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(54) **FUEL INJECTION SYSTEM FOR A PISTON ENGINE**

KRAFTSTOFFEINSPRITZSYSTEM FÜR EINEN KOLBENMOTOR

SYSTÈME D'INJECTION DE CARBURANT POUR UN MOTEUR À PISTONS

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Description

[0001] The invention relates to a fuel injection system for a piston engine according the preamble of claim 1.

[0002] For improving operation of piston engines a so-called common rail fuel injection system is commonly used. In the common rail system the pressure supply and the fuel injection are functionally separated from each other. Fuel is fed by means of high pressure pump into a common pressure supply, from which it is led through separate pipes into injector of each cylinder.

[0003] Document WO 2005/038232 discloses a fuel injection system in which the leak flow space of the high-pressure pipe is connected via a valve to an expansion space and furthermore, the pressure in the leak flow space is measured. The valve provides the operatively necessary limitation of the volume of the flow space for pressure measurement and at the same time it acts as a discharge passage for possible over-pressure and leak fuel. A direct passage out of the engine may act as an expansion space. Another option is to use the channel for continuous leak connected to the fuel recycle system as an expansion space.

[0004] The object of the present invention is to provide an improved fuel injection system for a piston engine.

[0005] The object of the invention is achieved by a fuel injection system according to claim 1. The fuel injection system according to the invention comprises at least one pressure accumulator for pressurized fuel and injectors connected to the pressure accumulator or pressure accumulators for injecting pressurized fuel into the cylinders. The system further comprises a leakage channel arrangement for removing fuel leaking from the injectors. The leakage channel arrangement is provided with a leak detector for detecting a fuel leak. Further, fuel injection from the injector is controlled by a fuel pressure in a control chamber of the injector and a return pipe is connected to the injector, through which return pipe fuel is removed from the control chamber.

[0006] In the following the invention is described by way of example with reference to the attached drawings, in which

Figure 1 shows schematically one fuel injection system according to the invention.

Figure 2 shows as a cross-sectional view a fuel injector that can be used in the fuel injection system of fig.1.

Figure 3 shows as a cross-sectional view a connection of the supply pipe to the fuel injector and to the cylinder head.

Figure 4 shows as a cross-sectional view a leaking fuel detector that can be used in the fuel injection system of fig. 1.

Figure 1 shows schematically a common rail fuel injection system 1 of a large piston engine, for example of a large diesel engine. Large piston engine refers here to such engines that can be used for instance as main and auxiliary engines in ships or in power plants for production of heat and/or electricity. The engine can be operated by heavy fuel oil. The fuel injection system 1 comprises a fuel source, for example a fuel tank 2, from which fuel is fed by means of a low pressure fuel pump 3 through a fuel pipe 4 to a high pressure pump 5, which in turn elevates the pressure of the fuel to a such level that a sufficient injection pressure may be obtained in the injectors 6.

[0007] The fuel injection system 1 comprises at least one pressure accumulator 7, 8 for high pressure fuel. The system shown in fig. 1 comprises two separate accumulators 7, 8 arranged in flow connection with each other via a connecting pipe 9. Fuel is fed from the high pressure pump 5 into the first pressure accumulator 7 from which fuel is further fed through the connecting pipe 9 into a second pressure accumulator 8. Further, each injector 6 may be provided with an injector pressure accumulator 18, into which fuel is fed from the pressure accumulator 7, 8. The second pressure accumulator 8 is provided with a circulation valve 10 through which fuel can be circulated in the injection system 1 for heating before the start-up of the engine. The second pressure accumulator 8 is also provided with a safety valve 11 for maintaining the pressure in the pressure accumulators 7, 8 and/or injector pressure accumulators 18 below a predetermined maximum value. Safety valve 11 can also be used to de-pressurize the pressure accumulators 7, 8 and/or injector pressure accumulators 18 when necessary. The volume of the pressure accumulators 7, 8 can be defined by the formula:

$$V_{acc} = S / (V_{inj} * N_{inj}),$$

in which

V_{acc} = volume of the pressure accumulator,
 V_{inj} = amount (volume) of fuel injected by the injector during one injection event at full (100 %) engine load,
 N_{inj} = number of injectors connected to said accumulator,
 so that value S is in the range from 50 to 100.

[0008] The fuel injection system 1 comprises injectors 6 for injecting fuel into the cylinders 12 of the engine. The structure of the fuel injectors 6 is shown in more detail in figure 2. The injectors 6 are mounted in the cylinder head 13 of the engine. Each injector 6 is connected via a supply pipe 14 to the pressure accumulator 7, 8. The end part of the supply pipe 14 is arranged in a bore 35 in the

cylinder head 13. In the embodiment shown in fig. 1 several injectors 6 are connected to each pressure accumulator 7, 8, but when necessary, only one injector 6 may be connected to each accumulator 7, 8. Fuel is fed from the pressure accumulators 7, 8 to the injectors 6 via supply pipes 14. The supply pipes 14 are provided with double walls. The inner flow space of supply pipe 14 is for high pressure fuel and the outer flow space acts as a collecting channel for possibly leaking fuel. The outer flow spaces of the supply pipes are in flow connection with a fuel leak detection system which can be arranged in connection with the pressure accumulator 7, 8. Examples of such fuel leak detection systems are described in EP-patent 1 150 006.

