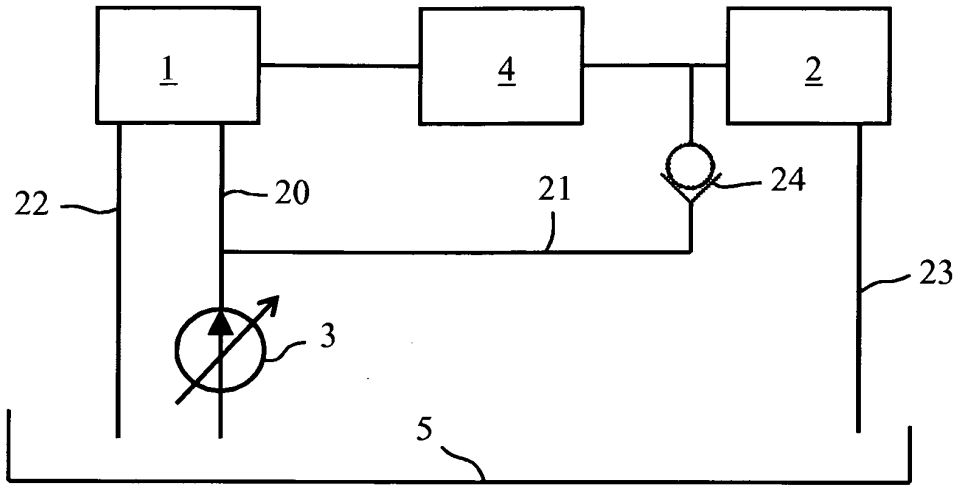
1
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FIG. 1

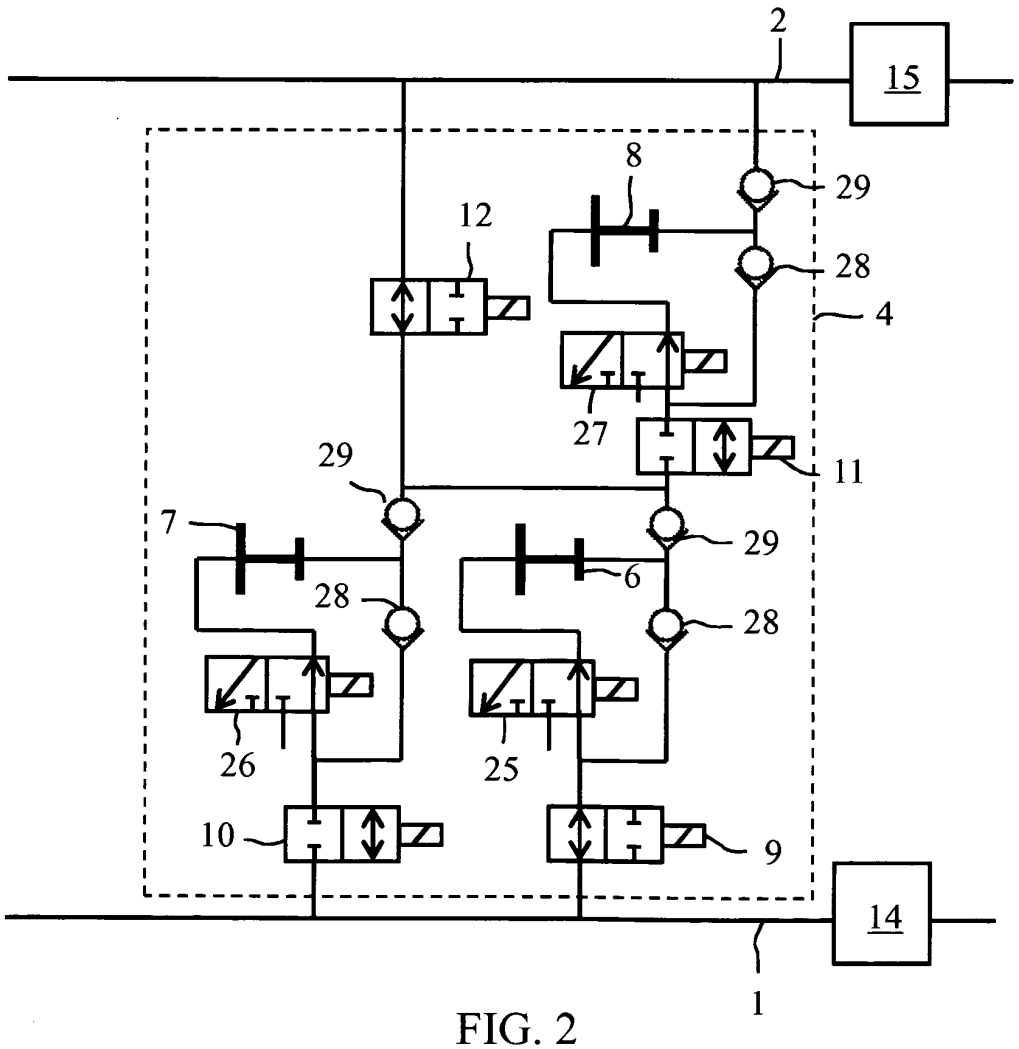
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FIG. 2