[0009] The injector 6 comprises a body 15 in which a valve needle 16 is arranged to control fuel injection from a fuel chamber 17 into the cylinder 12. Depending on the position of the valve needle 16 the fuel injection from the fuel chamber 17 into the cylinder 12 is either allowed or prevented. The injector 6 comprises an injector pressure accumulator 18 into which fuel is fed via the supply pipe 14. The volume of the injector pressure accumulator 18 is at least 40, typically 60 to 100 times the amount (volume) of fuel injected by the injector during one injection event at full (100 %) engine load. Fuel is fed from the injector pressure accumulator 18 via a connecting channel 34 into the fuel chamber 17. A flow fuse 19 is arranged between the injector pressure accumulator 18 and the fuel chamber 17. The flow fuse 19 prevents the fuel flow from the injector pressure accumulator 18 to the fuel chamber 17 in case of malfunction of the injector 6, for example when the valve needle 16 does not close properly.

[0010] The injector 6 comprises a control chamber 20 into which fuel is fed via the supply pipe 14. The fuel pressure in the control chamber 20 acts on the valve needle 16. The pressure force of the fuel in the control chamber 20 urges the valve needle 16 toward the closed position. The movement of the valve needle 16 and thus the fuel injection into the cylinder 12 can be controlled by fuel pressure prevailing in the control chamber 20. A return pipe 21 for removing fuel from the control chamber 20 is connected to the injector 6. Return pipe 21 is arranged in or connected to a second bore 42 in the cylinder head 13. Fuel removed from the control chamber 20 through the return pipe 21 is used for controlling the fuel injection from the injector 6. A control valve 22 is arranged in the return pipe 21 for controlling the discharge of fuel from the control chamber 20. The control valve 22 can be a solenoid valve. An inlet of the control chamber is provided with a throttle by which the fuel flow into the control chamber 20 is restricted. The injector 6 is also provided with a spring 23 which urges the valve needle 16 toward the closed position.

[0011] To initiate the fuel injection the control valve 22 is opened. Fuel flows from the control chamber 20 into return pipe 21 and the fuel pressure in the control chamber 22 decreases. Fuel flows through return pipe 21 into

the fuel tank 2. Fuel pressure in the return pipe 21 is typically about 4 bars or above 4 bars. As the pressure in the control chamber 22 is low enough, force caused by the fuel pressure in the fuel chamber 17 urges the valve needle 16 toward the open position against the force of spring 23. As a result, the valve needle 16 is lifted from its seat and fuel is injected from the fuel chamber 17 into the cylinder 12. When the control valve 22 is closed, fuel pressure in the control chamber 20 increases. Consequently, the valve needle 16 returns to its closed position against the seat so that fuel injection from the fuel chamber 17 into cylinder 12 stops.

[0012] The fuel injection system 1 is provided with a leakage channel arrangement 24 for removing so-called dirty leakage from the injectors 6. Dirty leakage is undesired fuel leakage from the injectors 6, for example leakage from the clearances between the injector parts and/or mixture of fuel and sealing oil of the injector. The leakage channel arrangement 24 comprises branch channels 25 connected to or in flow connection with the injectors 6. Further, the leakage channels arrangement 24 comprises collecting channel 26 connected to the branch channels 25 so that leaking fuel flow from the branch channels 25 is led to the collecting channel 26. The injector body 15 has a leakage outlet port through which dirty leakage can be removed from the injector 6 and introduced into the branch channel 25. The branch channel 25 is in flow communication with the leakage outlet port. Branch channel 25 is arranged in a bore in the cylinder head 13. The bore 35 in which the supply pipe 14 is arranged can also be utilized for the branch channel 25 so that the clearance 38, 39 between the outer surface of the supply pipe 14 and the inner surface of the bore 35 acts as the branch channel 25.

[0013] Figure 3 shows in more detail the connection of the supply pipe 14 to the fuel injector 6 and to the cylinder head 13. The supply pipe 14 comprises a first part 14a arranged between the pressure accumulator 7, 8 and the cylinder head 13 and a second part 14b arranged between the first part 14a and the injector 6. The first part 14a is provided with double walls. The second part 14b is a single wall pipe. Thus, the second part 14b comprises a flow space for high pressure fuel only. The second part 14b is arranged in a bore 35 in the cylinder head 13. The bore 35 comprises two chambers 38, 39. High pressure fuel from the pressure accumulator 7, 8 is delivered through the first part 14a of the supply pipe into the cylinder head 13 and through a second part 14b part of the supply pipe 14 further within the cylinder head 13 into the injector 6. A first end 36a of the second part 14b is tightly connected with the first part 14a. Any suitable fixing means 37, for example a sleeve with threaded connection with the pipe end 36a, may be provided for securing the tight connection between the first part 14a and the second part 14b. The second end 36b of the second part 14b is in direct connection with the injector 6 by means of mutual contact surfaces 37a and 6a respectively. The surface 6a may be cone formed and the sur-

face 37a is preferably ball shaped for providing a reliable and tight engagement.

[0014] The cylinder head 13 is provided with a first chamber 38 which is in communication with the leakage outlet port by means of a second chamber 39. The second chamber 39 has a smaller diameter than the first chamber 38. The arrangement includes a further fixing means 40, for instance a sleeve or the like bolt element, through which the second part 14b is led and which is engaged by threads 41 with the first chamber 38 in the cylinder head 13. The second part 14b is provided with an enlarged part 14c with a counter surface 37b arranged in cooperation with the surface 40a on the fixing means 40. These surfaces 37b and 40a can be cone formed. Alternatively, in analogy with the surface 37a the surface 37b may also be ball formed so as to better comply with possible bending of the second part 14b as discussed below. Hereby the second part 14b can be tightly sealed to the counter surface 40a of the fixing means 40 more close to the first end 36a of the second part. The enlarged part 14c need not be an integral part of the second part 14b but if desired it may also be implemented as a separate threaded connection sleeve for instance.

[0015] As can be seen from the fig. 3 the part of the second part 14b between the enlarged part 14c and the injector 6 is of substantial length especially in view of its diameter. The advantage of this kind of layout of the second part 14b within the second chamber 39 is the long strain length which enables retention of load despite fuel temperature operation extremes of 40°C up to 150°C with heavy fuel oil. If needed the second chamber 39 allows some bending of the second part 14b so that sufficient retention of load can be maintained under different conditions. On the other hand, this part of the second part 14b may be provided with some guidance to provide limits to a bending of this kind. In the figure this is only schematically indicated by means of a supporting element 41. Naturally such a supporting element should be designed to allow leakage through it so as to allow leakage flow through the chambers 38 and 39 as described below.

[0016] The first chamber 38 is through the second chamber 39 in communication with the leakage outlet port. Thus, these chambers 38, 39 act as a branch channel 25 and are utilised for removing dirty leakage from the injector 6. The branch channel 25 comprises a duct 42 through which dirty leakage is removed from the cylinder head 13.

[0017] Leakage channel arrangement 24 is provided with a leak detector 28 for detecting fuel leaks. The leak detector 28 is connected to the collecting channel 26 to a location through which all fuel from the branch channels 25 is arranged to flow. Because in normal operating conditions of the injectors 6 only a small amount of fuel is leaking, it is favorable that only larger flows of leaking fuel are detected. Therefore, the leak detector 28 is arranged to detect larger flows only i.e. only leaking fuel flows having a flow rate over a predetermined value. The leak detector 28 is incapable of detecting leaking fuel

flows having a flow rate below said predetermined value.

[0018] Figure 4 shows as a cross sectional view a leak detector 28 suitable for use in the fuel injection system of fig. 1. The collecting channel 26 is connected to a leakage inlet 30 of the detector 28. The leak detector 28 comprises a control chamber 29 in which leaking fuel enters through the leakage inlet 30. The bottom of the control chamber is provided with an orifice 31 through which fuel is drained from the control chamber 29. The orifice 31 is dimensioned so that fuel leakage occurring in normal operating conditions of the injectors 6 is completely drained from the control chamber 29. When larger flow of leaking fuel enters the control chamber 29, all the fuel cannot be drained through the orifice 31 and as a result the fuel level in the control chamber 29 rises. The control chamber 29 is provided with a fuel level detection means 32, e.g. a float or level detector, which triggers an alarm or otherwise informs when the fuel level in the control chamber 29 rises to a point indicating larger dirty fuel leakage from one or several injector(s) 6. Thus, the leak detector 28 is arranged to detect only leaking fuel flows having a flow rate over a predetermined value. Because of larger dirty fuel leakage from the injector 6, the corresponding cylinder 12 does not operate optimally and the operating parameters of the cylinder 12 are outside the normal limits. The leaking injector 6 can be located by an engine control system which monitors operating parameters of the cylinders, for example cylinder pressure or exhaust gas temperature. Upper part of the control chamber 29 is provided with a leakage outlet 33 through which excess fuel is drained. From the leak detector 28 fuel is led into the fuel tank 2. In normal operating conditions of the injectors 6 the branch and collecting channels 25, 26 of the leakage channel arrangement 24 and the control chamber 29 are pressureless (i.e. at atmospheric pressure).