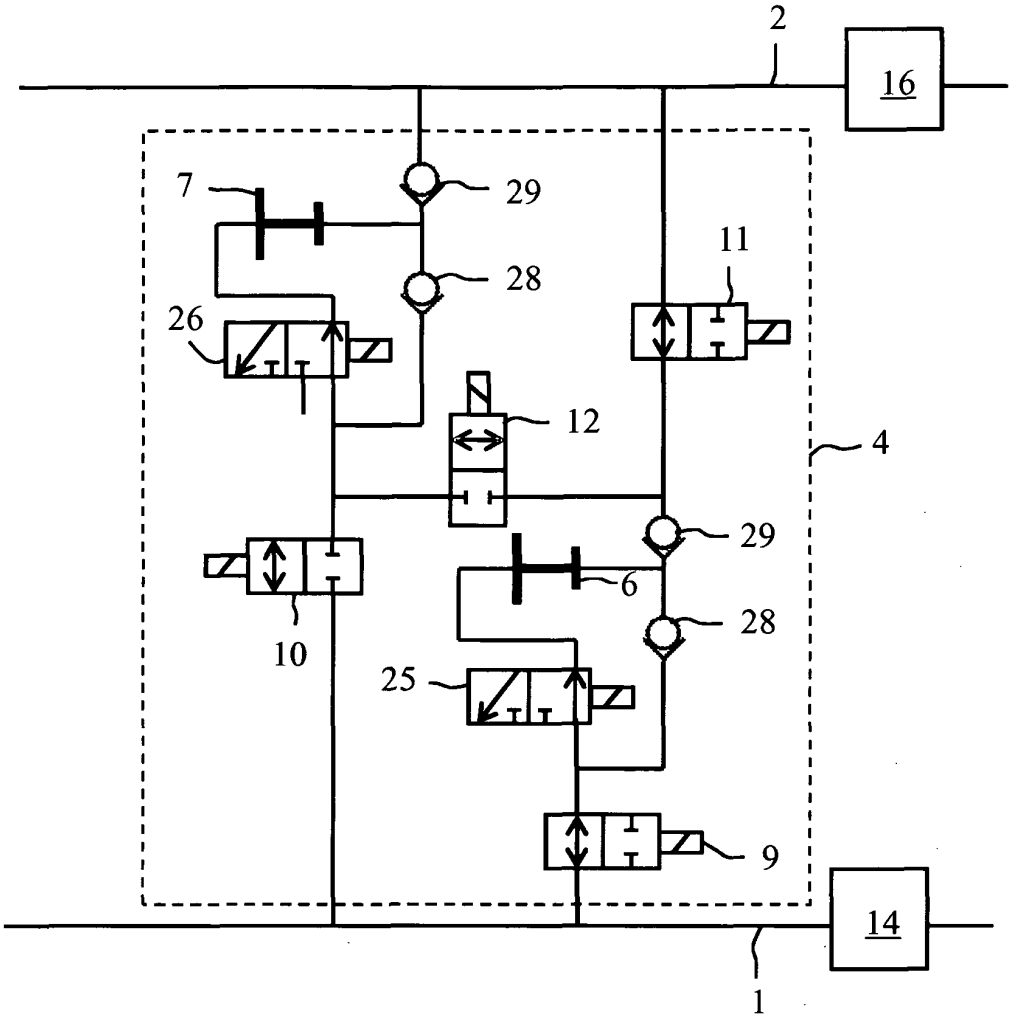

FIG. 3

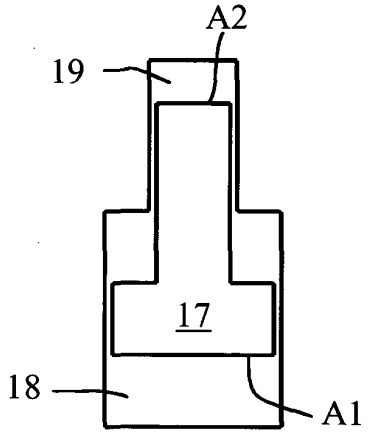

FIG. 4

REFERENCES CITED IN THE DESCRIPTION

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