Claims

1. Common rail fuel injection system (1) for a piston engine with several cylinders (12), the fuel injection system (1) comprising:
 - at least one pressure accumulator (7, 8, 18) for pressurized fuel,
 - injectors (6) for injecting pressurized fuel into the cylinders (12), said injectors (6) being connected to the pressure accumulator(s) (7, 8), from which fuel is fed to the injectors (6) via supply pipes (14), which are provided with double walls, wherein an inner flow space of the supply pipe (14) is for high pressure fuel and an outer flow space acts as a collecting channel for possibly leaking fuel, and
 - a leakage channel arrangement (24) for removing fuel leaking from the injectors (6), which leakage channel arrangement (24) comprises

- branch channels (25) connected to the injectors (6) and a collecting channel (26) arranged in flow connection with the branch channels (25), **characterized in that** a leak detector (28) for detecting a fuel leak is connected to the collecting channel (26), fuel injection from the injector (6) is controlled by a fuel pressure in a control chamber (20) of the injector (6), and a return pipe (21) is connected to the injector (6), through which return pipe (21) fuel is removed from the control chamber (20).
2. A fuel injection system according to claim 1, **characterized in that** the leak detector (28) is arranged to detect only leaking fuel flows having a flow rate over a predetermined value.
 3. A fuel injection system according to any preceding claim, **characterized in that** the injector (6) comprises an injector pressure accumulator (18) for fuel to be injected.
 4. A fuel injection system according to any preceding claim, **characterized in that** the injectors (6) are connected to the pressure accumulator(s) (7, 8) through supply pipes (14) that are arranged in bores (35) in a cylinder head (13) of the engine.
 5. A fuel injection system according to claim 6, **characterized in that** the clearance (38, 39) between the supply pipe (14) and the bore (35) forms part of the leakage channel arrangement (24).
 6. A fuel injection system according to any preceding claim, **characterized in that** the channels (25, 26) of the channel arrangement (24) are pressureless.
 7. A fuel injection system according to any preceding claim, **characterized in that** the leak detector (28) comprises a control chamber (29) for leaking fuel and an orifice (31) through which fuel can be removed from the control chamber (29), the orifice being dimensioned so that fuel leakage occurring in normal operating conditions of the injectors (6) can be removed from the control chamber (29).
 8. A fuel injection system according to claim 7, **characterized in that** the control chamber of the leak detector (28) is provided with a fuel level detection means (32).
- Patentansprüche**
1. Kraftstoff-Einspritzanlage (1) mit gemeinsamer Druckleitung für einen Kolbenmotor mit mehreren Zylindern (12), wobei die Kraftstoff-Einspritzanlage (1) Folgendes umfasst:
 - wenigstens einen Drucksammler (7, 8, 18) für unter Druck gesetzten Kraftstoff, Einspritzvorrichtungen (6) zum Einspritzen von unter Druck gesetztem Kraftstoff in die Zylinder (12), wobei die Einspritzvorrichtungen (6) mit dem/den Drucksammler(n) (7, 8) verbunden sind, von denen der Kraftstoff den Einspritzvorrichtungen (6) über Zufuhrrohre (14) zugeführt wird, die mit doppelten Wänden versehen sind, wobei ein innerer Durchflussraum des Zufuhrrohres (14) für Hochdruck-Kraftstoff ist und ein äußerer Durchflussraum als ein Sammelkanal für möglicherweise auslaufenden Kraftstoff wirkt, und eine Auslaufkanalanordnung (24) zum Entfernen von Kraftstoff, der aus den Einspritzvorrichtungen (6) ausläuft, wobei die Auslaufkanalanordnung (24) Zweigkanäle (25), die mit den Einspritzvorrichtungen (6) verbunden sind, und einen Sammelkanal (26), der in Durchflussverbindung mit den Zweigkanälen (25) angeordnet ist, umfasst, **dadurch gekennzeichnet, dass** ein Leckdetektor (28) zum Erkennen eines Kraftstofflecks mit dem Sammelkanal (26) verbunden ist, die Kraftstoffeinspritzung von der Einspritzvorrichtung (6) durch einen Kraftstoffdruck in einer Steuerkammer (20) der Einspritzvorrichtung (6) gesteuert wird und ein Rückführrohr (21) mit der Einspritzvorrichtung (6) verbunden ist, wobei durch das Rückführrohr (21) Kraftstoff aus der Steuerkammer (20) entfernt wird.
 2. Kraftstoff-Einspritzanlage nach Anspruch 1, **dadurch gekennzeichnet, dass** der Leckdetektor (28) dafür angeordnet ist, nur auslaufende Kraftstoffströme zu erkennen, die eine Durchflussgeschwindigkeit über einem vorbestimmten Wert haben.
 3. Kraftstoff-Einspritzanlage nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Einspritzvorrichtung (6) einen Einspritzvorrichtungsdrucksammler (18) für einzuspritzenden Kraftstoff umfasst.
 4. Kraftstoff-Einspritzanlage nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Einspritzvorrichtungen (6) Zufuhrrohre (14), die in Bohrungen (35) in einem Zylinderkopf (13) des Motors angeordnet sind, mit dem/den Drucksammler(n) (7, 8) verbunden sind.
 5. Kraftstoff-Einspritzanlage nach Anspruch 4, **dadurch gekennzeichnet, dass** der Freiraum (38, 39) zwischen dem Zufuhrrohr (14) und der Bohrung (35) einen Teil der Auslaufkanalanordnung (24) bildet.
 6. Kraftstoff-Einspritzanlage nach einem der vorherge-

henden Ansprüche, **dadurch gekennzeichnet, dass** die Kanäle (25, 26) der Kanalanordnung (24) drucklos sind.

7. Kraftstoff-Einspritzanlage nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Leckdetektor (28) eine Steuerkammer (29) für auslaufenden Kraftstoff und eine Öffnung (31), durch die der Kraftstoff aus der Steuerkammer (29) entfernt werden kann, umfasst, wobei die Öffnung so bemessen ist, dass ein Kraftstoff-Auslaufverlust, der unter normalen Betriebsbedingungen der Einspritzvorrichtungen (6) auftritt, aus der Steuerkammer (29) entfernt werden kann.
8. Kraftstoff-Einspritzanlage nach Anspruch 7, **dadurch gekennzeichnet, dass** die Steuerkammer (29) des Leckdetektors (28) mit einem Kraftstoffpegel-Erkennungsmittel (32) versehen ist.

Revendications

1. Système d'injection de carburant à rampe commune d'injection (1) pour un moteur à pistons avec plusieurs cylindres (12), le système d'injection de carburant (1) comprenant :

- au moins un accumulateur de pression (7, 8, 18) destiné au carburant pressurisé,
- des injecteurs (6) pour injecter du carburant pressurisé dans les cylindres (12), lesdits injecteurs (6) étant raccordés au(aux) accumulateur(s) de pression (7, 8), à partir desquels du carburant est alimenté dans les injecteurs (6) via des tuyaux d'alimentation (14), qui sont prévus avec des parois doubles, dans lequel un espace d'écoulement intérieur du tuyau d'alimentation (14) est destiné au carburant à haute pression et un espace d'écoulement extérieur agit comme un canal de collecte d'un carburant fuyant éventuellement, et
- un agencement de canal de fuite (24) pour éliminer du carburant fuyant des injecteurs (6), lequel agencement de canal de fuite (24) comprend des canaux d'embranchement (25) raccordés aux injecteurs (6) et un canal de collecte (26) agencé en raccordement de flux avec les canaux d'embranchement (25),

caractérisé en ce que un détecteur de fuite (28) pour détecter une fuite de carburant est raccordé au canal de collecte (26), une injection de carburant provenant de l'injecteur (6) est commandée par une pression de carburant dans une chambre de commande (20) de l'injecteur (6), et un tuyau de retour (21) est raccordé à l'injecteur (6), par l'intermédiaire duquel tuyau de retour (21) du carburant est éliminé de la chambre

de commande (20).

2. Système d'injection de carburant selon la revendication 1, **caractérisé en ce que** le détecteur de fuite (28) est agencé afin de détecter seulement les flux de fuite de carburant ayant un débit supérieur à une valeur prédéterminée.
3. Système d'injection de carburant selon une quelconque des revendications précédentes, **caractérisé en ce que** l'injecteur (6) comprend un accumulateur de pression d'injecteur (18) pour le carburant à injecter.
4. Système d'injection de carburant selon une quelconque des revendications précédentes, **caractérisé en ce que** les injecteurs (6) sont raccordés au(x) accumulateur(s) de pression (7, 8) par l'intermédiaire de tuyaux d'alimentation (14) qui sont agencés dans des alésages (35) dans une tête de cylindre (13) du moteur.
5. Système d'injection de carburant selon la revendication 6, **caractérisé en ce que** le dégagement (38, 39) entre le tuyau d'alimentation (14) et l'alésage (35) fait partie de l'agencement de canal de fuite (24).
6. Système d'injection de carburant selon une quelconque des revendications précédentes, **caractérisé en ce que** les canaux (25, 26) de l'agencement de canal (24) sont dépressurisés.
7. Système d'injection de carburant selon une quelconque des revendications précédentes, **caractérisé en ce que** le détecteur de fuite (28) comprend une chambre de commande (29) pour le carburant fuyant et un orifice (31) à travers lequel du carburant peut être éliminé de la chambre de commande (29), l'orifice étant dimensionné de telle sorte qu'une fuite de carburant se produisant dans des conditions de fonctionnement normales des injecteurs (6) puisse être éliminée de la chambre de commande (29).
8. Système d'injection de carburant selon la revendication 7, **caractérisé en ce que** la chambre de commande (29) du détecteur de fuite (28) est pourvue d'un moyen de détection du niveau de carburant (32).

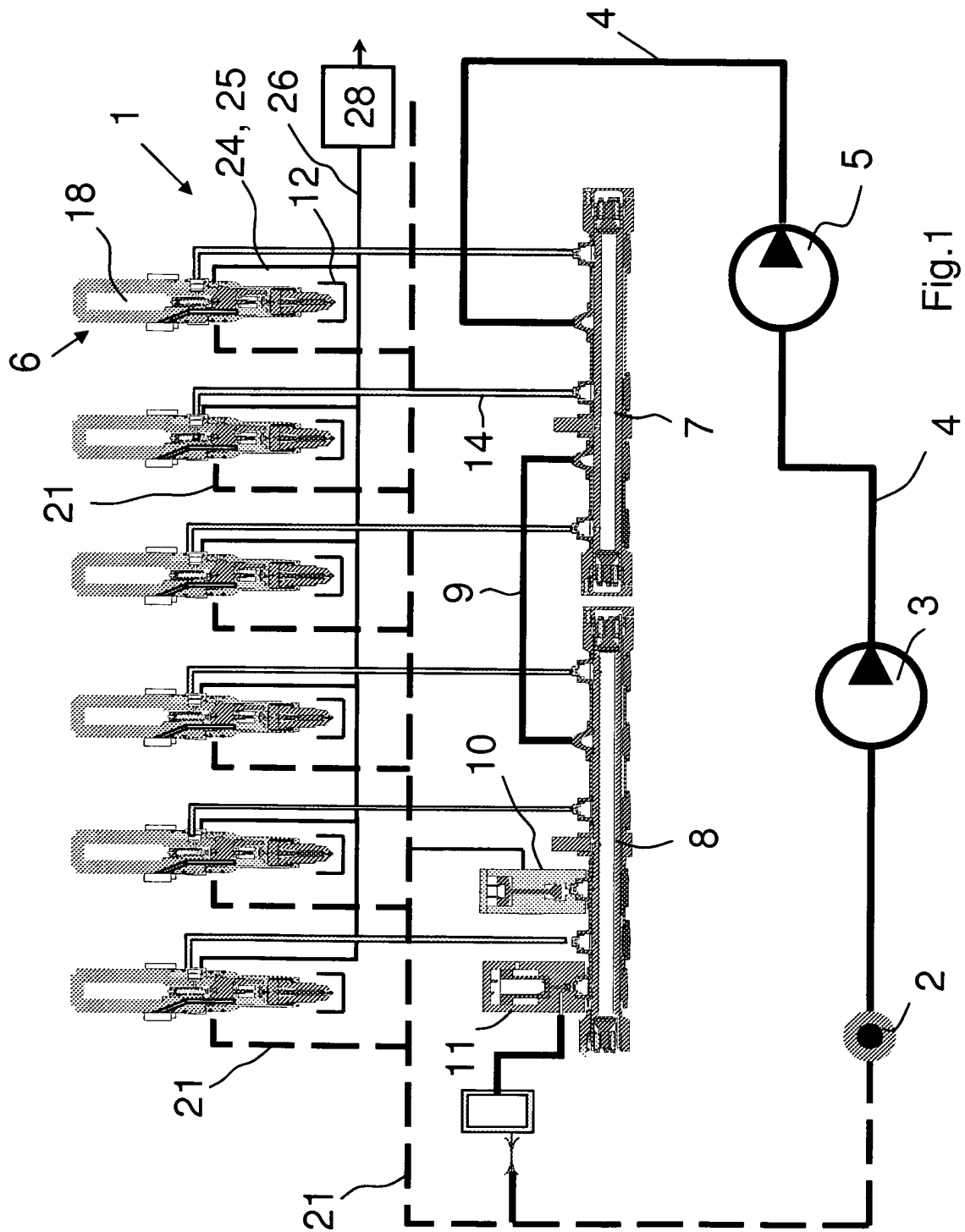


Fig. 1

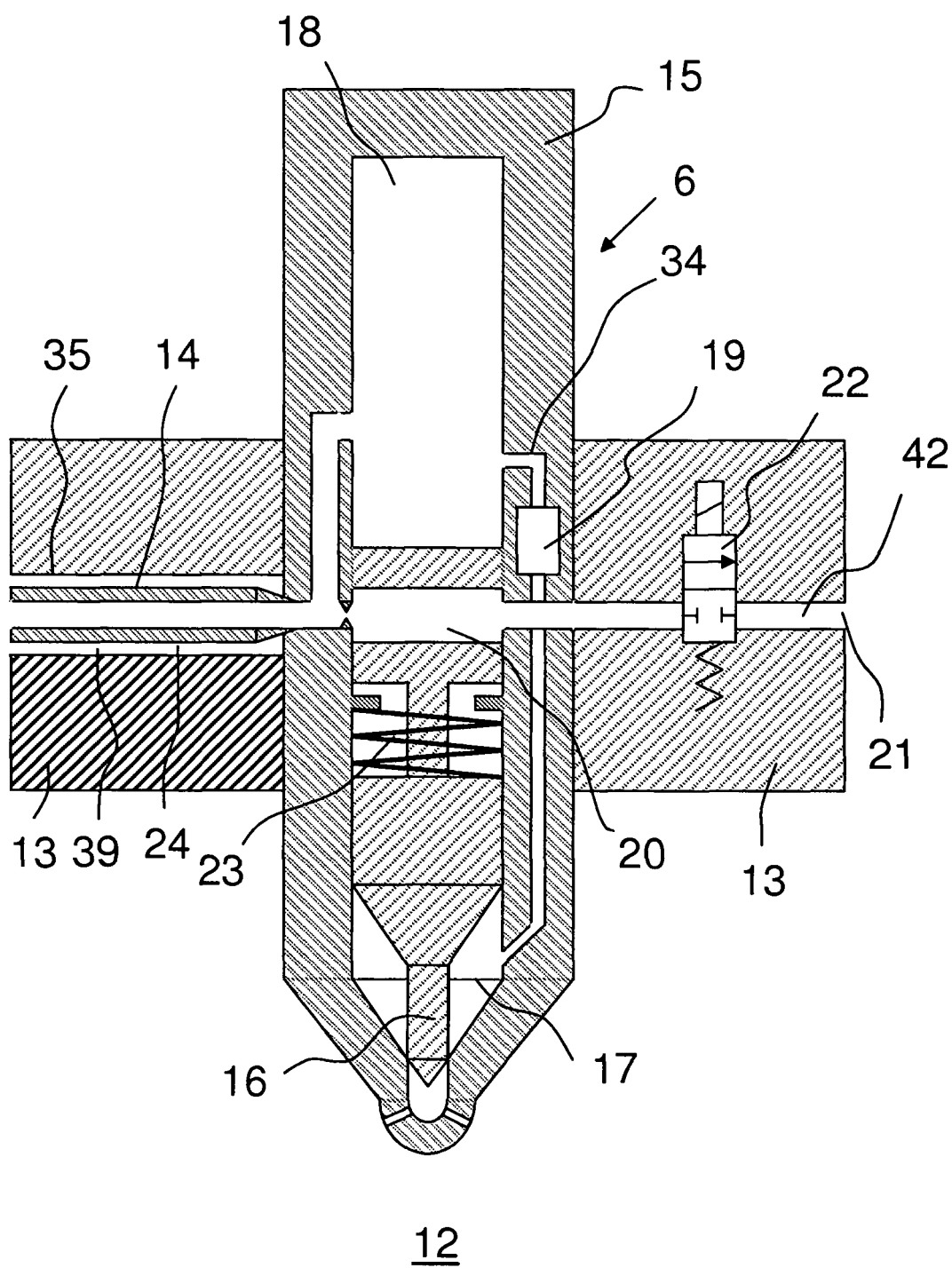


Fig. 2

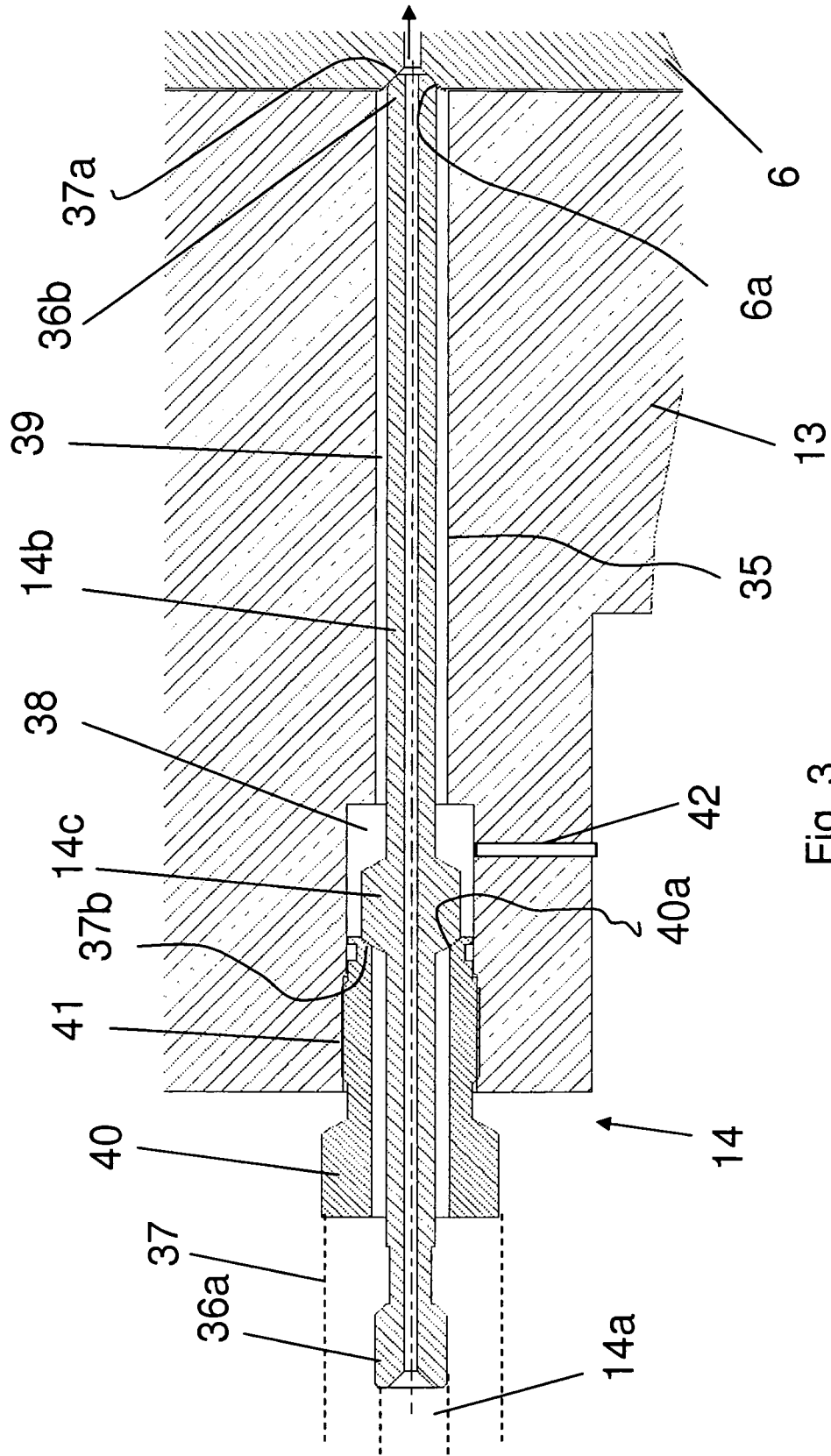


Fig. 3

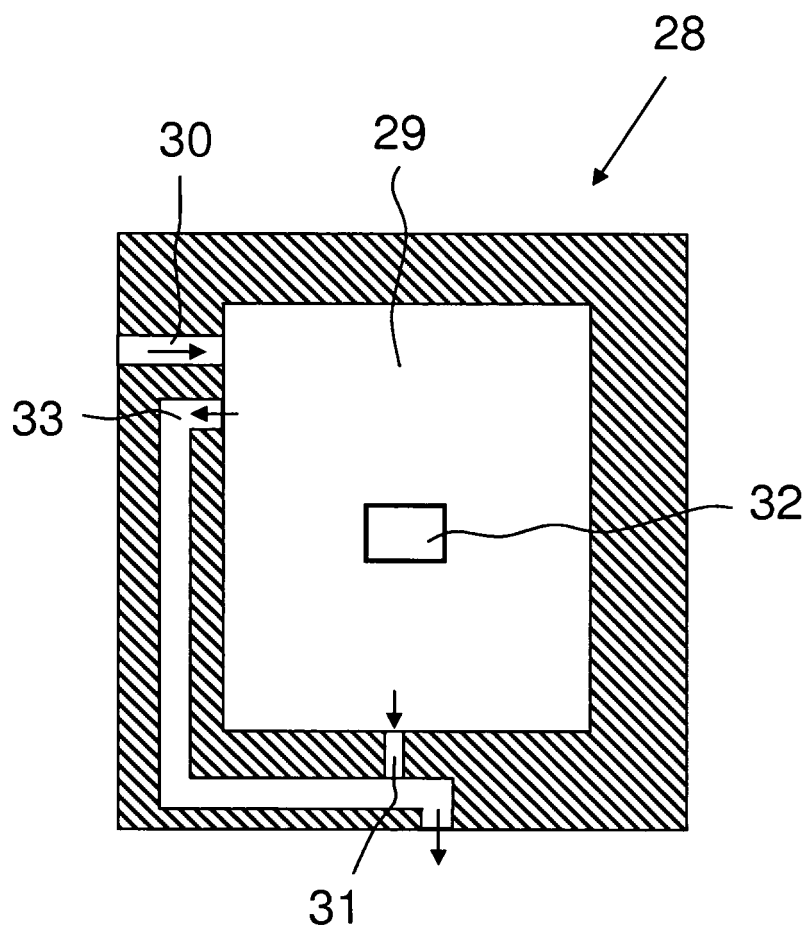


Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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